

Counting the costs: replacing pastoralism with irrigated agriculture in the Awash valley, north-eastern Ethiopia

Roy Behnke and Carol Kerven

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Executive summary

Economic analyses of the internal costs and benefits of irrigation projects are nothing new. Investors want to know if a particular project is likely to generate enough revenue to pay off its initial investment costs, sustain operations, and generate a profit, and they routinely commission studies that attempt to predict the answers to these questions.

Analyses of the opportunity costs of irrigation, such as is undertaken in this paper, are less common but are in some ways more meaningful. Almost all areas that are incorporated into large-scale irrigation schemes are already inhabited and are agriculturally productive. For regional planning purposes, one needs to know not only that a development scheme is economically viable, but that it produces economic benefits that will exceed those that were already being obtained from the pre-existing production systems that it will displace.

This study undertakes these calculations with regards to grazing lands on the banks of the Awash River in north-eastern Ethiopia. Beginning in the 1960s, these traditional pastoral grazing areas were converted into large-scale cotton and sugar plantations. The objective of this paper is to quantify the economic benefits generated by these three alternative agricultural systems – pastoral livestock production versus cotton and sugar cane estates. Some observers – in particular senior politicians and administrators within the Ethiopian government – would argue that the results of this comparison are a foregone conclusion. They view pastoralism as a primitive, unproductive way of life doomed to extinction, an economic dead end that poses no credible alternative to modern, technologically advanced and input-dependent forms of irrigated agriculture.

Our results call these presumptions into question. Despite considerable investment by government, pastoralism is consistently more profitable than either cotton or sugarcane farming while avoiding many of the environmental costs associated with large-scale irrigation projects. As we enter an increasingly climate constrained world, our findings suggest that pastoralism is a surer investment in the longer term resilience and economic stability of Ethiopia's dry lowlands.

1. Introduction

More than three decades ago, academics, development workers and scientists convened a conference in Nairobi to evaluate the likely 'future of pastoral peoples.' The conference followed a turbulent decade of drought and dislocation, and many researchers who attended that meeting thought it possible that they were witnessing the disappearance of a way of life (Galaty *et al.*, 1981). There have in the intervening decades been several similar stock-taking conferences, most recently a meeting in 2011 on the future of African pastoralism (Catley *et al.*, 2013). Contrary to what one might have expected in 1980, these subsequent meetings have chronicled the remarkable resilience, creativity, and increasing sophistication of African pastoral societies and of the civil society and advocacy groups that represent their interests. Pastoralists do willingly educate their children, farm, sell their livestock and take up paid employment – activities that some observers doubted were likely three decades ago. Pastoralists and their children now hold high positions in government ministries or teach in universities. And even if they do not yet enforce them, West African states have enacted laws that protect pastoral mobility. Despite continuing problems of poverty and marginality, pastoralism can and does change, and is here to stay.

Increasing problems of pastoral land loss are the counterweight to this optimistic picture. The erosion of pastoral resource entitlements was hardly a topic for discussion in the early 1980s, but it is arguably the single most critical impediment to contemporary pastoral development. Extensive livestock production requires access to natural resources, and it is difficult to see how pastoralism can sustain itself if this requirement is compromised. Despite progress on many other fronts, pastoral land rights are under pressure as never before. There are multiple dimensions to this problem, from 'land grabbing' by outside investors, the spontaneous privatisation and fragmentation of rangeland areas by those who live there, and the clearance of pastoral populations to make way for protected conservation areas (World Bank, 2010; Woodhouse, 2003; Chatty and Colchester, 2002). This paper examines one aspect of the broader issue of rangeland alienation: the loss of pastoral land to state-sponsored dams and irrigation schemes.

The development of hydropower and the availability of irrigated land per capita are 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 (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 4-5% of all the land area that is suitable for irrigation in Ethiopia (Awulachew *et al.*, 2007). But over 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.

Until the 1960s, Afar pastoralists retained unimpeded access to 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 stabilising 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). Much of the riparian forests that once 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). Like no other part of Ethiopia, the Awash valley illustrates what lies in store for pastoral areas if African governments pursue a policy of modernising agriculture by displacing mobile livestock production in favour of irrigated crop agriculture.



Afar cattle | Photo credit: C. Kerven

2. Clearing the river floodplain for plantations

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.

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,

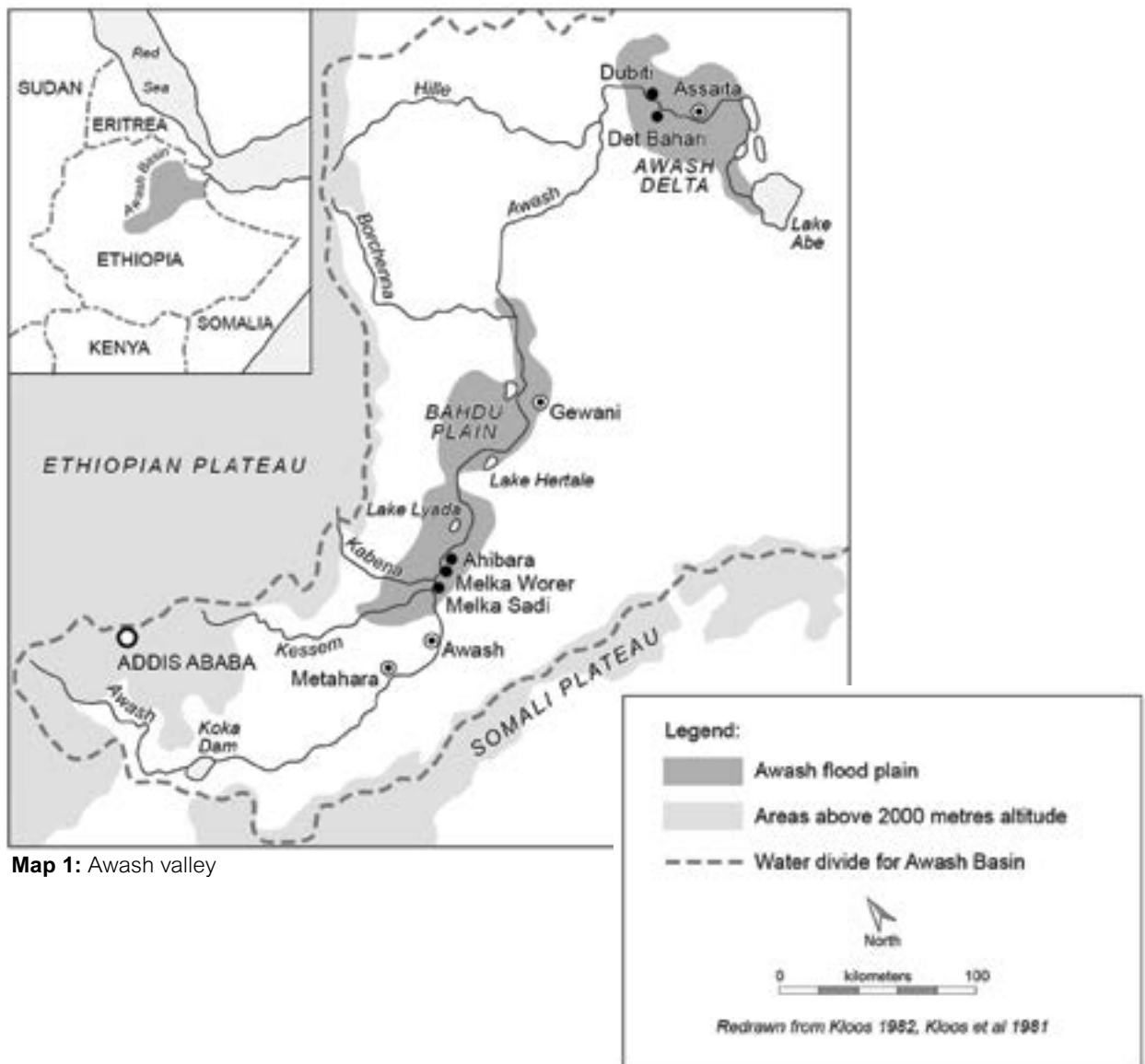
state cotton farms lost money for decades. Current development programmes suggest that the Ethiopian government is aware of this situation. For some time it has been either turning the operation of its cotton holdings over to private interests – the Afar clans or investors – or transforming old government 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.



Clearing the riverine forest for sugar plantations | Photo credit: C. Kerven

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.



Map 1: Awash valley

3. 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.

Prior to the transformation of the valley by irrigated agriculture, most Afar pastoral herds spent 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 varied 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 rainfed 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 2,300 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 summarises these variables.

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:

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

²Estimates of breeding component based on Davies, 2004.



Afar pastoralists with their milk and butter containers | Photo credit: C. Kerven

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 summarised in Table 2.

Table 3 summarises information on the volume and value of milk output per lactating female for each herd species at prices current in 2009. Table 4 does the same for the quantity of meat and its value per breeding female per year, again at prices current in 2009¹. 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 Ministry of Finance to estimate Ethiopia's GDP, and cross-checked in the field. We were unable to accurately assign a monetary value to the transport and traction functions of Afar herds.

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 2: Species composition, age and sex structures of Afar herds

| Herd species | Scenario (a) low stocking rate | | | Scenario (b) high stocking rate | | |
|--------------|--------------------------------|----------------------|----------------------------------|---------------------------------|-----------------------|----------------------------------|
| | 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 | 0.81 | 2.504 | 3.51 | 1.61 |
| Camels | 0.786 | 0.786 | 0.36 | 1.572 | 1.57 | 0.72 |
| Sheep | 0.252 | 2.52 | 1.08 | 0.504 | 5.04 | 2.17 |
| Goats | 0.337 | 3.37 | 1.45 | 0.674 | 6.74 | 2.90 |
| Total | 2.63² | | | 5.25⁵ | | |

Sources:

¹Getachew, 2001 for herd species composition.

²MAS 1991 for feed estimate and Jahnke,1982 for feed requirements.

³One Tropical Livestock Unit (TLU) equals 1 camel, 1.4 cattle or 10 sheep or goats, Jahnke, 1982

⁴Estimates of breeding component from Davies, 2004.

⁵Cossins, 1983 for feed estimate and Jahnke,1982 for feed requirements.

¹See Annex I for US dollar to Ethiopian birr (EB) exchange rates 1993-2010.

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 | 7.0 | 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:

¹Davies, 2004.²2008-09 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 | 0.9 | 0.47 | 0.42 | 686 |
| Camels | 0.5 | 0.55 | 0.275 | 870 |
| Sheep | 1.7 | 0.45 | 0.765 | 161 |
| Goats | 1.7 | 0.48 | 0.82 | 169 |

Sources:

¹Davies, 2004 and field work for this study.²2008-09 prices used by the Ministry of Finance and Economic Development to estimate GDP – 1,634 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.**Table 5:** Gross value in 2009 of live animal, meat and milk for human consumption, EB per hectare per annum at two stocking densities

| Herd species | Output EB per breeding female | Scenario (a) low stocking rate | | Scenario (b) high stocking rate | |
|--------------|-------------------------------|--------------------------------|-------------------|---------------------------------|-------------------|
| | | Breeding females/ha. | Gross value EB/ha | Breeding female/ha | Gross value EB/ha |
| Cattle | 2651 | 0.81 | 2147 | 1.61 | 4268 |
| Camels | 6551 | 0.36 | 2358 | 0.72 | 4717 |
| Sheep | 651 | 1.08 | 703 | 2.17 | 1413 |
| Goats | 758 | 1.45 | 1099 | 2.90 | 2198 |
| Total | | | 6307 | | 12596 |

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 5,000 to 7,000, roughly the sale value of two camels) and ammunition (a recurrent cost of up to EB 1,300-2,000 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 each animal. Table 6 summarises 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 have not calculated the average costs of security provision for Afar herds because we were unable to estimate 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 EB 6,000 (about \$543 US dollars) at the lower range of potential riverine stocking densities, and slightly less than EB 12,000 (about \$1,084 US dollars) at the upper range of potential stocking densities (Table 7).

In sum, at 2009 prices, EB 6,000-12,000 (roughly \$540 to \$1,080 US dollars) 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 use². 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 6: Husbandry costs in 2009 exclusive of weaponry and security provision at two stocking rates in EB

| Herd species | Total costs per head | Scenario (a) | | Scenario (b) | |
|--------------|----------------------|-----------------|------------------|-----------------|------------------|
| | | 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 | 0.786 | 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 |

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 |

²Using an approximate average exchange rate for 2008-09 of EB11 = US \$1.00.



Afar herder with gun belt | Photo credit: C. Kerven

4. Cotton cultivation and processing

Cotton cultivation produces a raw agricultural commodity – unginced 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.

Table 8 shows the returns to seed cotton farming on the Middle Awash Agricultural Development Enterprise (MAADE), a large, irrigated state-owned cotton farm in Amibara District. The farm was set up in 1969, nationalised 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 summarises 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 losses 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 | 32.0 | 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, privatised farm slipped in and out of

profitability in the period between 2004 and 2009, with yields averaging 2,159 kg/ha and average profits of EB 1,349 (about \$135 US dollars) per hectare (Table 9).

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 Prosopis to make cotton fields | Photo credit: C. Kerven

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 undermaintained 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 relevelled 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.

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 Ethiopian People's Revolutionary Democratic Front (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 summarises the income from the cooperative farm in 2009. In that year both yields (4,290 kg/ha) and net income per hectare (EB 6,774 or about \$616 US dollars per hectare) were 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 yielded a profit of about \$2,800 US dollars per hectare and 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 subsidised by government, paying nothing for the maintenance of irrigation infrastructure, for water, or for the initial costs of land development. A comprehensive

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.

assessment of the economic performance of the cooperative would need to take account of these costs, none of which appear in Table 10.

The preceding case studies underline the economic 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 losing 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. 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. As the next section will show, much the same results emerge from an analysis of sugar cane cultivation.



Raw cotton on private farm | Photo credit: C. Kerven

5. 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 HVA (Handels Vereniging Amsterdam, a Dutch firm), was nationalised 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 the 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 bagasse (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) bagasse. 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. However 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 itemise 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



New huts for plantation workers | Photo credit: C. Kerven

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 is provided in Annex 3.

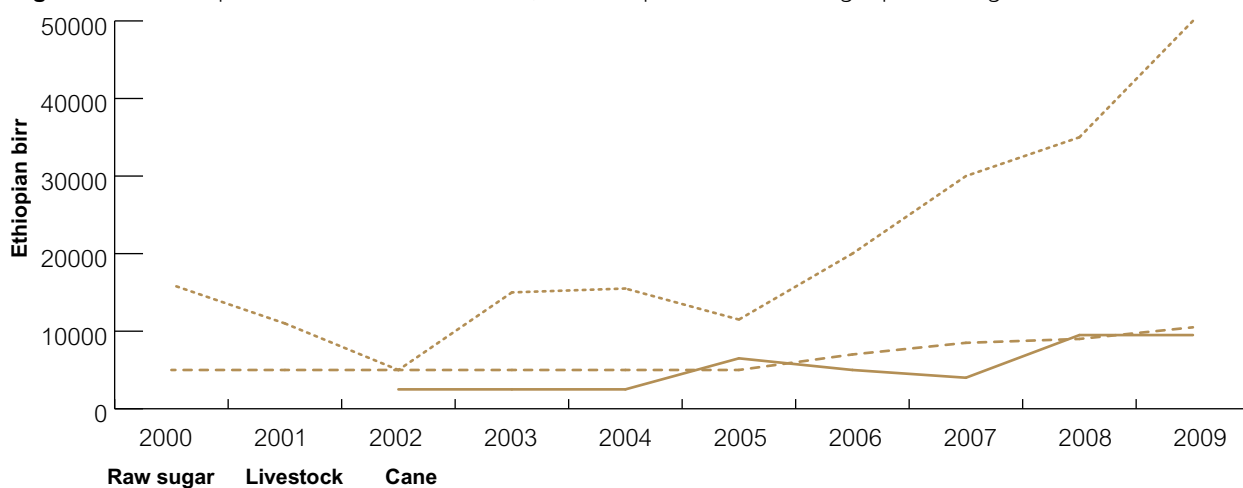
Using the data in Table 11, Figure 1 graphically illustrates the relative profitability of livestock keeping relative to cane cultivation and the processing of raw sugar. Cane cultivation was roughly as profitable as livestock in two years and less profitable in six out of the eight years in which this 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.

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 3.

Figure 1: Revenue per hectare - cane cultivation, livestock production and sugar processing



6. Livestock, cotton or sugar?

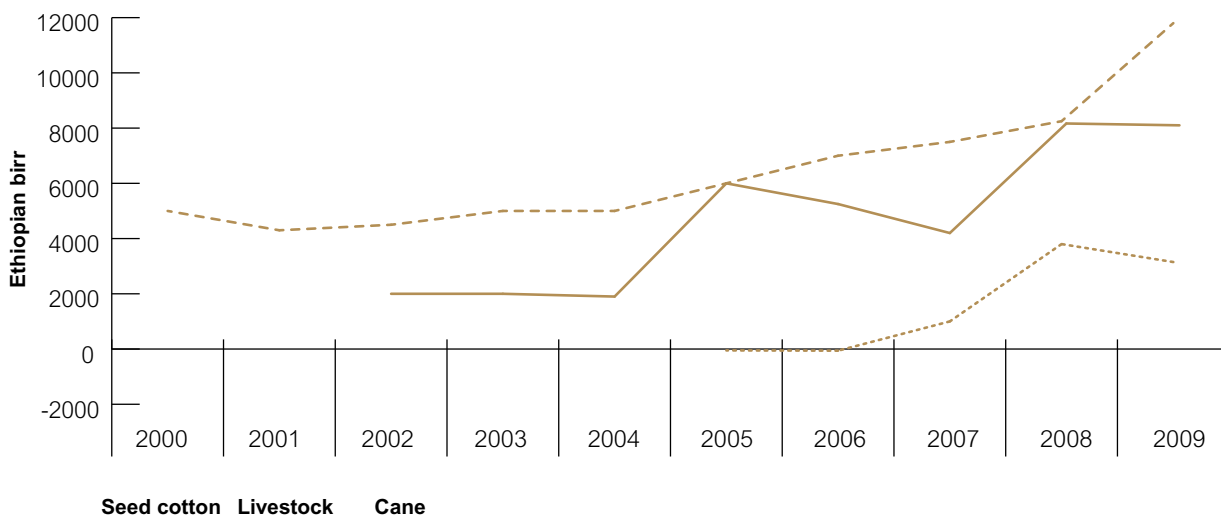
This study examines the relative profitability of three different farming options – cotton plantations, sugar plantations, and pastoral livestock keeping – for the Awash valley. For cotton farming in particular, the comparison is complicated by the different kinds of cotton farming operations that have been documented at different times. At 2008-09 prices, the estimated annual net returns to pastoralism per hectare of valley pasture were about EB 6,000 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 privatised 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 salinisation, 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 6,774 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

Figure 2: Revenue per hectare - alternative uses of the Awash floodplain



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.

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).

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 Sugar Factory, 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 sugar 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.

7. Stability, risk and climate change

In an unpredictable natural environment, the reliability of a production system may be as important as its profitability. It is impossible at present to accurately predict the impact of climate change on the Awash river system, but whatever it brings, climate change makes the future more uncertain (Ericksen *et al.*, 2013). 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 stabilising 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 overgrazing 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 labourers 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 (Gamaledin, 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 privatised 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 much 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 to reflect inflation.
- 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, it seems unlikely that cane farming helps to stabilise rural incomes. Instead of accepting financial responsibility for the risks that are inherent in plantation agriculture, the Ethiopian government has passed the cost of dealing with these risks along either to small-scale farmers who are forced to grow cane on contract or, as discussed previously, to pastoralists who have been forced to surrender their land to cane farming. If global climate change increases the risks that currently beset Ethiopian agriculture, then plantation agriculture will exacerbate the future impacts of climate change on the welfare of the farmers and herders who live in the vicinity of government irrigation schemes.

8. 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 salinisation or alkalinisation 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 utilise 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 disadvantages of alternative agricultural systems (Adams, 1992). Water denominated appraisals are appropriate to 'mature' irrigation systems (in the 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 emphasise the advantages of natural grazing which uses less water, adds few chemical pollutants to it, and leaves the remainder available for other purposes.



Canal and ditch | Photo credit: C. Kerven

9. Beyond Awash: wider implications

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 (Behnke, 1985). 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-subsidised irrigated cotton and sugar farming runs counter to reasonable expectations. Whether these results are anomalous or indicative of a broader trend remains unclear. Shine (Shine, 2002; Shine *et al.*, n.d.) 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. 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 Horowitz 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, summarised 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 nationalised 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 Sugar Factory, 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 EB 541 million or the equivalent of \$58 million US dollars at the then exchange rate (Metahara Sugar Factory, 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).

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.

Unfortunately, the economics of Afar dispossession in the middle Awash valley remains relevant for understanding current developments in the Ethiopian pastoral lowlands. The Omo River rises in the western highlands of Ethiopia and terminates in Lake Turkana in Kenya. The Gibe III dam, now nearing completion on the middle reaches of the Omo River in the Southern Nations Nationalities and Peoples Region (SNNPR) of Ethiopia, will be Africa's tallest dam. In addition to hydroelectric power, this dam will provide water for the planned creation of a 245,000 hectare state-owned sugar plantation – the Kuraz Sugar Industry – and another 150,000 irrigated hectares for private investors. To put these developments in perspective, the planned irrigated area resulting from Gibe III will be about six times larger than the total area of about 48,000 hectares under irrigation in the Awash basin in 2007, before the Metahara extension/Kesem Project (which is adding 20,000 irrigated hectares) and before the construction of the Tendaho Dam and Sugar Project in the middle and lower Awash valley (capable of irrigating 65,000 hectares) (Makakis, 2011). Along the Awash, the Tendaho Sugar Project will appropriate 'all the land cultivated by Afar for centuries in Aussa' along the lower Awash (Markakis, 2011: 298). For the Omo, Ethiopian government plans include 200 kilometres of irrigation canals along both banks of the river, 750 kilometres of internal roads, and six sugar factories (Human Rights Watch, 2012: 30). In other words, on the Awash itself and more especially on the Omo River, the developments described in this paper are set to be replicated on a very large scale.

After pastoralists lost the middle Awash to hydroelectric development and plantation agriculture, the 1972-3 drought killed thousands of people and livestock. There is little reason to think that the impact of Gibe III on the people of the Omo valley will be much different. In Ethiopia about 90,000 agro-pastoralists currently depend for their subsistence on flood cultivation along the Omo and an equal number of pastoralists depend on the flood for grazing (Turton, 2010: 4). In 2011 and 2012 in the areas along the Omo slated for plantation development, standing crops and grain stores were bulldozed, and residents were beaten and arrested by the police and military in order to encourage them to voluntarily resettle, with food aid made available only to those who agreed (Human Rights Watch, 2012). No resettlement plans, feasibility studies or impact assessments on the irrigation schemes have been published by the Ethiopian government (Turton, 2012). Information on current activities is difficult to obtain. Access to the area by journalists is restricted, locals have been warned not to talk to outsiders, and in 2009 41 NGOs in the SNNPR were denied licenses for 'illegal campaigning against the eradication of harmful traditional practices by using the cover of culture' (letter from the SNNPR administration, quoted in Human Rights Watch, 2012: 73).

In 2010 the European Investment Fund decided against providing a loan for the Gibe III dam. In the same year the African Development Bank published a report on the potential impact of irrigated sugar plantations on Lake Turkana, which receives more than 80% of its inflow from the Omo River (Avery, 2010). The report estimated that the irrigation of 150,000 hectares along the Omo would lower the level of the lake by twenty metres, half its volume and double its salinity level (Avery, 2010). In 2011 UNESCO urged Ethiopia 'to immediately halt all construction on the GIBE III dam' in view of the dam's likely impact on Lake Turkana, which is a World Heritage Site and the world's largest desert lake (World Heritage Committee, UNESCO, 2011). In 2012 when construction of the Gibe III dam had not been halted, the UNESCO committee responsible for overseeing World Heritage sites considered adding Lake Turkana to the List of World Heritage in Danger, a decision that is still pending (World Heritage Committee of UNESCO, 2012).

Speaking at an annual Pastoralists' Day celebration in South Omo in 2011, the late Prime Minister of Ethiopia, Meles Zenawi, noted the 'good results' achieved by the government with sugar cane development in Afar Region, and confirmed that the government was working hard to establish sugar plantations along the Omo. He continued:

There are also some people who are the best friends of backwardness and poverty, but claim to be concerned about environmental conservation....They just want to keep the pastoralist as a tourist attraction and make sure no development happens in pastoral areas....We want our people to have a modern life and we won't allow our people to be a case study of ancient living for scientists and researchers (Meles, 2011).

The analysis in this paper supports an alternative economic interpretation of the dilemma confronting the Ethiopian government. If agro-pastoralism along the Omo is as productive as pastoralism once was along the Awash (and we have no reason to think otherwise) then the government can ill afford to adequately compensate current occupants of the Omo valley for the loss of their riverine resources. This is because the returns to irrigated sugar or cotton cultivation are likely to be roughly comparable to the returns to indigenous systems of floodplain cultivation and pastoralism. To justly compensate previous owners, after completing construction of the irrigation system, the government of Ethiopia would need to give all the irrigated area back to local residents. There is no indication that this is the government's intention. The Ethiopian government has stated that it will provide 0.75 hectares of irrigated land for 2,050 resettled households – a total of about 1,540 hectares or about half of one percent of the area planned for irrigation (Ministry of Federal Affairs, undated, reproduced in Human Rights Watch, 2012).

Taking the property of the people of the Omo valley may make the Ethiopian government richer, but it will not increase net economic returns from agriculture, and it will almost certainly impoverish and contribute to the premature death of many who are dispossessed. At least that is the lesson of half a century of 'development' in the Awash valley.

10. Conclusions

This study compared the economic returns derived from pastoralism versus large-scale irrigated cotton or sugar plantations in the Awash valley of north-eastern Ethiopia. The analysis supports three main conclusions:

- In the Awash valley, pastoral livestock husbandry is more profitable than cotton farming. While private cotton cultivation may occasionally achieve rough productive parity with pastoralism, state cotton farms lost money for decades and their mismanagement has led to soil salinisation, water logging, lost soil productivity and weed infestation. It would appear that the irrigated fields that were once part of the state farms are no longer productive enough or profitable enough to pay for the reclamation and repairs that they now require, and that cotton production in these areas is unsustainable without additional capital investments or public subsidies.
- Sugar cane cultivation presents much the same picture. On the favourably situated plantation examined in this study, cane farming equalled the returns to livestock in one of four years, and fell short in three of four years. Despite high levels of government investment and the expropriation of local communities' land, there is no evidence of consistently higher economic returns per hectare to sugar cane rather than pastoralism.
- Cotton ginning and sugar refining are more profitable than simply farming cotton or sugar cane, but the integration of farming and processing is also more risky, offering higher profits in good years at the cost of greater losses in bad years. Large, vertically-integrated plantations and factory complexes thereby exacerbate the climatic instability that is characteristic of the Ethiopian lowlands. It is difficult to precisely predict the impact of climate change on Ethiopian agriculture and river systems. In the face of such uncertainty, government programmes that intensify economic instability may not be a prudent response to the challenge of climate change.

Irrigation projects have not improved the economic returns from agriculture in the Awash valley, but they have transferred the control of valuable natural resources from Ethiopian pastoralists and farmers to government officials. Agricultural output that once belonged to Ethiopian citizens now belongs to the state.

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Annexes

Annex 1 Exchange rates for the US 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 | 13.0 |
| 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 www.exchangerates.org.uk/USD-ETB-exchange-rate-history.html

Annex 2 Data sources on livestock production

Sources for Table 1 on the species, age and sex composition of Afar herds (page 12 of main report)

Table A2.1 summarises 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 A2.1).

Table A2.1: Afar herd species composition 1972-2006: expressed as a percentage of herd biomass

| Herd species | Ayele and Juhasz 1970 | Watson <i>et al.</i> 1972 | Dessaiegne 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 A2.2 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 A2.2 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 A2.1 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 A2.1 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.⁴

Table A2.2: 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 (246238) 61% | 253255 (177278) 56% | 51424 (35997) 38% | 77207 (54045) 46% | -300345 -85% | -274562 -78% |
| Camels | 98252 (98,252) 24% | 75630 (75,630) 24% | 34903 (34,903) 37% | 34754 (34,754) 30% | -63349 -64% | -63498 -65% |
| Sheep and goats | 586041 (58,604) 15% | 653906 (65,391) 21% | 240387 (24,039) 25% | 277128 (27,713) 24% | -345654 -59% | -308913 -53% |
| Total TLU | 403094 100% | 318299 101% | 94939 100% | 116512 100% | -308155 -76% | -286582 -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.

⁴Said (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 A2.3 summarises 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).

Table A2.3: 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 & 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 (page 16 of main report)

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 A2.4 (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 A2.4 (c)).

Table A2.4: 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 & 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 |

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 cost EB 5,000, with more sophisticated weapons costing EB 6,000 to 7,000.

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 1,300-2,000 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, EB 2.5/sheep or goat/year and EB 17.7/cattle/year, Table A2.4 (c). These provisional estimates are subject to amendment in light of more comprehensive field surveys.

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

Annex 3 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, page 23 in main report) 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 A3.1 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 A3.1: MOFED Producer Prices EB for Livestock and Livestock Products

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|-------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| | '97/98 | '98/99 | '99/00 | '00/01 | '01/02 | '02/03 | '03/04 | '04/05 | '05/06 | '06/07 | '07/08 | '08/09 |
| 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 (MOFED), National Accounts Department, based on annual surveys conducted by the Central Statistical Agency, Addis Ababa.



Climate Change

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