Animal power, a cheap alternative for the construction of reservoirs in Ethiopia?

Abiye Astatke, Kai Sonder, Girma Tadesse and Don Peden

Abstract

Water for crop production as well as human and animal consumption is a limiting factor in most areas of Ethiopia. Due to restricted accessibility humans as well as animals spend a great amount of time and energy to reach and gather water. At the same time, Ethiopia has the greatest livestock population in Africa and about 14 million oxen available. These oxen are used almost exclusively for seasonal land preparation in cropping systems and remain unproductive during the remainder of the year. During the socialist regime in Ethiopia, community based work with draught oxen was used in two Peasant Associations to construct two ponds of 9,500 and 8,700 m^3 capacity, respectively. For loosening of the soil, the traditional Ethiopian ox drawn plow "Maresha" was used, the soil was then removed by ox-drawn scoops with a capacity of 0.13 m^3. The construction involved 140 oxen in one association and 90 oxen in the other, thus using a great part of the farmers and oxen available in the Peasant Associations. The experiences from these community works show that the construction of water harvesting structures is viable using draught animal power. Due to the changed socio-political situation, concerning land ownership and Peasant Associations, it is doubtful that works of this size can still be implemented. Therefore it is suggested to limit the number of farmers involved in the construction to a maximum of 30, all of whom should benefit from the ponds and be placed not more than one kilometre away. The capacity of the ponds should be reduced to 1,500 – 3,000 m^3, reflecting the decrease in available human and animal power involved in the construction. The farmers are expected to benefit in multiple ways from the pond construction: improved availability and accessibility of water, improved crop and livestock production, work and time used for water transport reduced.

Introduction

Water is a scarce resource in most parts of rural Ethiopia during the nine months dry period which extends from October to May. Both people and their livestock commonly travel long distances daily to obtain the water they need thus impairing agricultural productivity. Existing water supplies can be supplemented by improving water collection at spring sites, by constructing wells to tap group water supplies or by harvesting runoff water with excavated ponds or dams[1]. Constructing ponds or dams using manual labour has been found to labour intensive with social consequences of not benefiting all who participated in the construction. The use of heavy machinery for construction of ponds or dams is expensive and difficult to sustain in a country like Ethiopia which has very limited foreign exchange for buying parts and fuel for running the machinery. An alternative of using ox-drawn scoops for excavating ponds has been developed and tested on-farm around the Debre Berhan area (Astatke and Saleem, 1996), about 130 km north of Addis Ababa.

The 2001 published document on 'Rural development policies, strategies and instruments' (Ministry of Information, 2001) states that "without water agriculture is unthinkable. It is only when agricultural products get sufficient water at the right time that agri-

[1] *Even though the ratio of water stored for the amount of soil excavated is high in dams, the construction of dams implies the storage of water above ground behind a properly compacted embankment. As dams require proper design and water for the compaction of the embankments, they could not be totally managed by rural communities.*

culture can be effective. If the supply of water is higher or less than the required amount or if it is not available at the right time, production could significantly decrease or even be zero. Therefore, in order to ensure rapid and sustainable agricultural development, there should be a reliable supply of water and appropriate or sustainable water management systems. If people engaged in agriculture get a sufficient amount of water supply throughout the year, it is possible to harvest higher yields on a smaller size of land and keep labour busy on production throughout the year. This is what should be set as a goal."

The same document explains that "although having policies and laws for water use is of paramount importance, without building a capacity to catch water and manage it, it will remain to be just a futile exercise. Because we have not built the capacity to control and manage the surface and ground water of our country, in places where there is high endowment of water, our people suffer from shortage of water and are forced to move from place to place following the tails of their animals in a very backward husbandry system and thus live in sever poverty. In places where uninterrupted sufficient amount of rain is available, we do not get economic benefits as much as we should because of failures to work throughout the year. To get a yield, even once a year, sometimes there will be untimely and too much rain and at other times it will be too short causing production to highly fluctuate from year to year. Our people are exposed to severe hunger due to the alarmingly erratic and short rainfall.."

The Technology

The major contribution of cattle to the agricultural production in the Ethiopia is through the draught power provided by oxen. Ethiopia presently has the largest draught oxen population in sub-Saharan Africa with some 14 million oxen routinely used for cultivation (Worldbank, 2003). However, these oxen only work for about 60 days a year and the rest of the time they are not used for productive agricultural purposes (Gryseels and Anderson, 1983). The annual working cycle of an ox is characterized by short periods of high intensive labour and long periods of idleness, with about 15% of the feed intake actually used for work and the remainder being just dedicated to maintenance (Wilson, 2003). Considering that oxen have to be trained one year, the training starting at the age of two and that the working life lasts only about 4-5 years (Spiess, 1994), it is obvious that the farmers should try to diversify the use of the animals. Thus the high investments concerning training time and feed could bring better returns.
Draught animals have been used for soil excavation and landscape shaping in some parts of the world. The basic scoop design employed in Ethiopia in 1983 was similar to the traditional Dutch 'mouldbaert' and the British eighteenth century levelling box' (Brandford, 1976). These European implements were designed to be drawn by large animals and so a smaller version with a capacity of 0.15 m^3 that could be pulled by a pair of Ethiopian zebu oxen was designed by staff of the International Livestock Centre for Africa (ILCA), ILRI's predecessor (Fig. 1). Initial testing of the technology began in 1983, with the excavation of a 7,000 m^3 pond on ILCA's previous, now the sheep research station of the Amhara Regional Agricultural Research Institute (ARARI) in Debre Berhan,120 km northeast of Addis Ababa.

Pond construction requires the use of two simple implements: the traditional cultivation implement the ‘maresha’ and the animal drawn scoop as shown in Figures 1 and 3. The ‘maresha’ is first used to break-up the soil surface where the pond is to be excavated. The loosened material is removed with the scoop to a dumping site at the end of the pond. The ‘maresha’ is then used again to break-up the sub-soil which in turn is removed by the scoop. This pattern of tillage and scooping continues until the completion of the pond. The rate of scooping to tillage will depend on the size of the excavation to be made, the condition of the animals being used, the type and moisture content of the soil. For the on-station pond at Debre Berhan, approximately 10 hours of tillage were required for moving 100 m^3 of soil.

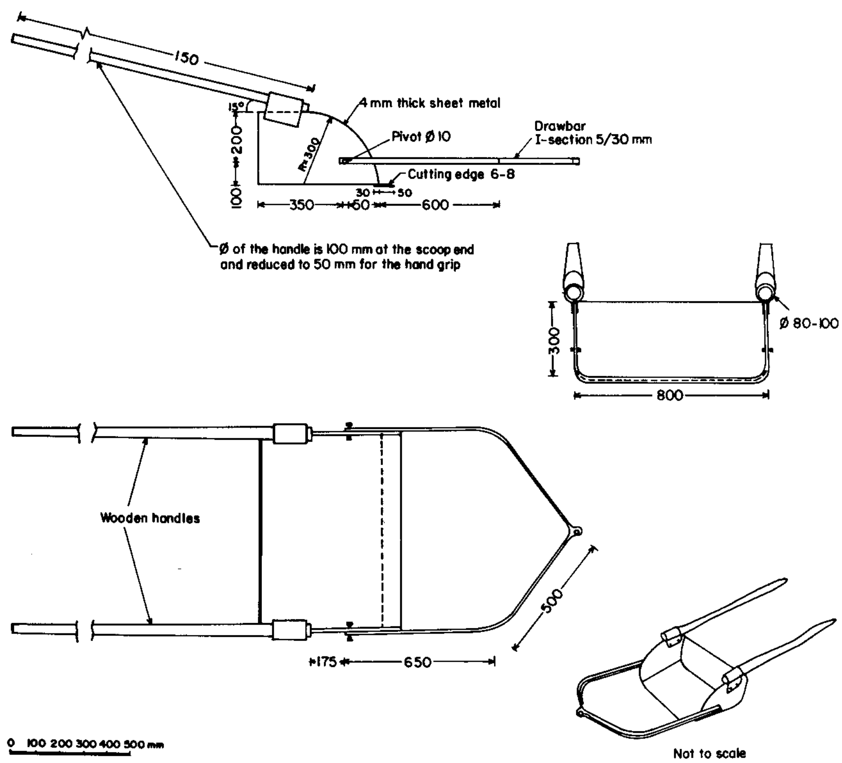

Figure 1. Scoop design (Astatke et al., 1986)

The problem that will be faced by the owners of the oxen is the extra feed required by their animals for the construction of the ponds. Most of the feed comes from the grazing of uncultivated areas or cereal straw stored after the cropping season. From the on-station work at Debre Berhan it was estimated that 11.20 MJ are required to excavate 1 m^3 of soil (Astatke, 1984). Since a kg of dry matter straw (straw has an average 10% moisture) contains about 6.5 MJ, the amount of hay required to excavate 1 m^3 of soil will be 1.83 kg for a pair of oxen. If the energy balance is done for the excavation of 7 m^3 of soil, an ox will have to be fed 7 kg of straw for the work (Astatke, 1984). This is similar to what farmers fed their oxen during the cultivation period (5 kg).
The average draught power developed by a pair of local zebu oxen pulling a full scoop was 0.92 kW which falls within the upper range of the amount needed for the first pass

with the 'maresha' (Astatke, 1984). Subsequently the Ethiopian Ministry of Agriculture (MoA) modified the scoop to reduce power requirements. New models with a 15 % capacity reduction compared to the first prototype and with two metal skids on the bottom to reduce friction were introduced and tested. Using these animal drawn scoops, two ponds of 9,500 and 8,700 m^3 capacities were constructed in 1985 by two Peasant Associations called at the time Kormargefia and Faji & Bokafia.

Experiences of the two Peasant Associations in pond construction

The work started in December 1984 and ended in March 1985. An inventory of working oxen showed that there were 148 and 93 pairs in the Kormargefia, and Faji & Bokafia Peasant Associations respectively at the start of the work. The oxen owners in each association were grouped by the location of their dwellings in relation to the pond sites. The numbers of oxen in each group were approximately the same. In Kormargefia, they formed seven groups with an average of 21 oxen pairs per group, while in Faji and Bokafia five groups were formed with an average of 18 pairs per group. A work programme for three months was then arranged by the Executive Committee of each Association for each group. In Kormargefia each group was scheduled to work once every nine or ten days while due to the lower number of oxen in Faji and Bokafia, each group was assigned to work once every six or seven days. Fines were set by each Peasant Association's Executive Committee for all absentees and un-punctual participants in the work.
The pond at Kormargefia was constructed as a square with sides of 60 m while the Faji & Bokafia is rectangular with dimensions of 40 by 80 m. In both cases the oxen pulling the scoops entered the work sites from the higher end and dumped the excavated earth on the lower end. The soil dumping sites were 60 m and 80 m, the length of the pond sites for Kormargefia and Faji and Bokafia respectively, with a width of 20 m for both ponds. After dumping the soil the animals returned around the outer perimeter to re-enter on the upstream side for next cycle of excavation and dumping. Loosening of the ground surface to be excavated was done with the traditional cultivation implement, the maresha (Fig. 3). This was done in the same line as the direction of scooping to minimize cross-directional work going at the same time. One average the circuit length at the Kormargefia site was 140 m while that at Faji & Bokafia it was 200 m. The entry and exit slopes were approximately 1:3, while the other two sides had a slope of 1:1 (Fig 2). The estimated average quantity of soil excavated by a pair of oxen in one circuit was 0.13 m^3 (Figs. 4&5). The rate of work at both sites varied from day to day depending on the time worked, the conditions of the oxen pairs and the interest of the group on that day (Anderson and Astatke, 1985).

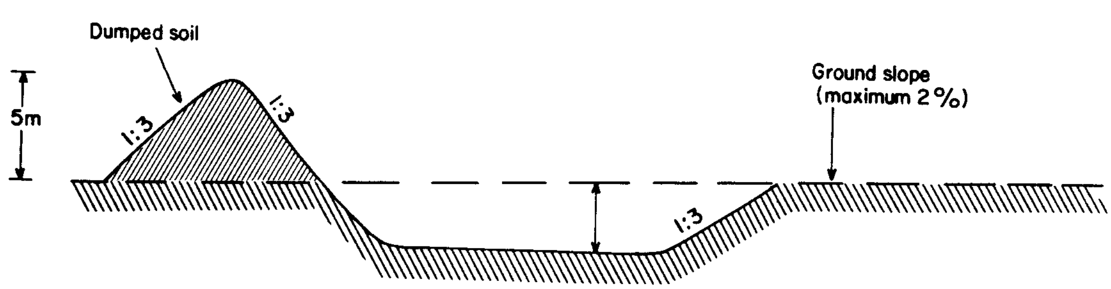

Figure 2. Pond construction scheme

At the end of the work period in March 1985, the amount of soil excavated at Kormargefia and Faji & Bokafia sites were 9,500 m^3 and 8,700 m^3 respectively (Fig. 6). Farmers at Kormargefia site worked for 79 days on their pond in the period from December 1984 to March 1985 while farmers at Faji and Bokafia site worked a total of 76 days. The average length of a working day was 6.5 hours at Kormargefia while it 5.9 hours at Faji & Bokafia. At Kormargefia an average 3.1 oxen pairs per day were used to break the earth with a maresha prior to excavation and 15.2 oxen pairs per day were used with scoops for excavation. The corresponding numbers at Faji & Bokafia were 2.8 and 13.7 respectively. The net excavation rate per oxen pair per day, including oxen involved in both ploughing and scooping was 6.6 m^3 at Kormargefia and 7.0 m^3 at Faji & Bokafia (Anderson and Astatke, 1985). The oxen used at both sites were in good condition throughout the working period. All farmers were also able to handle the scoops properly by the end of their first working day. A few breakages of scoop handles occurred during the first week of work while the oxen were being trained. The broken handles were replaced by the farmers.

Figure 3. Loosening of the soil with the maresha with scoops working in the background

Figure 4. Group of farmers working on pond excavation


Figure 5. Dumping of soil from scoop


Figure 6. Finished pond at Kormargefia Peasant Association

Conditions suggested for the use of animal power in pond construction under current conditions

The experience of the two PAs, Kormargefia and Faji & Bokafia, show that technically there are no problems in using animal power for the construction of ponds. The scoops also proved to be robust and practical and the current costs are estimated to be between 250-300 Birr per scoop. Even though rents for a pair of oxen with the handler have risen to 30-40 Birr/day (Spiess, 1994) in the last 20 years, thus raising the excavation rate to 5 Birr per m^3 of soil, it is still probably the cheapest means of soil excavation in the country at present. It is also means diversifying the power source available to farmers for other essential activities that would improve the livelihood of rural people.

However, the experience of the two PAs was during the socialist period (command system) where the Executive Committee exercised a lot of power. The Executive Committee selected the site and landownership being no factor as all land belonged to the government and the whole PA worked for the benefit of only a third of the community. Fines where set by the Executive Committee for absentees and farmers coming late for work on the ponds. Due to the socio-political changes within Ethiopia these conditions have changed, mainly concerning availability of common land. The authors of this paper strongly argue that if the social mechanisms are not properly set to fit the present situation, even though simple, the use of scoops for the construction of ponds will not work. If the social framework could be developed in a way that all participants in the community work benefit from its outputs, it will not only succeed but will facilitate in creating cheap and practical water conservation structures in the rural areas of Ethiopia.

Some of the suggestions for the implementation of animal drawn scoops in the rural areas would be:

- water is a major constraint in the area and the communities are not only aware of it but are willing to alleviate the problem through their efforts
- clusters of 20-30 households will be taken as a unit for pond construction and usage
- the pond site selected should not be more than a kilometre from the furthest house in the unit
- in the unit of 30 households it is assumed that there will be more than 15 pairs of oxen and the community is willing to use them for pond excavation
- those who do not own oxen in the unit are willing to participate in other ways in the construction of the pond
- As the number of households will be limited to 30, the capacity of the pond would be reduced proportionally (1,500-3,000 m^3) as compared to the previously constructed ponds, depending on the purposes of the water use in the community
- the capacity of the pond would also determine the size of the area, in this case with an average area of 600 m^2 and an average pond depth of 3.5 m

Implications

There is a high potential for use of untapped animal power in Ethiopia based on the livestock population and that traditionally the draught oxen are only used for soil cultivation. Acceptance of the construction itself by the farmer community can be assumed as high, if the stakeholders are direct beneficiaries of the constructed ponds. The location of the pond will be a critical issue, as farm sizes tend to be small (around 2 ha) and farmers will be reluctant to part with their land if more people will be beneficiaries. The farmer groups will have to decide were to put the reservoirs and how to compensate lands that have been used for this purpose.

Benefits of pond construction:

- Water availability for households throughout the year
- Improved livestock production
- Time and labour for water transport reduced
- Higher water availability for vegetables and homegardens
- Improved hygiene due to better to access to water
- Potential for pisciculture (Tilapia) which is new in the farming systems
- Water harvesting and runoff reduction
- Animal power used not only for land preparation (better opportunity costs)
- Second harvest possible even without belg (short rainy season) rains
- Better recharge of groundwater and springs
- Additional water available for biogas production and other water related processes

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