# Replacing Pastoralism with Irrigated Agriculture in the Awash Valley, North-Eastern Ethiopia: Counting the Costs

by Roy Behnke and Carol Kerven

Paper presented at the International Conference on

**Future of Pastoralism**

**21 – 23 March 2011**

Organised by the **Future Agricultures Consortium** at the **Institute of Development Studies**, University of Sussex and the Feinstein International Center of Tufts University

# REPLACING PASTORALISM WITH IRRIGATED AGRICULTURE IN THE AWASH VALLEY, NORTH-EASTERN ETHIOPIA

# COUNTING THE COSTS

*Roy Behnke and Carol Kerven*

ODESSA centre

*June 2011*

# REPLACING PASTORALISM WITH IRRIGATED AGRICULTURE IN THE AWASH VALLEY, NORTH-EASTERN ETHIOPIA: COUNTING THE COSTS

***Introduction***

The development of hydropower and the availability of irrigated land per capita is lower in sub-Saharan Africa than in any other major region of the world. After several decades of avoiding investment in large infrastructural projects, particularly big dams, international donors are under pressure from African governments to remedy this situation or themselves look forward to doing so (Lautze et al. 2010; You 2010; World Bank 2004). Accelerated dam development would impact directly on pastoral welfare and livestock productivity. With the exception of the Congo, all of Africa's major river flood plains – the Niger, Nile, Zambezi, Senegal, Volta, Okavango and Lake Chad basin – support significant numbers of pastoralists. In East Africa alone, 56% of the Nile Basin is used by pastoralists (Amede et al. 2011), and smaller river systems used by pastoralists include the Tana, Omo, Jubba-Shebelle and Awash. Few other systems of land use can survive in the empty expanses of rangeland that pastoralists can profitably exploit, but it is also clear that African pastoralists rely upon access to valuable riverine real-estate, and new dam building will intensify competition for these key resources (Scudder 1991).

Key resources – often relatively small but extremely productive areas that serve as drought and dry-season refuges for pastoral herds – are the assets that allow mobile pastoralists to exploit vast, erratically productive rangeland areas. The economic performance of pastoralism, its capacity to support human populations and to ride out droughts, depends on continued access to these key assets, especially river valley lands. Across Africa and Asia, many pastoralists lack secure land rights, and the loss of pastoral access to small pockets of highly productive land and the alienation of this land to other uses is a widespread occurrence (Reid et al. 2008; BurnSilver et al 2008; Behnke 2008). These changes are frequently justified *a priori* by unrealistic projections of the increased income that will be generated by irrigated agriculture, or by simply ignoring the opportunity costs of excluding pastoral users (Adams 1992).

Because it has been used so intensively for so long, the Awash valley in north-eastern Ethiopia provides a realistic yardstick for evaluating the benefits and liabilities of irrigated agriculture. The valley contains only 4 to 5 percent of all the land area that is suitable for irrigation in Ethiopia (Awulachew et al 2007). But over a one-third of all Awash valley land that can be irrigated is already irrigated, which amounts to just about half of all the land that is presently under irrigation in Ethiopia (48,311 irrigated hectares out of a national total of 107, 265 hectares (Awulachew et al 2007: 123). Some of this land has also been under irrigation for four or five decades and long term effects are now apparent. Like no other part of Ethiopia, the Awash valley illustrates what lies in store for pastoral areas if African governments pursue a policy of modernizing agriculture by displacing mobile livestock production in favour of irrigated crop agriculture.

If there was a single transformational event, a revelatory crisis that exposed the increasing precariousness of traditional livelihood systems in the Awash valley, it was the Ethiopian drought of 1972-73. It has been estimated that 25-30 percent of the Afar, a pastoral people inhabiting the lowlands of north-eastern Ethiopia, died in that drought (Bondestam 1974)[1]. Drought and famine have a long history in Ethiopia (Pankhurst 1985). What set this occurrence apart was not only its severity but the role of government development programmes in exacerbating the crisis.

For centuries the Afar had used the Awash River valley as a source of grazing for their livestock. Their herds congregated in the valley in the dry season or during droughts and spread out onto the surrounding plains when it rained. This oscillation provided the herds with access to two feed sources – abundant riparian grazing supported by the flooding of the Awash river, and sparse but extensive grazing dependent on local rainfall. Rainfall in Afar is low and highly variable from year to year (Cheung et al. 2008). Floodplain grazing supported by river water drawn from more reliable highland sources was essential for stabilizing the system and preserving life whenever the local rains failed.

By the early 1970s pastoralists along the Awash were rapidly losing their riverine grazing due to upstream hydroelectric projects that regulated river flow and to land concessions granted by the then Imperial Ethiopian government to international agricultural companies for the development of irrigated cotton and sugar plantations (Cossins 1972; Bondestam 1974; Emmanuel 1975; Flood 1976; Kloos 1982; Gamaledin 1993, 1987). When the rains failed in the early 1970s, people and their animals had nowhere to go. A government demographer at the time estimated that 100,000 up to 200,000 people died (Bondestam 1974); an aerial livestock census conducted during the drought documented the disappearance of more than three quarters of all the livestock (Helland 1980; Watson et al. 1972, 1973).

Four decades later, much of the riparian forests that supported traditional Afar pastoralism have been bulldozed under and replaced by irrigated or abandoned fields. It is difficult to conceive of these areas – many of them now damaged by soil salinity and bush encroachment – ever returning to natural vegetation and pastoral use. For the Awash valley there probably is no turning back. An evaluation of agricultural development in the Awash is nonetheless important because the Awash exemplifies general development trends in Ethiopia (Kloos and Legesse 2010), and more broadly across semi-arid Africa (Adams 1992). Where the Awash has been, other areas may soon follow.

The object of this study is to compare the economic returns derived from devoting the Awash valley to pastoralism versus irrigated cotton or sugar cultivation. Our unit of comparison is a hypothetical hectare of riverine floodplain left to pastoralism versus the observed returns per hectare to various forms of cotton and sugar cultivation in the Awash valley.

[1] These estimates probably include Afar living in what is now Eritrea, which was then part of Ethiopia.

CLEARING THE RIVER FLOOD PLAIN FOR SUGAR PLANTATIONS

The following analysis will show with reasonable certainty that pastoralism is either economically comparable or more advantageous than either cotton or sugar cane cultivation. While a well-run private cotton farm can achieve rough productive parity with pastoralism, state cotton farms lost money for decades. Current development programmes suggest that the Ethiopian government is aware of this situation. For some time it has been either turning the operation of its cotton holdings over to private interests – the Afar clans or investors – or transforming old government cotton farms into sugar plantations. The state's sugar estates are more profitable than its old cotton estates, but whether farming sugar cane is more profitable than livestock production is doubtful. Pastoralists in Afar are nonetheless currently losing additional land to expanding state-owned sugar plantations. Later sections of this paper clarify the economic returns and losses to this conversion.

***Study area***

The research study area roughly corresponds to the middle Awash, a stretch of river between the towns of Awash and Gewani (Map 1), an area traditionally inhabited by the Afar people and now part of Afar Region within the Ethiopian federal administrative system. Field work on cotton farming and livestock production was carried out in 2009 and 2010 in three districts of Afar Region – Awash Fantale, Amibara and Gewani. Data on sugar cane cultivation was collected from the Metahara Sugar Factory which is located in Metahara District on the Oromiya-Afar regional border. The current Metahara sugar estate is located in Oromiya Region; the Kesem extension to the estate, described later in this paper, is located in Awash Fantale District of Afar Region.

***Livestock production***

The first step in this analysis is to estimate the returns to pastoralism from the seasonal use of a hypothetical average hectare of Awash valley grazing land. To do this we build a model of Afar herd performance based on a body of field research stretching back over the last four decades.

The calculation begins with an estimate of primary production – the amount of natural vegetation produced on a given area of floodplain grazing, a certain proportion of which is usable as forage for livestock. Estimates in the scientific literature for floodplain forage production from the Awash Valley vary widely, so the results of our calculations are expressed as two estimates of livestock output – one based on low levels (3 tons of consumable dry matter per hectare per year, MAS 1991) and the other on high levels of riverine forage production (6 tons of consumable dry matter per hectare per year, Cossins 1983). These are labelled respectively scenarios a and b in the following analysis.

Most Afar pastoral herds spend only a portion of their year grazing on floodplain vegetation, typically between 3 to 8 months in the period between November and June (Cossins 1983), but the actual amount of time spent in the Awash Valley varies from herd to herd and from year to year depending on rainfall conditions, herd composition, the herder's land tenure rights and other factors. For the purposes of this calculation, we have assumed that herds spend six months of the year feeding on floodplain grazing, with the rest of the year spent on rain fed pastures outside the river valley.

The exit of pastoral herds from the valley for half of the year has the effect of doubling the estimated livestock carrying capacity of valley pastures. For example, valley pastures that produce 3 tons of feed per year could, on average, support 1.3 permanently resident TLU (tropical livestock units) requiring a standard yearly ration of about 2300 kg/TLU/year of feed (Jahnke 1982). With herds absent for half the time, this same hectare will support about 2.6 TLU with similar feed requirements, half of which are now met on upland grazing and half in the valley. No attempt has been made in this analysis to describe where herds go or how much rangeland they use when they leave the valley. It is instead assumed that herds without seasonal access to valley grazing simply could not survive, and that the loss of valley grazing entails the loss of a herd's entire, year-round output. In short, we have assumed that herds depend on valley pastures for their existence, and that the opportunity cost of denying access to valley pastures is the loss of all their productivity.

Different herd species produce different combinations of dairy, traction/transport or meat products at different rates, and male animals yield differently than female animals. The productivity of Afar herds therefore depends, among other factors, on the species, age and sex composition of those herds. Table 1 summarizes these variables.

**Map 1**: *The Awash Basin*

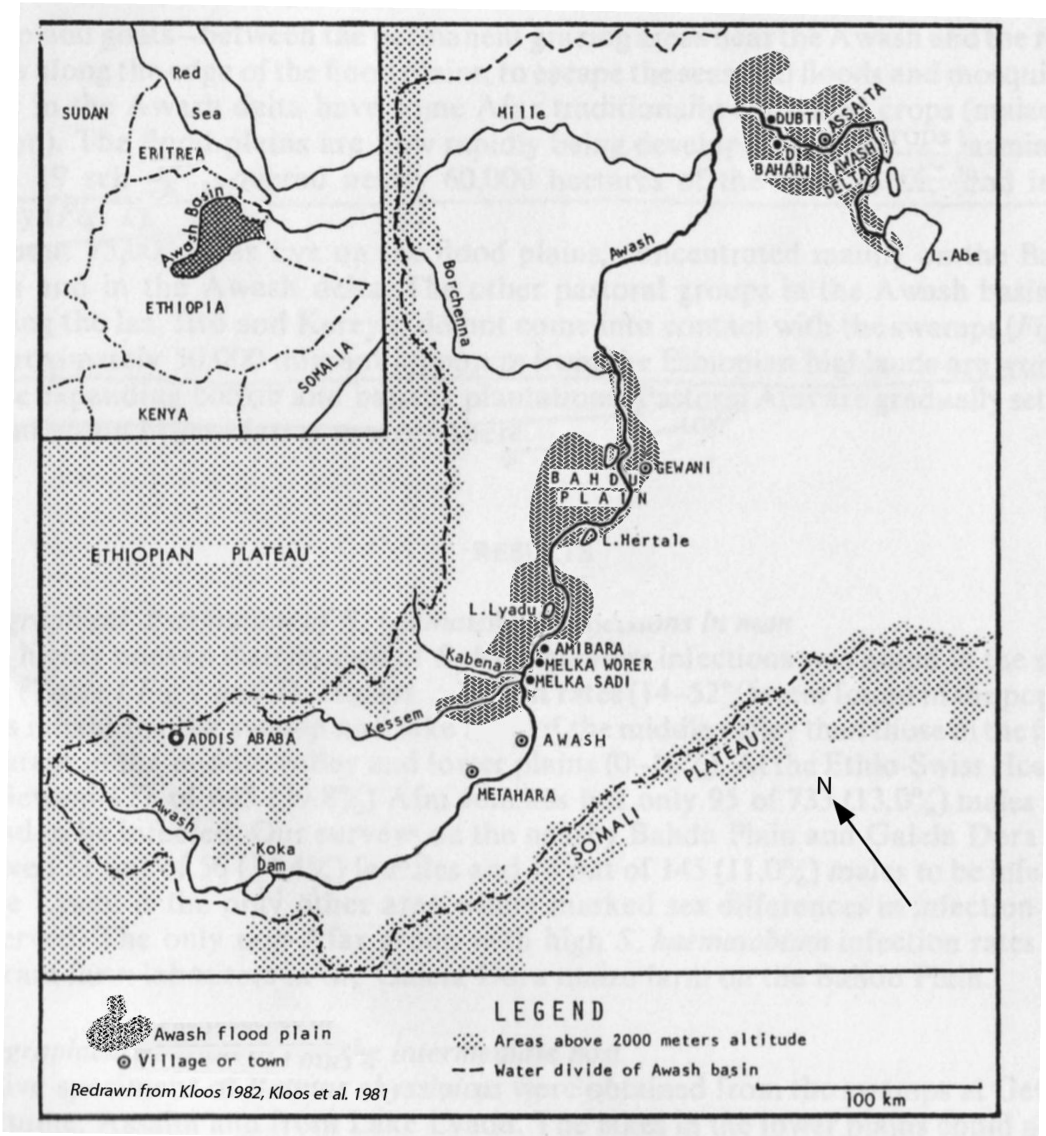



**Table 1**: *Species composition, age and sex structures of Afar herds*

| Species | % herd biomass[1] | % breeding females[2] |
|---|---|---|
| Cattle | 47.6 | 46 |
| Camel | 29.9 | 46 |
| Sheep | 9.6 | 43 |
| Goat | 12.8 | 43 |
| Total | 100 | |

Notes:

[1]Average herd species composition expressed as a percentage of herd biomass, based on Getachew 2001.

[2]Estimates of breeding component based on Davies 2004

Based on the characteristic Afar herd composition and the feed requirements of each species, we can calculate the species mix, the number of animals and the number of breeding females that will on average be supported by a single hectare of valley grazing for six months at high and low stocking rates. This calculation is summarized in Table 2.

**Table 2:** *Head of stock and breeding females supported per hectare of valley grazing at alternate stocking rates*

| | **Scenario (a) low stocking rate** | | | **Scenario (b) high stocking rate** | | |
|---|---|---|---|---|---|---|
| **Herd species** | **TLU/ha [1]** | **Head/ ha [3]** | **Breeding females/ha [4]** | **TLU/ha [1]** | **Head/ha [3]** | **Breeding females/ha [4]** |
| Cattle | 1.252 | 1.75 | .81 | 2.504 | 3.51 | 1.61 |
| Camels | .786 | .786 | .36 | 1.572 | 1.57 | .72 |
| Sheep | . 252 | 2.52 | 1.08 | .504 | 5.04 | 2.17 |
| Goats | .337 | 3.37 | 1.45 | .674 | 6.74 | 2.90 |
| TLU | 2.63 [2] | | | 5.25[5] | | |

Sources:

[1]Getachew 2001 for herd species composition
[2]MAS 1991 for feed estimate and Jahnke 1982 for feed requirements
[3]One Tropical Livestock Unit (TLU) equals 1 camel, 1.4 cattle or 10 sheep or goats, Jahnke 1982
[4]Estimates of breeding component from Davies 2004
[5]Cossins 1983 for feed estimate and Jahnke 1982 for feed requirements

**AFAR PASTORALISTS WITH THEIR MILK AND BUTTER CONTAINERS**

Table 3 summarizes information on the volume and value of milk output per lactating female for each herd species at prices current in 2009[2]. Table 4 does the same for the quantity of meat and its value per breeding female per year, again at prices current in 2009. Total herd output includes the imputed value of milk and meat that is consumed by livestock owners in addition to livestock products that are sold. The value of home consumption is based on commodity prices collected in market surveys conducted by the Central Statistical Agency, as interpreted by the

[2] See Annex I for US dollar to Ethiopian birr exchange rates 1993-2010.

Ministry of Finance to estimate Ethiopia's GDP, and cross-checked in the field. We are at present unable to accurately assign a monetary value to the transport and traction functions of Afar herds.

**Table 3:** *Annual milk yields for human consumption: volume, duration and value in Ethiopian Birr (EB) per breeding female, 2009*

| Species | Lactation period (months)[1] | Offtake per lactation (litres) [1] | Births/yr [1] | Annual milk production (litres) | Value of annual milk production (EB)[2] |
|---|---|---|---|---|---|
| Cattle | 7 | 446 | 0.9 | 401 | 1965 |
| Camels | 9.7 | 2066 | 0.5 | 1033 | 5681 |
| Sheep | 2.8 | 45 | 1.7 | 76.5 | 490 |
| Goats | 2.8 | 54 | 1.7 | 92 | 589 |

Sources:

[1]Davies 2004.

[2]2008-09 prices used by the Ministry of Finance and Economic Development to estimate GDP – 4.9 EB/litre cow milk, 6.4 EB/litre goat and sheep milk, and 5.5 EB/litre camel milk.

**Table 4:** *Value (EB) of surviving offspring per breeding female per year, 2009*

| Herd species | Birth rate[1] | Survival rate[1] | Surviving offspring | Total annual value of surviving offspring (EB)[2] |
|---|---|---|---|---|
| Cattle | .9 | .47 | .42 | 686 |
| Camels | .5 | .55 | .275 | 870 |
| Sheep | 1.7 | .45 | .765 | 161 |
| Goats | 1.7 | .48 | .82 | 169 |

Sources:

[1]Davies 2004 and field work for this study

[2]2008-09 prices used by the Ministry of Finance and Economic Development to estimate GDP – 1634 EB/head of cattle, 3163 EB/head of camels, 210 EB/head sheep and 206 EB/head goats. Cattle value is a mean of MOFED's stock (1400.9 EB) and sale (1867.7 EB) values per head..

Combining the information in Tables 2-4, it is possible to calculate the gross value of livestock production per hectare at 2008-09 prices for two stocking densities (Table 5).

Afar pastoralism is labour intensive and by far the most important input is family labour supplemented by the assistance of friends, relatives and neighbours. These inputs were valued at rural wage rates current in 2009 – adults at EB 8 per day, EB 4 for children and EB 5 for older men – giving annual labour costs per head of EB 16 for sheep and goats, EB 83 for camels and EB 65 for cattle.

**Table 5:** *Gross value in 2009 of live animal, meat and milk for human consumption, EB per hectare per annum at two stocking densities*

| | | Scenario (a) low stocking rate | | Scenario (b) high stocking rate | |
|---|---|---|---|---|---|
| **Herd species** | **Output EB per breeding female** | **Breeding females/ha.** | **Gross value EB/ha** | **Breeding female/ha** | **Gross value EB/ha** |
| Cattle | 2651 | .81 | 2147 | 1.61 | 4268 |
| Camels | 6551 | .36 | 2358 | .72 | 4717 |
| Sheep | 651 | 1.08 | 703 | 2.17 | 1413 |
| Goats | 758 | 1.45 | 1099 | 2.90 | 2198 |
| Total | | | 6307 | | 12596 |

AFAR HERDER WITH GUN BELT

By far the most important cash cost of herding is the provision of security which requires the purchase of an automatic weapon (a capital expenditure of EB 5000 to 7000, roughly the sale value of two camels) and ammunition (a recurrent cost of up to EB 1,300-2000 per year, about the sale price of an ox in 2009). The other cash costs of livestock husbandry – the purchase of stock water, health care or feed supplementation or the expense of transporting animal and their products to markets – are low, something in the vicinity of 1% annually of the sale price of an animal. Table 6 summarizes herding costs exclusive of weaponry and security provision, which varies markedly from community to community depending on location. ‘Front line’ communities facing hostile non-Afar neighbours bear the brunt of protecting Afar territory (Rettberg 2010; Unruh 2005). We are unable at present to estimate the average costs of security provision for Afar herds because we do not know the proportion of front line communities relative to those in more secure areas.

Deducting the costs of production (Table 6) from gross output (Table 5), the annual net returns to Afar pastoralism per hectare are slightly less than 6000 birr (about $543 US dollars[3]) at the lower range of potential riverine stocking densities, and slightly less than 12,000 birr (about $1084 US dollars) at the upper range of potential stocking densities (Table 7).

**Table 6:** *Husbandry costs in 2009 exclusive of weaponry and security provision at two stocking rates in EB*

| | | Scenario (a) | | Scenario (b) | |
|---|---|---|---|---|---|
| **Herd species** | **Total costs per head** | **Head per ha (a)** | **Costs per ha (a)** | **Head per ha (b)** | **Costs per ha (b)** |
| Cattle | 82.9 | 1.75 | 145 | 3.51 | 291 |
| Camels | 107.7 | .786 | 85 | 1.57 | 169 |
| Sheep | 18.1 | 2.52 | 46 | 5.04 | 91 |
| Goats | 18.1 | 3.37 | 61 | 6.74 | 122 |
| Total | | | **337** | | **673** |

In sum, at 2009 prices, 6000-12,000 birr is the opportunity cost per year of excluding pastoralism from a hectare of Awash valley grazing, i.e., the economic contribution of pastoralism that is forgone with the conversion of a hectare of valley grazing to another land use.[4] The following sections of this analysis examine the ability of cotton and sugar farming to compensate the national economy for this loss in livestock output.

**Table 7**: *Net returns in 2009 to one hectare of riverine land under seasonal pastoral land use in EB*

| Scenarios | Value of gross output | Husbandry costs | Net returns |
|---|---|---|---|
| Low stocking rate (a) | 6307 | 337 | **5970** |
| High stocking rate (b) | 12596 | 673 | **11923** |

***Cotton cultivation and processing***

Cotton cultivation produces a raw agricultural commodity – un-ginned seed cotton – that is then processed into lint cotton and seeds. Seed cotton is comparable to the live animals and milk production used in this analysis to calculate the returns to pastoralism – all are lightly processed agricultural commodities that producers might sell onward for further processing.

[3] Using an approximate average exchange rate for 2008-09 of EB11 = $1.00.
[4] Annex II provides additional data to substantiate these estimates of the value of Afar pastoral production.

Table 8 shows the returns to seed cotton farming on MAADE, a large, irrigated state-owned cotton farm in Amibara District. The farm was set up in 1969, nationalized when the Derg came to power in the mid-1970s, and expanded to over 13,000 ha. in the mid-1980s following high levels of government investment (Said 1992; Nicol 2000; Getachew 2001). Table 8 summarizes the performance of the farm in the 1980s, when it reached its greatest size and was strongly supported by government.

Despite respectable yields, the farm was unprofitable in this decade, losing money 7 out of the 11 years covered in Table 8. The farm was also losing annually between 200-300 ha of cultivated area to salinity, a cost that is not reflected in these figures since reclamation was not taking place. According to estimated reclamation costs at that time, about half of the gross revenue of the farm would have been spent on land reclamation in order to maintain a stable farm size – around EB 7,600/ha at 1985 prices (Said 1992).

Including operating and administrative expenses, interest, corporate overheads, and reclamation costs, average annual loses per hectare from 1980-90 were EB -2,412 or the equivalent of a loss of US dollars $ -1,165/ha at 1990 exchange rates.

***Table 8:*** *MAADE yields, operating expenses and revenue from seed cotton 1980-90*

| ***Year*** | ***Area (ha)*** | ***Yield, 100 kg/ha*** | ***Production costs, EB/ha*** | ***Gross revenue, EB/ha*** | ***Profit or loss, EB /ha*** |
|---|---|---|---|---|---|
| *1980* | *6337* | *31.7* | *4267.9* | *4021.0* | *-247* |
| *1981* | *7940* | *29.4* | *4255.7* | *3730.0* | *-526* |
| *1982* | *9268* | *24.9* | *3554.6* | *3158.0* | *-397* |
| *1983* | *11169* | *24.6* | *2898.0* | *3124.0* | *226* |
| *1984* | *13000* | *32* | *3476.2* | *4060.0* | *584* |
| *1985* | *12470* | *32.8* | *3499.3* | *4170.0* | *671* |
| *1986* | *12998* | *32.4* | *3541.2* | *4118.0* | *577* |
| *1987* | *12998* | *26.6* | *3547.1* | *3380.0* | *-167* |
| *1988* | *12058* | *23.7* | *3736.0* | *3012.0* | *-724* |
| *1989* | *12696* | *21.8* | *3843.1* | *2774.0* | *-1069* |
| *1990* | *12318* | *17.7* | *3526.0* | *2250.0* | *-1276* |
| *Average* | *-* | *26.15* | *3650.0* | *3402.0* | *-248* |

Source: Said 1992 Appendix 5 and tables 6.4 and 5.3

By 2009 MAADE had shrunk in size, ceased to be a state farm and was instead leased to a private investor . This smaller, privatized farm slipped in and out of profitability in the period between 2004 and 2009 (Table 9).

This modest improvement in economic performance was achieved despite lower yields as a result of long-term underinvestment in farm and irrigation infrastructure. Land was still being lost to salinity and overall soil fertility was probably declining, irrigation canals and equipment were under-maintained and ground water levels were elevated, no land reclamation was taking place and in some years no fertilizer was used, and for decades fields had not been re-leveled to promote efficient irrigation (MAADE 1997/2005, also unpublished estate records and interviews with farm management). In short, after about 40 years of cultivation, the MAADE farm was showing its age. Even with conscientious management, at this point the farm appeared to be incapable of internally generating income sufficient to cover its own rehabilitation, and any stable improvement in farm performance was dependent on an infusion of fresh capital.

***Table 9:*** *MAADE yields, costs and revenue from cotton production and processing 2004-09*

| ***Year*** | ***Area (ha)*** | ***Yield, 100 kg/ha*** | ***Production costs, EB/ha for seed cotton*** | ***Gross revenue, EB/ha from seed cotton*** | ***Profit or loss, EB /ha seed cotton*** | ***Profit or loss, EB /ha lint cotton*** |
|---|---|---|---|---|---|---|
| *2004-05* | *6569* | *16.4* | 5348 | 4920 | -428 | -941 |
| *2005-06* | *6569* | *19.57* | 5868 | 5382 | -540 | -1745 |
| *2006-07* | *6515* | *24.88* | 6037 | 6966 | 929 | 4240 |
| *2007-08* | *6448* | *19.95* | 5283 | 8977 | 3694 | 5555 |
| *2008-09* | *6368* | *27.16* | 8318 | 11407 | *3089* | |

Source: Unpublished MAADE records, 2004-09

**CLEARING RIVERINE LAND OF PPROSOPIS**

Increasingly towards the end of the Derg regime in the late 1980s, the Afar clans violently opposed the expropriation of their land for irrigated agriculture. Livestock incursions onto cotton fields were routine and there were periodic outbursts of physical violence against farm employees (Getachew 2001). Given this insecurity, many irrigated areas were abandoned when central government authority broke down at the end of the Derg regime and in the transition to the current EPRDF government (Nicol 2000). After the new federal government reasserted control in the early 1990s, it handed back some of these abandoned areas to the

Afar clans. By this time, however, the uncultivated fields had been taken over by *Prosopis juliflora*, an exotic thorn tree that had been intentionally introduced on the cotton farms but subsequently spread uncontrollably. Bringing abandoned fields back into production was largely a matter of clearing them of *Prosopis*. This task was typically undertaken by outside investors working on a sharecropping basis for Afar clan elders.

Our final case study comes from one of these abandoned irrigated areas, in this instance a cooperative farm in Gewane District that was handed back to its original clan owners. Instead of relying on outside investors, one clan formed a cooperative and farmed the land itself. By early 2009 the cooperative farm had been in operation for five complete cropping cycles, growing annually from 16 to 27, 42, 64 and 70 hectares, with further expansion planned for subsequent years.

Table 10 summarizes the income from the cooperative farm in 2009. Both yields and net income per hectare are roughly double those achieved by MAADE even in good years. Seed cotton production was therefore profitable, but the profits from cotton farming were nothing compared to the exceptionally high profitability of exporting ginned lint cotton, which was the cooperative's sales strategy in 2009.

These are exemplary results; indeed we are almost certainly looking at the financial returns to one of the best-run cotton farms in Afar Region. In addition to exceptionally committed management, the cooperative farm has the advantage of newly cleared fields that lay fallow in the transition years from the Derg to the EPRDF. Whether present yields can be maintained over decades of use is unclear. Because it is a cooperative, the farm pays no taxes. Like the other private 'investor' cotton operations in this region, the cooperative is also indirectly subsidized by government expenditure, paying nothing for the maintenance of irrigation infrastructure, for water, or for the initial costs of land development. A comprehensive assessment of the economic performance of the cooperative would need to take account of these largely hidden costs, none of which appear in Table 10.

***Table 10:*** *Clan cooperative yields, costs and revenue from cotton production and processing 2008-09*

| ***Year*** | ***Area (ha)*** | ***Yield, 100 kg/ha*** | ***Production costs, EB/ha for seed cotton*** | ***Gross revenue, EB/ha from seed cotton*** | ***Profit or loss, EB /ha seed cotton*** | ***Profit or loss, EB /ha lint cotton*** |
|---|---|---|---|---|---|---|
| *2008-09* | *70* | *42.9* | 12513 | 19287 | 6774 | *30714* |

Source: Interviews with cooperative managers, 2009

Comparing the financial returns in tables 8-10 underlines the variability inherent in cotton farming, depending on factors such as management skill, the age of the farm, and the overhead costs that the farming operation must support. MAADE has spent the better part of four decades either loosing money or barely breaking even. In contrast, with good management, newly opened fields and low overheads, private farms like the Gewane cooperative can at least match the lower estimates of the returns per hectare to pastoralism, 6774 EB per ha. for seed cotton versus 5970 EB per ha. for livestock. This assessment is based on a like-for-like comparison of relatively unprocessed agricultural and pastoral output – unginned cotton versus live animals, milk and home-preserved milk products. The real profitability of cotton farming arises not from farming itself but from the value added by industrial processing and export – the transformation of raw cotton into lint cotton that can be sold on high-priced international markets returning 30,714 EB per ha. As the next section will show, much the same results emerge from an analysis of sugar cane cultivation.

***Sugar cane cultivation and refining***

Located on the Awash River near Lake Beseka, the Metahara Sugar Factory began producing sugar in the 1960s under the management of H.V.A. (Handels Vereniging Amsterdam, a Dutch firm), was nationalized under the Derg and has remained a wholly state-owned operation (Nicol 2000). Two other large sugar estates are located elsewhere in Oromiya Region, and two additional factories are currently under construction in Afar Region, all under government ownership (Girma and Awulachew 2007; Awulachew et al. 2007; interviews with Metahara managers and Ministry of Water Affairs).

Like cotton, sugar production begins with a raw agricultural commodity – sugar cane – that is comparable to the live animals and dairy produce sold by pastoralists. The first stages of processing turn cane into three intermediate products – raw sugar, molasses and baggasse (cane residue after pressing). An on-site factory at Metahara produces these three products which are then sold. The only estimates that the factory makes of its revenue pertain to the manufactured industrial commodities that it sells – raw sugar, molasses and (since 2007) baggasse. As semi-refined products, raw sugar and molasses, like lint cotton, are not comparable to unprocessed pastoral produce in the form of live animals or dairy output. The value added by industrial processing makes this contrast invalid. But because the Metahara estate neither buys nor sells cane, it makes no attempt to separately calculate its returns from cane farming, though it does separately itemize the costs. To estimate the returns to cane cultivation we must impute a value to Metahara's cane output that is based on a reasonable 'producer price', in this case the cane prices received by private farmers when they sold their cane to another Ethiopian government-owned facility, the Wonji-Shoa sugar refinery, located up-stream from Metahara (Girma and Awulachew 2007).

Table 11 gives the estimated returns to cane cultivation and the actual returns to the processing and selling of raw sugar and molasses at the Metahara factory over the last ten years. These are compared to the estimated performance of pastoral livestock over the same period. Returns per hectare for raw sugar and molasses are based on the total annual sales of these products as reported by the factory management, divided by the area of the entire concession, 14,733 hectares. Annual estimates of net revenue per hectare from sugar cane are based on the total imputed value of cane output divided by the cultivated area, with unprocessed cane valued at producer prices for cane farmers attached to a neighbouring government sugar plantation. All estimates of profits are net of operational and overhead/indirect costs, including depreciation on fixed assets. Given Metahara's favourable location, the estimates of livestock revenues per hectare are based on the high levels of forage output used in Scenario (b). A more detailed explanation of the methods used to construct Table 11 are provided in Annex III.

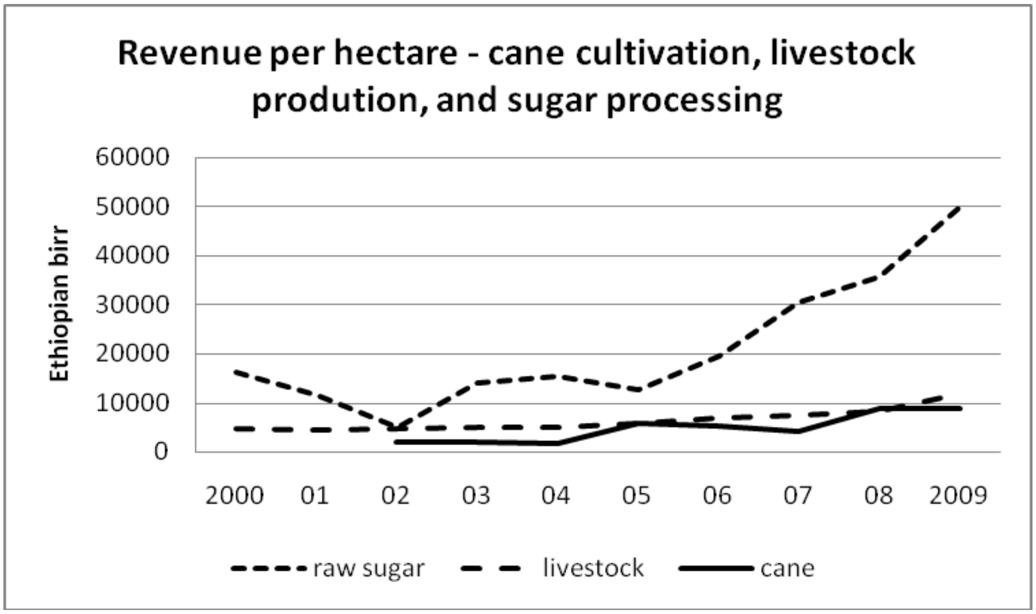
***Table 11:*** *Metahara Sugar Factory – sugar cane yields and net revenue from cane cultivation and the processing of raw sugar and molasses*

| ***Year*** | ***Area (ha)*** | ***Yield sugar cane, ton/ha*** | ***Net revenue EB/ha sugar cane*** | ***Net revenue EB /ha Afar pastoral livestock*** | ***Net revenue EB /ha raw sugar + molasses*** |
|---|---|---|---|---|---|
| *1999-00* | *6568* | *152.6* | | 4767 | *16105* |
| *2000-01* | *6650* | *156* | | *4352* | *11532* |
| *2001-02* | *6678* | *152.9* | 2103 | *4558* | *4883* |
| *2002-03* | *6813* | *153.5* | 2090 | *4948* | *13843* |
| *2003-04* | *6605* | *171.4* | 1739 | *5012* | *15218* |
| *2004-05* | *6162* | *172.4* | 5914 | *5799* | *12660* |
| *2005-06* | *6609* | *173.7* | 5334 | 6971 | 19534 |
| *2006-07* | *7090* | *165.1* | 4254 | 7325 | 30332 |
| *2007-08* | *7056* | *160.2* | 8811 | *8413* | *35672* |
| *2008-09* | *7588* | *158.3* | 8744 | *11927* | *49981* |

Source: Based on unpublished data from the Metahara Sugar Factory and Wonji-Shoa Sugar Estate; see Annex III

Using the data in Table 11, Figure 1 graphically illustrates the relative profitability of livestock keeping relative to cane cultivation and the processing of raw sugar. Cane cultivation was roughly as profitable as livestock in two years and less profitable in six out of the eight years in which this comparison is possible. As with cotton farming and processing, the real profits were to be made not from cultivating cane but in adding value by refining it and marketing raw sugar.

*Figure 1*




***Livestock, cotton or sugar?***

This study examines the relative profitability of three different farming options – cotton plantations, sugar plantations, and pastoral livestock keeping – for the Awash valley. For cotton farming in particular, the comparison is complicated by the different kinds of cotton farming operations at that have been documented at different times. At 2008-09 prices, the estimated annual net returns to pastoralism per hectare of valley pasture were about EB 6000 at the lower range of potential stocking densities, up to EB 12,000 at high animal densities. These benefits are in marked contrast to annual losses of more than EB 2,000 per hectare suffered by the MAADE state cotton farm in the decade of the 1980s. As long as the comparison is with state cotton plantations, there is no argument – pastoralism is unequivocally the more productive use of the valuable floodplains and river water of the Awash and its tributaries. At least up to the mid-1990s, state-owned cotton plantations in the middle Awash provide a clear example of dysfunctional development – a country investing in making itself poorer.

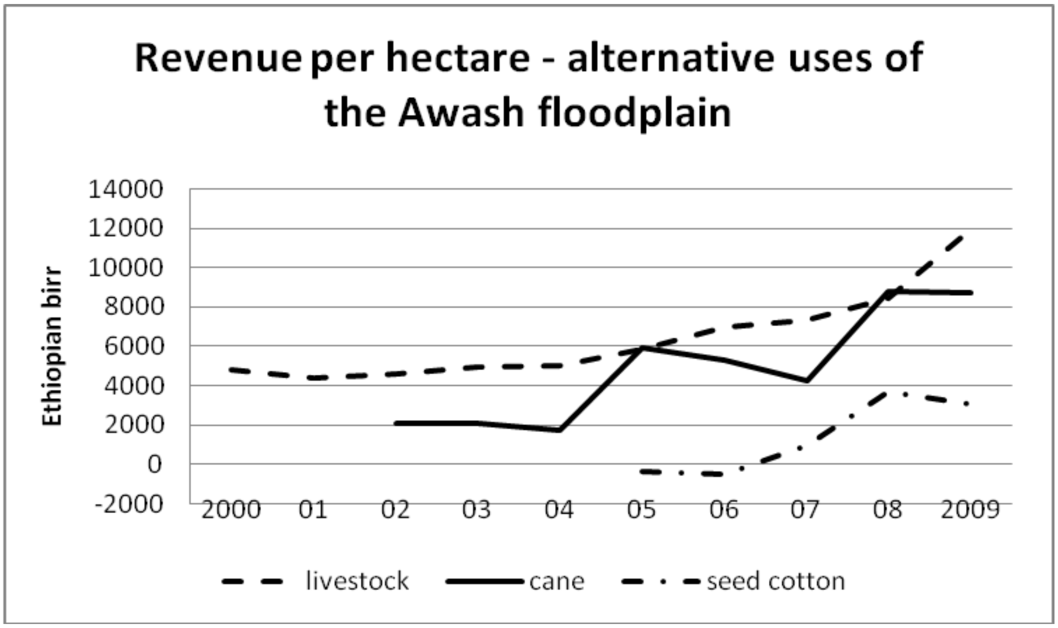
Cotton also appears in an unfavourable light if we look at current yields on the newly privatized MAADE farm. Despite conscientious management by those who now run the farm, years of cultivation have reduced yields to the point where farm profitability is marginal and appears incapable of paying for the maintenance, reclamation and repairs needed to recover decades of lost soil productivity and inefficient water use. If this farm is a reliable indicator of the future, cotton farming may occasionally be as profitable as pastoralism, but it leads in the long term to soil salinization, and is environmentally and economically unsustainable without public subsidies.

The situation is more equivocal when pastoralism is compared to private cotton cultivation on the Afar cooperative farm, which can give an annual net return of EB 6774 per hectare in 2008-09, roughly equivalent to the lower estimate of the profits from pastoralism. This comparison excludes several important costs about which we have insufficient information – missing for cotton are the hidden government subsidies that support private cotton cultivation, and missing for livestock are the substantial costs of providing security in some pastoral communities. Nonetheless, it would appear that there is approximate productive parity between pastoralism and well-managed, private cotton farming. This implies that the opportunity costs of excluding pastoralism from sections of the Awash valley are roughly comparable to the revenues generated by the cotton farming that might replace it. The promotion of cotton farming has radically changed the ecology, the agricultural production systems, and the ethnic background of the people that exploit the valley, but despite years of investment, there is little evidence that it has significantly improved agricultural income per unit area.

**RAW COTTON ON PRIVATE FARM**

Sugar cane presents much the same picture. Judging from the Metahara data, in one of four years the returns from cane farming roughly equal those from livestock, but fall short in three of four years. For all the investment and dislocation involved in shifting from livestock to sugar, there has been little change in the value of farm output per hectare (Figure 2).

***Figure 2***




There are additional reasons to be cautious about using Metahara as a model for expanding sugar production into new areas. One of the principal reasons for Metahara's success is its favourable location on a broad, alluvial plain with rich volcanic soils high in the course of the Awash River where water supplies are reliable because there are few prior claims to them. In contrast to the other two large Ethiopian sugar plantations (Fincha and the Wonji-Shoa Sugar Estates, both in Orimya Region) Metahara's water supply is gravity-fed directly from the river, without the expense of building and maintaining either a dam or water pumping facilities. As a consequence, a very low proportion of Metahara's fixed assets – only 16% – is tied up in investment in irrigation infrastructure (Metahara 2008). To put this in perspective, more of the estate's capital is invested in buildings and office furniture than in irrigation infrastructure.

The estate's favourable circumstances also hold down the cost of bringing new land into production. Using 2008-09 development costs and sales figures, the investments needed to bring a new hectare of unirrigated land into cultivation at Metahara could be paid off with the profits of 1.6 years of raw cane and molasses sales from that land – a remarkably rapid return on a long-term agricultural investment (unpublished records, Metahara). But these figures refer to incremental additions to the existing plantation, not a major expansion onto a new site. Such a major expansion is currently underway adjacent to Metahara using the water of Awash tributaries, and the economics of this project look very different from those of Metahara itself. The Kesem Project involves the construction of a dam capable of storing 500 million cubic meters of water adequate for the irrigation of 20,000 ha, half of which will belong to a new state-owned sugar factory and plantation. This complex was under construction when this study was carried out, and final construction costs were not known and had recently escalated due to technical problems with the dam itself. Assuming that the dam can be successfully built, it is likely that the capital invested in it alone will equal the investment in all other aspects of the plantation – effectively doubling the level of capital expenditure that was needed to construct Metahara (Metahara 2009, interviews with farm managers). If these cost estimates are accurate, after land has been brought into full production on the Kesem extension (a process that will take some years), it will require more than a decade of raw sugar and molasses sales from this land to simply recoup the initial capital investment, irrespective of additional financing, operating or overhead costs.

In sum, the profitability of sugar farming is site specific. Metahara sits on an extraordinary favourable site, maybe the best in the Awash valley, and probably produces some of the most profitable sugar in Ethiopia. It therefore provides little indication of the likely returns to future sugar cultivation elsewhere along the Awash or on other Ethiopian river systems. Even with these advantages, the best that can be said for sugar cane cultivation at Metahara is that intermittently it is about as profitable as livestock keeping.

***Stability and risk***

In an unpredictable natural environment, the reliability of a production system may be as important as its profitability. Stability of income may therefore provide a second yardstick against which we can judge the suitability of alternative agricultural production systems for the Awash valley.

The Ethiopian government views the agricultural development of the Awash as a means of both increasing and stabilizing incomes to reduce dependency on food relief. The government officials responsible for promoting the development programme assert that mobile pastoralism was an economically appropriate use of the valley thirty or forty years ago, but that falling rainfall levels and recurrent droughts now make it necessary to abandon pastoral mobility for settled livestock and crop farming (Kesem-Tendahu Integrated Development Project, interview with staff). The accuracy of this narrative is open to doubt.

With respect to rainfall, a recent study of 13 Ethiopian watersheds found no strongly significant changes in annual rainfall levels for individual watersheds, including the Awash, or for Ethiopia as a whole between 1960 and 2002 (Cheung et al. 2008). The problems of pastoralism in the Awash cannot, it would seem, be attributed to documented changes in rainfall levels or to an increase in the meteorological incidence of drought.

There is, on the other hand, a broad scientific consensus that drought and famine in Afar are exacerbated by government-sponsored development programmes. This interpretation was initially advanced by observers in the 1970s, quoted below, and has been repeatedly endorsed by later scholars (Gamaledin 1993; Asfaw 1996; Gebre and Kassa 2009):

> With the introduction of cash-crop production, some of the Afar were forced to leave their river-watered pastures – where they had lived more or less

> permanently since the 16th and 17th centuries – to become increasingly dependent on the availability of rain. This has led to a relative over-population of the less fertile areas to which they had to move, with consequent over-grazing and livestock starvation, followed by diminishing herds and malnutrition. (it is the rainfall in the highlands, of course, which determined almost entirely the level of the river; so the Afar are lost if they are denied access to this lifeline when there is a drought in the lowlands.) (Bondestam 1974: 428-9).
>
> Man-made famine is a recent phenomenon in the Awash Valley. The available evidence suggests that the 1972/73 famine was not caused entirely or primarily by failure of the rains or deliberate overstocking by local pastoralists, but rather by dam construction, large-scale irrigation development that relied almost exclusively on migrant laborers from the highlands and ensuing loss of grazing and water resources and environmental degradation. These changes rendered the pastoralism particularly vulnerable to the climatological drought. The meagre rains between 1971 and 1973 were the last of a series of calamities that disrupted local food production systems (Kloos 1982: 40).

Government programmes are not a solution but a cause of increased instability in pastoral livelihood support systems that are already exposed to significant rainfall, disease and security risks:

> The critical characteristic of the imported concepts of land use and control used by the state is that they do not incorporate empirical experience gathered over time of the extreme rather than the average conditions which the agriculturalist and pastoralist are likely to encounter. Given that ecological survival hinges on the ability to survive extreme rather than average conditions, the designs of the state represent an elementary threat to rural producers who cannot fall back on alternative state income (Gamaledinn 1987: 340).

Finally, there is little evidence that the agricultural systems that have displaced pastoralism – huge, integrated plantations and processing complexes – have actually increased the stability of agricultural performance in the valley. All farming ventures are vulnerable to disruption caused by changes in market prices or the weather, but the size of plantations exposes them to large-scale environmental and economic problems if things go wrong, and the uniformity of plantation agriculture can leave a region without alternatives if the plantation system proves unworkable. The current performance of the privatized MAADE farming and processing complex illustrates these risks. This is an operation, it will be recalled, that is profitable in some years and loss making in others. Returning to the economic data on that scheme, it is apparent that between 2004 and 2009 the processing of lint cotton both increased profits in good years and magnified the financial losses to the farm in bad years, as compared to raw seed cotton cultivation (Table 9). Processing made economic returns more not less volatile.

The economic performance of the Metahara Sugar Factory between 1999 and 2009 replicates this pattern. Using international producer prices for sugar cane to estimate the net revenue from cane cultivation at Metahara, we can compare the annual variability in revenue derived from cane versus that from raw sugar and molasses. The coefficient of variation (CV, a measure of variability), for annual sugar and molasses income was nearly six times higher than that for the imputed income from unrefined cane – 65% for sugar and molasses versus 11% for cane. Apparently, refining adds considerable value to raw cane in good years, but the high fixed costs of maintaining a factory are a risk in poor years when the factory works at reduced capacity. Like cotton ginning, sugar refining may be more profitable than farming alone, but it would also appear to be more risky, and vertical integration may exacerbate income instability.

This, at least, is the picture that emerges if we use international prices to impute the value of Metahara's cane production. If we value Metahara's cane at producer prices set by a neighbouring government-owned sugar factory, the Wonji-Shoa Sugar Estate, (Table 11), a different picture emerges. In this case the CV in annual income from cane production rises to 59%. This second calculation suggests that government pricing policies at the Wonji-Shoa estate displace some of the increased risk associated with sugar refining back onto private cane growers. According to the growers supplying the estate, the uncertainty caused by pricing policies is further exacerbated by several additional features of their contractual relationship to the factory:

- On a designated portion of their land, they cannot grow crops other than sugar cane, nor can they sell their cane to other refiners.
- Any payments by the factory to farmers are net of production costs, which are set at levels determined by the factory, which provides inputs that farmers are obliged to use.
- Producer prices are agreed at three-year intervals, but the estate's production costs are based on current prices and can be adjusted upwards annually.
- Farmers pay for replanting fields that are destroyed by emergency discharges of flood waters from upstream, government-managed dams.

From the perspective of the private farmer who is forced to absorb these risks, it seems unlikely that cane farming helps to stabilize rural incomes.

### *Environmental impacts*

Distinctive environmental problems are associated with each of the production systems reviewed here. For pastoralism, rangeland overgrazing and degradation is the main concern. Cotton cultivation is associated with deforestation to create arable fields, the introduction of the invasive tree *Prosopis juliaflora*, and with raised water levels leading to the salinization or alkalization of soils and the eventual abandonment of cultivated areas. The Metahara Sugar Estate is threatened by the expansion of Lake Beseka, an adjacent saline Rift valley lake, but it would appear that excessive irrigation or improper drainage are not major contributors to the lake's expansion (Belay 2009). The current

Kesem extension to Metahara has recently destroyed large areas of riparian forest. For those living in the valley, irrigation has increased the risk from malaria and schistosomiasis (Kloos and Lemma 1977; Haile Meskal and Kloos 1989; Kloos et al. 1981).

Quantification of the economic costs of these environmental hazards is beyond the scope of this analysis. Water scarcity issues that are just now emerging also alter fundamentally the framework for evaluating alternative land use systems. As a result of increased levels of water extraction following the completion of the Kesem extension to Metahara and the rehabilitated Tendahu plantation near Logia, the availability of water across the Awash drainage system as a whole is becoming an issue. Reduced water supplies are especially a concern for down-stream consumers who are most exposed to shortages – i.e. the traditional agro-pastoralists of Aysaita (the old Awassa Sultanate). Production for these farmers and pastoralists could be falling or becoming more erratic in years of low river flow, even if these producers manage to avoid losing their land.

Heretofore we have compared different systems according to how efficiently they utilize scarce river bottom land. The emergence of water scarcity suggests the need to look at water use efficiency as well as land use efficiency in calculating the dis/advantages of alternative agricultural systems (Adams 1992). Water denominated appraisals are appropriate to 'mature' irrigation systems (in American southwest or Israel, for example) where water scarcity not land availability is the dominant concern. The Awash is the only river system in Ethiopia approaching this level of use. Calibrating returns in terms of cubic meters of water rather than hectares of irrigated land would reduce the apparent advantages of water-demanding agricultural production systems and emphasize the advantages of natural grazing which uses less water, adds few chemical pollutants to it, and leaves the remainder available for other purposes.

### ***Conclusions***

Throughout the 1960s and 1970s there was a blueprint for African range and livestock development projects: the ranching model. Improved levels of livestock production were one of the many benefits that ranching projects promised to deliver, and at first this claim seemed so self-evidently true that no one critically examined it. When researchers did compare ranch and pastoral productivity in the early 1980s, their studies revealed that, contrary to expectations, pastoralism was the more productive of the two systems (Penning de Vries and Djiteye 1982; Cossins 1985; Western 1982; de Ridder and Wagenaar 1984). But by this time repeated project failures had undermined confidence in the ranching model, and donors were already moving on to other things. Having missed an opportunity to influence the design of policy, research results arrived just in time to explain its failure.

Like the older work on ranch and pastoral productivity, the results of the present study could not have been foreseen. That an indigenous African pastoral production system would produce returns per hectare equal to or greater than those from state-subsidized irrigated cotton and sugar farming runs counter to reasonable expectations. Whether these results are anomalous or indicative of a broader trend remains unclear. Shine compared the returns from a system of intensive sorghum cultivation recommended by donor agencies to a prevailing multiple use system that included pastoralism in seasonal wetlands in semi-arid eastern Mauritania. Returns to the existing multiple-use system were estimated to be six to thirteen times greater than those from the putatively improved system (Shine 2002; Shine et al. n.d.). Barbier and Thompson (1998) examined the benefits and costs from large-scale irrigation schemes in the Hadejia-Jama'are River Basin in northern Nigeria. These wetlands provided seasonal grazing for mobile pastoralists, but the researchers were unable to place a monetary value on grazing benefits. They nonetheless found that gains in irrigation benefits accounted for at most around 15% of the losses from reduced floodplain inundation to existing production systems and advised against further expansion of large-scale irrigation. Salem-Murdock and Horwitz examined the downstream impacts of Manantali Dam on a major tributary of the Senegal River (Horowitz 1995; Salem-Murdock and Horowitz 1991). In this case, irrigated agriculture offered higher returns per unit land area but lower returns to capital and labour than a pre-existing multi-use system that included livestock keeping: 'The paradox of irrigation is that effective production requires both a good deal of liquid capital and a large, stable labour supply, but yields relatively poor returns to both' (Salem-Murdock and Horowitz 1991, cited Horowitz 1995: 490). Adams (1992, cited in Scudder 1996) found that the costs to downstream villages in terms of reduced crop, livestock and fish productivity exceeded the benefits derived from the Bakolori dam and irrigation project on the Sokoto River, a tributary of the Niger (Adams 1987).

Various studies have assigned monetary values to the grazing resources of the Zambezi Basin (Seyam et al. 2001 and Turpie et al. 1999, summarized in Schuyt 2005), wetlands in Lesotho and peri-urban South Africa (Lannas and Turpie 2009), wetland in the Olifants river catchment in South Africa (Adekola et al. n.d.), a Limpopo wetland in southern Africa (Jogo and Hassan 2010), and the Okavango Delta of Botswana (Turpie et al. 2006). None of these latter studies compared the returns from grazing or multiple-use systems to the benefits that might be derived from intensive agricultural development based on large-scale irrigation or wetlands drainage. We could locate no studies that attempted to quantify the grazing-irrigation trade-off for several of Africa's great 'pastoral' rivers or floodplains – the Nile, Zambezi, Volta, Limpopo, Okavango and Juba-Shebelle.

Whether the economic performance of alternative land use systems in the Awash valley has broader significance for pastoral land use policy in semi-arid Africa will only become apparent when additional comparative work is available. Until then, the one conclusion that does emerge unequivocally from this analysis is the remarkable continuity of Ethiopian irrigation policy for the Awash valley, across half a century and despite radical changes in political regimes. What is now Afar Region was formally annexed to the Abyssinian Empire late in the 19th century but retained a degree of independence until the middle of the 20th century (Harbeson 1978). Irrigation schemes along the Awash were part of the incorporation process, a way for the central government to control resources by putting immigrant Ethiopian highlanders on those resources and by reengineering the environment to provide labouring jobs that accommodated their farming backgrounds – cutting cane and picking cotton.

Plantation agriculture has been a consistent feature of the incorporation process. In the Imperial period the concessions went to UK, Dutch, Israeli and Italian firms. The Derg government nationalized the plantations and turned them into state farms (Nicol 2000). Borrowing from each of its predecessors, the present EPRDF government is both expanding its sugar estates – at Wonja, Metahara, and Tendaho – and contemplating the leasing of thousands of hectares of concessions to Egyptian, Saudi, Turkish and Israeli commercial interests (interview with Ministry of Water Resources).

The advantages of this policy for government are illustrated by the finances of the Metahara Sugar Factory in 2007-08, a year in which we have complete annual accounts (Metahara 2008). In that year the government, which was the combined estate owner and taxing authority, used a variety of different accounting devices – excise tax, Sugar Development Fund, State Dividend, Industrial Development Fund – to claim for itself 65% of the sales turnover of the Factory, about 541 million birr or the equivalent of $58 million US dollars at the then exchange rate (Metahara 2008). Whatever else it does, Metahara makes a lot of money for government. Despite their importance to the Ethiopian national economy, pastoralists almost certainly do not match, and would not want to match, this level of contribution to the state treasury. Indeed, the recurrent complaint by the authorities against the informal cross-border trade in livestock is that this trade escapes taxation, despite its obvious contribution to the welfare of Ethiopians (UNDP 1998; Little et al. 2001; Little 2002; Devereux 2006).

**NEW HUTS FOR PLANTATION WORKERS**

Plantation agriculture may or may not be good for the Ethiopian environment and economy, but it has been good for the government. It has transformed a fiscally sterile grazing environment into a fiscally productive agricultural one, and displaced independent pastoral producers with tractable taxpayers. James C. Scott has drawn a distinction between gross domestic product and what he has termed state-accessible product. It was, he has argued, not the size of the total economy but the size of that portion of the economy that the authorities could appropriate, that animated pre-modern state behaviour in Asia (Scott 2009). Scott's observation may also explain the great attraction of vertically integrated plantations and processing facilities for Ethiopian governments irrespective of their different ideological backgrounds. The real advantage of plantation agriculture may not be its purported efficiency, productivity or contribution to the national economy. Its greatest virtue may be that it makes money that is accessible to government. Don Donham has argued that the modern Ethiopian state survives largely through the exploitation of its margins, the 'subsidy of the core by the periphery' (Donham 1986: 24, quoted in Pankhurst and Johnson 1988). The lopsided contest between pastoralism and plantation agriculture in the Awash conforms to this pattern.

**ACKNOWLEDGEMENTS**

Many people and organizations generously supported this study. The International Institute of Environment and Development (IIED) funded the initial field research and Ced Hesse of IIED has provided consistent encouragement as our results slowly emerged. The Feinstein International Center of Tufts University supplied logistical support and funded field work by Gezu Bekele, who investigated sugar production and prices at the Wonji-Shoa Sugar Estate and contributed the information on those topics that appears in this paper. Research on sugar production was funded in part by the Department for International Development, DFID, of the British government, and supported by the Ethiopian Development Research Institute (EDRI) which provided letters of introduction to farm managers at the Metahara Sugar Factory and the MAADE cotton estate and to Afar regional government officials. Herrie Hamedu Ali and Kassa Negussie Getachew introduced us to Afar Region and Mohamodu Duwod and Mohammed Awel served ably as translators and field assistants. Mintewab Bezabih, Steve Mandel, John McPeak, Essam Mohammed and Peter Little all commented on various drafts of this paper. Finally, we wish to thank numerous staff at the Metahara and MAADE estates, and the Afar pastoralists and farmers whom we interviewed for their open and helpful responses to our questions. The content of this paper represents the views of the authors, and does not necessarily represent those of our funding or implementing partners. We are solely responsible for any errors this paper may contain.

## REFERENCES


Adams, W.M. 1992. *Wasting the Rain: Rivers, People and Planning in Africa.* Earthscan Publications Ltd., London.

Adams, W.M. 1987. Approaches to water resource development, Sokoto Valley, Nigeria: the problem of sustainability. In Anderson, D. and Grove, R. (eds.) *Conservation in Africa: People, Policies and Practice*, pages 307-326. CUP, Cambridge.

Adekolaa, O., Morardetbc, S., de Groota, R. and Grelotc, F. n.d. The economic and livelihood value of provisioning services of the Ga-Mampa wetland, South Africa. http://halshs.archives-ouvertes.fr/docs/00/46/85/52/PDF/MO2008-PUB00024482.pdf

Amede, T., Descheemaeker, K., Mapedza, E., Peden, D., van Breugel, P., Awulachew, S., and Haileslassie, A. 2011. Livestock-water productivity in the ile Basin: solutions for emerging challenges. In Melesse, A. (ed.) *Nile River Basin: Hydrology, Climate and Water Use*, pages 297 - . Springer, Dordrecht.

Asfaw Desta 1996. Large-scale agricultural development and survival issues among pastoralists in the Awash valley. Paper presented at *Conference on Pastoralism in Ethiopia*, 4-6 Feb 1993. Ministry of Agriculture, and IIED, Addis Ababa.

Awulachew, S.b., Yuma, A.D., Loulseged, M., Loiskandl, W., Ayana, M., Alamirew, T., 2007. *Water resources and irrigation development in Ethiopia.* Working Paper 123. International Water Management Institute, Colombo, Sri Lanka.

Ayele, Kassahun and Juhasz F. 1970. *Report on the socio-economic conditions of nomadic pastoralists in the Awash River basin.* Mimeo Appendix 3 p. 4 cited in Emmanuel 1975.

Barbier, R. and Thompson, J. 1998. The value of water: floodplain versus large-scale irrigation benefits in northern Nigeria*. Ambio* 27: 434-440.

Behnke, R.H. 2008. The drivers of fragmentation in arid and semi-arid landscapes. In Galvin, K.A., Reid, R.S., Behnke, R. H. and N. T. Hobbs (eds.) *Fragmentation in Semi-Arid and Arid Landscapes: Consequences for Human and Natural Systems,* pp 305-340. Springer, Dordrecht, The Netherlands.

Behnke, R., Devereux, S., Teshome, A., Wekesa, M. and White, R., 2007. *Piloting the productive safety net programme in pastoral areas of Ethiopia*. Report to Food Security Coordination Bureau and Pastoralist Task Force, for Ministry of Agriculture and Rural Development and Save the Children USA, Addis Ababa.

Belay, E.A. 2009. *Growing Lake with Growing Problems: Hydrological Investigation on Lake Beseka.* Doctoral dissertation, University of Bonn, Bonn, Germany.

Bondestam, L. 1974. People and Capitalism in the North-Eastern Lowlands of Ethiopia. *The Journal of Modem African Studies,* 12, 3, pp. 423-439

BurnSilver, S.B., Worden, J., and R.B. Boone. 2008. Processes of fragmentation in the Amboseli Ecosystem, Southern Kajiado District, Kenya. In Galvin, K.A., Reid, R.S., Behnke, R. H. and N. T. Hobbs (eds.) *Fragmentation in Semi-Arid and Arid Landscapes: Consequences for Human and Natural Systems,* pp 225-253. Springer, Dordrecht, The Netherlands.

Cheung, W., Senay, G., Singh, A. 2008. Trends and spatial distribution of annual and seasonal rainfall in Ethiopia. *International Journal of Climatology*. DOI: 10.1002/joe

Cossins, N. 1972. *No Way to Live: A Study of the Afar Clans of the North-East Rangelands*. Livestock and Meat Marketing Board, Addis Ababa.

Cossins, N.J. 1983. *Where the Grass is Greener: Bringing the Answer Closer to Home*. Tcheffa Valley Study Summary Paper. Joint Ethiopian Pastoral Systems Study: research Report No. 1. International Livestock Centre for Africa (ILCA) study for Rangelands Development Project. Addis Ababa. [ILCA doc]

Cossins, N.J. 1985. The productivity of pastoral systems. *ILCA Bulletin* 21: 10-15.

Davies, J. 2004. *The Role of Livestock in Afar Pastoral Livelihoods: Capitalisation, Commoditisation and Obligation*. Ph. D. thesis, Department of Agricultural and Food Economics, University of Reading, UK.

De Ridder, N. and Wagenaar, K. 1984. A comparsion between the productivity of traditional livestrock systems and ranching in eastern Botswana. *ILCA Newsletter* 3 (3): 5-6. International Livestock Centre for Africa, Addis Ababa.

Dessalegne, Belete 1979. *Livestock production monitoring in the North East rangelands of Ethiopia. Baseline Study report*. International Livestock Centre for Africa (ILCA), Addis Ababa. [ILRI doc]

Devereux, S. 2006. *Vulnerable Livelihoods in Somali Region, Ethiopia*. Research Report 57, Institute of Development Studies, Brighton, U.K.

Donham, D. 1986. Old Abyssinia and the new Ethiopian empire: themes in social history. In Donham, D. and W. James 9eds.) *The Southern Marches of Imperial Ethiopia: Essays in History and Social Anthropology*, Cambridge University Press, Cambridge.

Emmanuel, H.W. 1975. *Land tenure, land-use development in the Awash valley, Ethiopia*. University of Wisconsin Land Tenure Centre (USAID Contract AID/CSD 2263), Madison, Wisconsin.

Eshete, Alemayehu 2006. *Irrigation management and institutional arrangements: The case of two smallholder irrigation schemes in middle Awash, northeastern Ethiopia*. Master's thesis for Regional and Local Development Studies, Addis Ababa University.

Flood, G. 1976. Nomadism and its future: the 'Afar. In (ed) A. M. Hussein. *African Environment Special Report* (2 ):64-66. In Rehab: Drought and Famine in Ethiopia. International African Institute.; London; Institute, UK

Gamaledinn, M. 1987. State policy and famine in the Awash Valley of Ethiopia: The lessons for conservation. In Anderson, D., Grove, R. (eds.) *Conservation in Africa: People, Policies and Practice* pp. 327-344, Cambridge University Press, Cambridge.

Gamaledinn, M. 1993. The decline of Afar pastoralism. In Markakis, J. (ed.) *Conflict and the Decline of Pastoralism in the Horn of Africa.* Pp 45-62. Institute of Social Studies, Macmillan Press, UK.

Gebre, A. and G. Kassa 2009. The effects of development projects on the mid-Awash Valley. In A. Pankhurst and F. Pignet (eds.) *Moving People in Ethiopia: Development, Displacement and the State,* pp. 66-80. James Currey, London.

Gebre-Mariam, A. 1987. Labour inputs and time allocation among the Afar. *Nomadic Peoples* 23:37-56

Getachew, Kassa Negussie 2001. *Among the Pastoral Afar n Ethiopia: Tradition, Continuity and Socio-economic Change*. International Books, Utrecht.

Girma, M.M., and S.B. Awulachew. *Irrigation Practices in Ethiopia: Characteristics of Selected Irrigation Schemes*. Working Paper 124. International Water Management Institute, Colombo, Sri Lanka.

Haile Meskal, F. and Kloos, H. 1989. Vector-borne disease occurrence and spread as affected by labor migrations to irrigation schemes in Ethiopia. In Service, M. (ed.) *Demography and Vector-borne Diseases*, pages 225-236. CRC Press, Boca Raton.

Harbeson, J. W. 1978. Territorial and development politics in the Horn of Africa: the Afar of the Awash valley. *African Affairs* 77 (309): 479-498.

Helland, J. 1980. *An analysis of 'Afar pastoralism in the northeastern rangelands of Ethiopia*. Working Document, International Livestock Centre for Africa (No. 19). Addis Ababa.

Horowitz, M. 1995. Dams, cows, and vulnerable people: anthropological contributions of sustainable development. The Pakistan Development Review 34 (4): 481-508.

ILCA 1990. *Report on the low-level aerial sample survey of part of the middle Awash valley (Ethiopia) October 15-24 1990 and January 5-11 1990*. International Livestock Centre for Africa, Addis Ababa [ILRI doc]

Jahnke, H.E. 1982. *Livestock Production Systems and Livestock Development in Tropical Africa*. Keiler Wissenschaftsverlag Vauk, Kiel.

Jogo, W. and Hassan, R. 2010. Balancing the use of wetlands for economic well-being and ecological security: the case of the Limpopo wetland in southern Africa. *Ecological Economics* doi:10.1016/j.ecolecon.2010.02.021.

Kloos, H. 1982. Development, drought, and famine in the Awash Valley of Ethiopia. *African Studies Review* 25 (4):21-48 1982

Kloos, H; Desole, G; Lemma, A. 1981. Intestinal parasitism in seminomadic pastoralists and subsistence farmers in and around irrigation schemes in the Awash valley, Ethiopia, with special emphasis on ecological and cultural associations. *Social Science & Medicine Part B-Medical Anthropology* 15 (4B):457-469.

Kloos, H. and Lemma, A. 1977. Schistosomiasis in irrigation schemes in the Awash valley, Ethiopia. *American Journal of Tropical Medicine and Hygene* 26: 899-908.

Kloos, H. and Legesse, W. (eds.) 2010. *Water Resources Management in Ethiopia: Implications for the Nile Basin.* Cambria Press, Amherst, New York.

Lannas, K., and Turpie, J. 2009. Valuing the provisioning services of wetlands: contrasting a rural wetland in Lesotho with a peri-urban wetland in South Africa. *Ecology and Society* 14 (2): article 18 (online).

Lautze, J., Giordano, M., and Kloos, H. 2010. In Kloos, H. and Legesse, W. (eds.) *Water Resources Management in Ethiopia: Implications for the Nile Basin,* pages 1-30. Cambria Press, Amherst, New York.

Little, P. 2002. The global dimensions of cross-border tade in the Somalia borderlands. In A Ghaffar and M Ahmed (eds.) *Globalisation, Democracy and Development in Africa: Future Prospects.* Organisation for Social Science Research in Eastern and Southern Africa, Addis Ababa.

Little, P. Smith, K., Cellarius,B., Coppock, D., and C. Barrett. 2001. Avoiding disaster: diversification and risk management among East African herders. *Development and Change* 32: 401-33.

MAADE 1997/2005. *Operational Budget for 1998 [2006].* Middle Awash Agricultural Development Enterprise, Melka Sedi, Afar Region, Ethiopia.

Mariam, A. G. 1991. Livestock and economic differentiation in North East Ethiopia: the Afar case. *Nomadic Peoples* ( 29):10-20.

MAS 1991. *Amibara Irrigation Project II: Pastoralist and Forestry Development Studies*. Report to WRDA Vols. I and II. Cambridge, Macdonald Agricultural Services Ltd.

Metahara Sugar Factory 2008. Financial Statement of 2007/08. Metahara.

Nicol, A. 2000. *Contested Margins: Water Resources, decentralisation and the state in the Awash valley, Ethiopia, 1985-1998*. Ph.D. dissertation, School of Oriental and African Studies, University of London.

Pankhurst, R. 1985. *The History of Famine and Epidemics in Ethiopia Prior to the Twentieth Century*. Relief and Rehabilitation Commission, Addis Ababa.

Pankhurst, R. and D.H. Johnson 1988.The great drought and famine of 1888-92 in northeast Africa. In Anderson, D., and D.L. Johnson (eds.) *The Ecology of Survival: Case Studies from North-east Africa History*, pp. 47-70. Westview Press, Boulder, Colorado.

Penning, de Vries, F., and Djiteye, M. 1982. *The Productivity of Sahelian Rangelands: A Study of Soils, Vegetation and Land Use in the Region.* Wageningen, The Netherlands.

Reid, R.S., Gichohi, H., Said, M.Y., Nkedianye, D., Ogutu, J.O., Kshatriya, M., Kristjanson, P., Kifugo, S.C., Agatsiva, J.L., Adanje, S.A., and R. Bagine. 2008. Fragmentation of a peri-urban savanna, Athi-Kaputiei Plains, Kenya. In Galvin, K.A., Reid, R.S., Behnke, R. H. and N. T. Hobbs (eds.) *Fragmentation in Semi-Arid and Arid Landscapes: Consequences for Human and Natural Systems,* pp 195-224. Springer, Dordrecht, The Netherlands.

Rettberg, S. 2010. Contested narratives of pastoral vulnerability and risk in Ethiopia's Afar Region. *Pastoralism* 1 (2): 248-273.

Said, Ali 1992. *Resource Use Conflicts between Pastoralism and Irrigation Development in the Middle Awash Valley of Ethiopia*. M.Sc. thesis, Noragric, Agricultural University of Norway.

Salem-Murdock, M. and Horowitz, M. 1991. Monitoring development in the Senegal River Basin. *Development Anthropology Network* 9:2 8–15.

Schuyt, K. 2005. Economic consequences of wetland degradation for local populations in Africa. *Ecological Economics* 53: 177-190.

Scott, J.C. 2009. *The Art of Not Being Governed: An Anarchist History of Upland Southeast Asia*. Yale University Press, New Haven and London.

Scudder, T. 1991. The need and justification for maintaining transboundary flood regimes: the Africa case. *Natural Resources Journal* 31: 75-107.

Scudder, T. 1996. Development-induced impoverishment, resistance and river-basin development. In McDowell, C. (ed.) *Understanding Impoverishment: The Consequences of Development-Induced Displacement*, pages 49-74. Berghahn Books, Oxford, UK

Seyam, I., Hoekstra, A., Ngabirano, G., and Savenije, H. 2001. *The Value of Freshwater Wetlands in the Zambezi Basin.* Value of Water Research Report Series No. 7. IHE Delft, Delft, The Netherlands.

Shine T. (2002). *An integrated Investigation of the Ephemeral Wetlands of Eastern Mauritania and Recommendations for Management.* PhD thesis, University of Ulster.

Shine, T., Dunford, B., Guyer, C., and J. Pollard. No date. An economic valuation of development alternatives for ephemeral wetlands in eastern Mauritania. Manuscript.

Tilahun, Negussie 1983. *The southern Afar: A household economics study*. Joint Ethiopian Pastoral Systems Study Research Report No. 10, International Livestock Centre for Africa (ILCA) study for Rangelands Development Project. Addis Ababa. [ILRI doc]

Turpie, J., Barnes, J., Arntzen, J., Nherera, B., Lange, G-M. and Buzwani, B. 2006. *Economic Value of the Okavango Delta, Botswana, and Implications for Management*. Okavango Delta Management Plan, Republic of Botswana, Gaborone, Botswana.

Turpie, J., Smith, B., Emerton, L., and Barnes, J. 1999. *Economic Value of the Zambezi Basin Wetlands*. IUCN Regional Office for Southern Africa. Harare, Zimbabwe.

U.S. Department of Agriculture. 2009. *Agricultural Prices*, Agricultural Statistics Board, National Agricultural Statistics Service. Washington, D.C.

UNDP Emergencies Unit for Ethiopia. 1998. Cessation of Livestock Exports Severely Affects the Pastoralist Economy of Somali Region. Mission of 31 March to 7 April 1998. http://www.africa.upenn.edu/eue_web/eue_mnu.htm

Unruh, J. D. 2005. Changing conflict resolution institutions in the Ethiopian pastoral commons: the role of armed confrontation in rule-making. *Geojournal* 64 (3):225-237

Watson, M. Tippet C.I. and Tippet M.J. 1972-1973. *Aerial Livestock and Land Use Surveys Vol. I Aug-Sept 1972; Vol. II Jan 1973; Vol. III May 1973.* Nairobi, and ILCA Addis Ababa.

Western, D. 1982. The environment and ecology of pastoralists in arid savannas. *Development and Change* 13: 183-211.

World Bank 2004. *Four Ethiopias: A Regional Characterization. Assessing Ethiopia's Growth Potential and Development Obstacles*. Ethiopia: Country Economic Memorandum, Poverty Reduction and Economic Management 2. May 24, 2004.

You, L., Ringler, C., Nelson, G., Wood-Sichra, U., Robertson, R., Wood, S., Guo, Z., Zhu, T., Sun, Y., 2010. *What is the Irrigation Potential for Africa? A Combined Biophysical and Socioeconomic Approach*. IFPRI Discussion Paper 00993. International Food Policy Research Institute.

## ANNEX I EXCHANGE RATES FOR THE U.S, DOLLAR AND ETHIOPIAN BIRR

| Year | Birr per US $1.00 |
|---|---|
| 1993 | 5.0 |
| 1994 | - |
| 1995 | 6.3 |
| 1996 | 6.4 |
| 1997 | 6.9 |
| 1998 | 7.5 |
| 1999 | 8.1 |
| 2000 | 8.3 |
| 2001 | 8.5 |
| 2002 | 8.6 |
| 2003 | 8.6 |
| 2004 | 8.7 |
| 2005 | 8.7 |
| 2006 | 8.8 |
| 2007 | 9.2 |
| 2008 | 9.9 |
| 2009 | 13 |
| 2010 | 13.6 |

Sources: 1993-2000 CIA *World Factbook 2001;*
*2001-2007 Ministry of Finance, National Accounts Department, unpublished;*
*2008-09 http://en.wikipedia.org/wiki/Ethiopian_birr;*
*July 2010 http://www.exchangerates.org.uk/USD-ETB-exchange-rate-history.html*

## ANNEX II DATA SOURCES ON LIVESTOCK PRODUCTION

***Sources for Table 1 on the species, age and sex composition of Afar herds***

Table II.1 summarizes available information on the species composition of Afar herds. The two most authoritative sources are ILCA's 1990 aerial survey and Getachew's 1994 ground survey, both of which were large-scale and carefully executed. It is reassuring that they give similar results. In terms of biomass, roughly 50% of a typical Afar herd is composed of cattle, 30% of camels and 20% of sheep and goats. Computations of herd output for this study (Table 1 in the main text of the paper) use the herd composition estimates provided by Getachew which distinguish between sheep and goats (figures in bold in the far right column of Table II.1).

**Table II.1:** *Afar herd species composition 1972-2006: expressed as a percentage of herd biomass*

| **Herd species** | Ayele and Juhasz 1970 | Watson et al. 1972 | Dessalegne 1979 | Cossins 1983 | Tilahun 1983 | ILCA 1990 | Said 1992 | Eshete 2006 | **Getachew (2001) 1994 survey** |
|---|---|---|---|---|---|---|---|---|---|
| **Cattle %** | 64 | 61 | 56 | 89 | 44 | 50 | 65 | 64 | **47.6** |
| **Camel %** | 8 | 24 | 29 | 8 | 22 | 31 | 22 | 22 | **29.9** |
| **Sheep %** | 28 | 15 | 9 | 3 | 14 | 19 | 13 | 14 | **9.6** |
| **Goat %** | | | 6 | 1 | 20 | | | | **12.8** |
| **Total %** | 100 | 100 | 100 | 101 | 100 | 100 | 100 | 100 | **100** |

As with most of the mean values used in this report, basing our calculations on one stable herd composition is convenient but misleading. Table II.2 shows changes in herd species composition during the course of a severe drought. The top row of the table gives the date of the aerial survey relative to drought conditions. The final two columns calculate the extent of livestock loss (or movement out of the survey area) by species at the height of the drought and about a year after the drought had broken. From the early stages to the height of the drought, cattle biomass as a proportion of total herd biomass fluctuated by 23%, camels by 13% and small stock by 10%. (The distinctive responses of sheep and goats – respectively graziers and browsers and therefore likely to be differentially impacted by the loss of riverine pastures – is obscured by the fact that the two species could not be distinguished from the air.) In sum, Table II.2 demonstrates that the species composition as well as the size of herds fluctuates in droughts. If droughts are severe and frequent enough, many Afar herds will spend little time looking like a statistically average herd in terms of their species makeup.

Re-examination of Table II.1 suggests further complexities with respect to shifts in long term herd composition. Getachew has made a compelling case for species change in Afar herds as a response to the loss of riverine land to irrigated agriculture – cattle and sheep which require grass being replaced by browsers like camels and goats

(Getachew 2001). Others have argued that the great drought of 1972-73 was a critical watershed, and that neither cattle numbers nor other aspects of Afar society and economy ever recovered from that shock (Gamaledinn 1993; Kloos 1982; Bondestam 1974). Table II.1 supports this interpretation. Observers before the drought (Ayele and Juhasz 1970) or at the onset of the drought (Watson et al. 1972) estimate cattle at more than 60% of total biomass; by the 1990s cattle constitute by weight half or less of the regional herd.[5]

**Table II.2:** *Herd composition in the course of a severe drought: head by aerial count, TLU in ( ), and %*

| **Herd species** | **Sept 72** weak large rains beginning in July and ending in Sept | **Jan 73** end of dry season just before small rains, which fail | **May 73** small rains Feb-April fail and disaster strikes | **Aug 74** about 1 yr after return of normal rains | Change to May 73 | Change to Aug 74 |
|---|---|---|---|---|---|---|
| **Cattle** | 351769<br>(246238)<br>61% | 253255<br>(177278)<br>56% | 51424<br>(35997)<br>38% | 77207<br>(54045)<br>46% | -300345<br>-85% | -274562<br>-78% |
| **Camels** | 98252<br>(98,252)<br>24% | 75630<br>(75,630)<br>24% | 34903<br>(34,903)<br>37% | 34754<br>(34,754)<br>30% | -63349<br>-64% | -63498<br>-65% |
| **Sheep and goats** | 586041<br>(58,604)<br>15% | 653906<br>(65,391)<br>21% | 240387<br>(24,039)<br>25% | 277128<br>(27,713)<br>24% | -345654<br>-59% | -308913<br>-53% |
| **Total TLU** | 403094<br>100% | 318299<br>101% | 94939<br>100% | 116512<br>100% | -308155<br>-76% | -286582<br>-71% |

Source: Reported in Helland 1980, page 16; original reports were unavailable to this study. Microfiches of these documents were apparently evacuated from the ILCA library in Addis Ababa to Nairobi during the Ethiopian civil war of the early 1990s and subsequently locked in a storeroom of the ILRI library in Nairobi, but without the key to the cabinet which contains them.

Table II.3 summarizes available information on the sex and age makeup of Afar herds. Davies (2004) has cross-checked the logical consistency of his estimates relative to birth and mortality rates, and his figures are used in this study (Table 1 in the main text of the paper).

[5] Said (1992) and Eshete (2006) report cattle populations of about 65% of the total herd; these figures are biased to riverine communities (Said) or explicitly focus on agro-pastoralists who keep more cattle (Eshete). Cossins' (1983) estimate of 89% cattle refers to migrant animals especially sent to riverine areas in the dry season and does not represent total livestock holdings; Dessalegne (1979) is based on only four herds. Getachew's survey was conducted among sedentary, riverine pastoralists who are likely to be more heavily involved in cattle herding than mobile pastoralists.

**Table II.3:** *Herd age and sex structures, as percentage by species*

| Source | Herd species | Adult F | Adult M | Immature F | Immature M | Calves | Total % |
|---|---|---|---|---|---|---|---|
| Gebre Mariam 1991 | Cattle | 54.3 | 2.3 | 33.1 | 6.0 | 4.7 | 100 |
| | Camel | 26 | 0 | 40 | 12 | 22 | 100 |
| | Sheep | 55.1 | 3.4 | 12.7 | 4.2 | 24.6 | 100 |
| | Goats | 62 | 1 | 24 | 11 | 2 | 100 |
| Cossins 1983 | Cattle | 59.2 | 5.8 | 19.7 | 8.6 | 6.7 | 100 |
| | Sheep | 59.2 | 2 | 18.5 | 1.8 | 18.5 | 100 |
| Davies 2004 | Cattle | 46 | 4 | 20 | 4 | 27 | 101 |
| | Camel | 46 | 12 | 19 | 3 | 21 | 101 |
| | Sheep and goats | 43 | 9 | 18 | 7 | 25 | 102 |

Note: Davies' estimate of the adult female component of pastoral herds is low relative to information on the age and sex structure of herds in other pastoral areas of Africa, where the adult female component is routinely well above 50%. His data may reflect the considerable difficulties of marketing livestock from his remote study area, which could lead to the retention of a high proportion of unsold male animals. All else equal, lower estimates of the proportion of adult females depress estimates of herd output.

### *Sources for Table 6 on production costs*

Gebre Mariam (1987) has provided a comprehensive description of pastoral labour inputs and time allocation in the mid-1980s before the widespread adoption of water pumps, which reduced labour costs. Tables II.4 (a) and (b), based in part on Gebre Mariam's work, illustrate the basis adopted in our study for calculating the monetary value (opportunity cost) of unpaid pastoral labour.

In 2009 urban wage rates for casual unskilled labour in Afar towns varied between EB 6 to EB 10 per day, and in rural areas the spread was just as great. In 2009 daily wages for clearing the invasive tree *Prosopis juliaflora* – a strenuous task more demanding than herding – were about EB 12, but daily wages for a plantation farm guard – seasonal employment less demanding than herding – were EB 5. In 2007 the Productive Safety Net Programme, an Ethiopian national programme for the routine distribution of food aid to needy families, paid a daily wage of EB 6 but had difficulty attracting pastoral labour as long as any substantial work was really required (Behnke et al. 2007). On the other hand, employment opportunities outside pastoralism are extremely limited, such that able-bodied highland men who immigrate to Afar Region for work are occasionally reduced to begging in the region's towns, their *de facto* wage rate approaching zero. In the absence of additional data or a more sophisticated analysis, we estimate the opportunity costs of adult pastoral labour at EB 8 per day, at EB 4 for children and EB 5 (the rate at which guards are paid) for older men. The older men, as heads of families, engaged in supervision of their family's husbandry operations and these labour costs are calculated per herd rather than per livestock head. Similarly, labour inputs of women for milking and dairy processing are calculated per herd. The annual labour costs per head for sheep and goats is EB 15.60, for camels EB 82.70 and for cattle EB 65.20 (Table I.4 (c)).

**Table II.4:** Herding costs in 2008-09 in Ethiopian Birr (EB), excluding the costs of security provision

*(a) Species specific herding costs*

| **Activity** | **Person days per year** | **Labour rate EB/day** | **Annual cost EB** | **Assumed herd size in head and TLU** | **Herding cost per head EB** |
|---|---|---|---|---|---|
| Small stock herding | 365 | 4 | 1460 | 200 head (20 TLU) | 14.6 |
| Kids and lambs herding | 365 | 4 | 1460 | | |
| Camel herding | 365 | 8 | 2920 | 40 head (40 TL) | 73 |
| Cattle herding | 365 | 8 | 2920 | 50 head (35 TLU) | 58.4 |
| Total | 1460 | Na | 8760 | 95 TLU | Na |

*(b) Milking and supervision costs for an entire herding operation of 95 TLU*

| **Activity** | **Person days per year** | **Labour rate EB/day** | **Annual cost EB** | **Cost/TLU EB** |
|---|---|---|---|---|
| Milking and dairy processing | 40 | 8 | 320 | 3.4 |
| Supervision | 120 | 5 | 600 | 6.3 |
| Total | 160 | Na | 920 | 9.7 |

*(c) Total costs per head*

| **Herd species** | **Herding cost per head EB** | **Milking and supervision cost/head EB[1]** | **Cash costs per head** | **Total costs per head** |
|---|---|---|---|---|
| Cattle | 58.4 | 6.8 | 17.7 | 82.9 |
| Camels | 73 | 9.7 | 25 | 107.7 |
| Sheep | 14.6 | .97 | 2.5 | 18.1 |
| Goats | 14.6 | .97 | 2.5 | 18.1 |

[1]Based on 10 sheep or goat, 1 camel and 1.4 cattle per TLU.

The potential cash costs of livestock husbandry include the provision of stock water, health care, security, and feed supplementation and the expense of transporting animals and their products to markets. According to our informants in 2009, by far the most important of these additional costs is the purchase price of an automatic weapon, which is essential operating equipment for herders in hostile areas. In 2009 a standard AK47 currently cost EB 5000, with more sophisticated weapons costing EB 6000 to 7000.

Young men buy a rifle once, rarely twice in their lives; repair and maintenance costs are minimal. Bullets cost EB 15 apiece. In calmer areas the function of ammunition may be largely decorative and its cost minimal, but young men living on hostile borders can spend up to EB 1,300-2000 per year on ammunition. The labour costs of security provision are also significant. In potentially hostile areas, an advance guard of 15-20 armed men (the number depending on the perceived level of threat) stakes out a grazing area prior to the arrival of the herds and maintains a defensive perimeter. Fatal casualties are routine.

The remaining cash costs of husbandry are variable and low. Herd owners who use pumped water need to contribute to the costs of purchasing fuel and to pump maintenance, but many pastoralists simply walk their animals to rivers or ponds, and still others raise water by hand. A small number of agro-pastoralists purchase feed supplements for sick or nursing animals. All pastoralists we interviewed walked their animals to market and most purchased modest amounts of veterinary supplies.

Exclusive of the costs of weaponry, field work for this study suggests that the cash costs of herding can be generously estimated at EB25/camel/year, EB2.5/sheep or goat/year and EB17.7/cattle/year, Table II.4 (c). These provisional estimates are subject to amendment in light of more comprehensive field surveys.

## ANNEX III DATA SOURCES ON SUGAR PRODUCTION

Factory management provided data on the direct costs of cane cultivation 'up to weight bridge' and the direct costs of sugar processing from 1999 to 2009. These data included depreciation costs (at about 5% per annum) but excluded administrative or other indirect or overhead costs, which are not apportioned between the refinery and the farm in company accounts. The audited accounts for Metahara in 2007-08 suggest that 75% of total overhead and administrative costs can be attributed to the farm in that year, giving total costs for the farming operation (inclusive of indirect costs) that are 1.771 of the direct costs of farming. For sugar manufacturing, total costs were a multiple of 1.503 of the direct costs alone in 2007-08. We do not have information on administrative and overhead costs for Metahara for any year other than 2007-08. To estimate net revenue inclusive of indirect costs from 1999 to 2009 (Table 11) we have assumed a constant ratio between direct costs and total costs for the entire period – 1.771 for farming and 1.503 manufacturing – based on data from 2007-08.

Table III.1 gives the producer prices for livestock commodities used to calculate the net revenue from pastoralism 1999-2009 in Table 11 in the main body of the text. Production costs are assumed to be constant throughout this period at 5.34% of the value of output, the ratio of costs to output value in 2008-09.

**Table III.1: MOFED Producer Prices EB for Livestock and Livestock Products**

| | 1990<br>1997/98 | 1991<br>1998/99 | 1992<br>1999/00 | 1993<br>2000/01 | 1994<br>2001/02 | 1995<br>2002/03 | 1996<br>2003/04 | 1997<br>2004/05 | 1998<br>2005/06 | 1999<br>2006/07 | 2000<br>2007\08 | 2001<br>2008\09 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CATTLE** | | | | | | | | | | | | |
| **Average price** | **442.0** | **383.0** | **384.0** | **413.2** | **416.5** | **413.7** | **429.9** | **580.9** | **797.4** | **995.2** | **1217.4** | **1400.9** |
| **Off-take price** | **509.5** | **442.0** | **444.5** | **476.3** | **483.1** | **477.8** | **488.1** | **631.8** | **1006.0** | **1248.1** | **1492.6** | **1867.7** |
| **GOAT** | **61.7** | **50.4** | **56.4** | **62.3** | **63.7** | **72.3** | **75.3** | **99.9** | **126.3** | **155.4** | **180.1** | **206.4** |
| **SHEEP** | **61.7** | **55.2** | **59.8** | **70.7** | **75.1** | **86.3** | **88.8** | **105.6** | **133.7** | **159.1** | **180.9** | **209.5** |
| **CAMEL** | **953.6** | **804.8** | **974.8** | **1072.8** | **1072.7** | **959.8** | **979.0** | **1481.8** | **1879.3** | **2006.4** | **2794.7** | **3162.9** |
| **COW MILK** | **2.2** | **2.0** | **2.3** | **2.2** | **1.9** | **2.2** | **2.2** | **2.5** | **2.9** | **2.8** | **3.7** | **4.9** |
| **GOAT MILK** | **2.1** | **2.0** | **2.1** | **2.1** | **2.5** | **2.8** | **2.9** | **3.2** | **3.7** | **4.4** | **3.4** | **6.4** |
| **CAMEL MILK** | **2.2** | **2.0** | **2.6** | **2.0** | **2.3** | **2.4** | **2.4** | **2.7** | **3.2** | **3.0** | **3.8** | **5.5** |
| **BUTTER** | **18.6** | **17.2** | **19.4** | **16.7** | **15.1** | **18.6** | **18.9** | **23.5** | **29.8** | **27.1** | **40.9** | **49.8** |
| **MILK after BUTTER** | **0.9** | **0.8** | **0.9** | **0.9** | **0.8** | **0.9** | **0.9** | **1.0** | **1.1** | **1.1** | **1.5** | **1.9** |

Source: Unpublished data compiled by the Ministry of Finance and Economic Development, National Accounts Department, based on annual surveys conducted by the Central Statistical Agency, Addis Ababa.