ANIMAL POWER-BASED TECHNOLOGICAL PACKAGE FOR (APTP) ENVIRONMENTALLY SUSTAINABLE DEVELOPMENT IN ETHIOPIA: SOME ISSUES AND ARGUMENTS

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Abstract

Human-powered simple implements (e.g. hoe, digging sticks), animal-powered and, though limited in the extent of use, tractor-based technologies in Ethiopia have neither brought food security nor improved the means of farm transportation. They rather aggravated severe degradation. In order to rehabilitate the deteriorated biophysical environment and improve the production performance, the replacement of the above technologies by appropriate and intermediate ones is essential and urgent. This paper argues for the important role of Animal-powered Technological Package (APTP) for environmentally sustainable development.

1. Introduction

In a broader context, APTP can be defined as an intermediate and multi-purpose technology package consisting of improved (a) farm implements, (b) means of transportation, (c) technical

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and environmental knowledge, and (d) animal power for traction, construction and conservation. Nation-wide educational system can also be included as an important element of the technological package. The goal of APTP is to improve living standard and sustainable utilisation of natural resources. Hurni (1988) argues that sustainable development is equivalent to conservation-based sustainable livelihood. For the purpose of this study, sustainable development 'implies consideration of the limits and restriction imposed on environmental resources by current technology and social organisations and ability of the biosphere to adapt to and meet all human needs and activities' (Ganning and Kessler, 1989).

The role of power, particularly traction power, in agricultural development is significant. The positive role of animal traction has already been observed in some African countries, despite geographical, political, ideological, financial and cultural variations and constraints (CADU, 1971; ILCA, 1981; Starkey, 1995). Some organisations and institutions have attempted to promote the replacement of centuries old traditional animal-drawn implements like *maresha* (iron-tipped plow) in Ethiopia by improved agricultural implements with little success (Abiye and Matthews, 1983; Abiye and Girma, 1998; Goe, 1987; Girma, 1995). The little success could be ascribed to many factors, the main one probably is the fragmented or piecemeal approach to develop an implement without giving attention to farmers' attitude and knowledge, costs, availability of

maintenance and repair service, availability and use of complementary inputs. In short, it was lacking a package approach.

The idea of APTP approach is open to challenges from different directions and perspectives: (a) ideological or economic interest, and (b) lack of deeper understanding of the effects of the existing motor-powered machineries and chemical technologies on the general environment in comparison to animal power-based technological package.

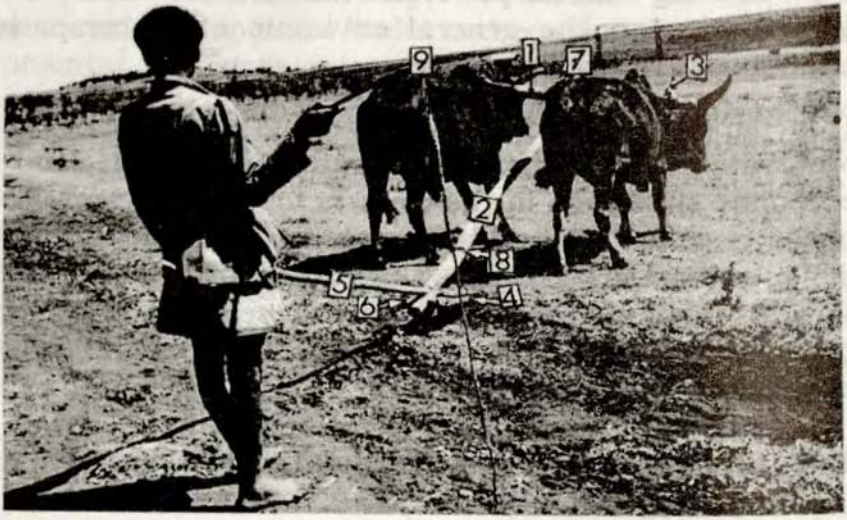
This paper is based on the authors' field experience and observations on agricultural, natural resources and socio-economic situations in the country for the last 15 years. The paper is aimed primarily at serving as a basis for further dialog and empirical work. The authors also intend to develop the idea into applied and integrated research and development project in collaboration with any interested individual and institutional partners.

2. Potentials and Issues of Animal Power-based Technologies

Presently, three types of agricultural mechanical technologies are employed in Ethiopia: (a) rudimentary tools such as hoe and digging sticks, (b) animal drawn implements, e.g. *maresha,* which is widely used in most parts of the country (Figure 1), and (c) tractor-based technologies. The latter

belong to a few private and State farms, confined to special and limited agroecological zones and produce mainly cash crops. Smallholder farming systems produce mainly food crops and use animals as a source of traction.

Figure 1. Ploughing with a pair of farm oxen.



1.Kember (wooden yoke), 2. Mofer (wooden beam), 3. Maneko (double wooden neck), 4. Maresha (iron-tipped plough), 5.Erf (wooden handle), 6. Digr (wooden wings), 7. Miran (leather strip), 8. Wogel and Tefir (B-shaped iron piece and leather to adjust distance between Maresha and beam), 9. Jiraf (whip) made of leather or other material.

In smallholder farming systems, animal power is used in different agricultural operations including land preparation, threshing and transportation. In most operations, they pool different equipment and implements like *maresha*, wagon and carts in limited cases. Pack animals are used to transport food and cash crops, firewood, charcoal, some industrial goods and people. Pack animals seem to be indispensable for about 90% of the population of the country. There are some animal power-based improved technologies (e.g. water harvesting, small irrigation, etc.) that are used to a limited extent among smallholders. All this shows the great potential and importance of animal power for agricultural systems and rural development, and that the power could be utilised in a cheaper and effective manner by a larger section of the agricultural population.

Nevertheless, the agriculture that employs animal power-based traditional agricultural instruments of production could not alleviate food shortage and famine, environmental deterioration and environmental migration. This may partially imply the inefficient and ineffective utilisation of animal power. This, in turn, could be attributed to various reasons:

- lack of research attention to development of animal power-based technological package;

- lack of deeper understanding and comparison of the effects of animal power-based technology and tractor-based technology on environmentally sustainable agriculture;
- mechanised farming techniques are considered to be important solution to food insecurity and environmental degradation;
- low mass production of elements of an improved technology package;
- lack of policies that encourage local technologists (innovators);
- poor empowerment of women, individuals and groups;
- lack of cost-benefit analysis;
- lack of thorough investigation of problems related to animal power in Ethiopia; and
- lack of public awareness and capacity building measures.

The components of animal power-based technology package need to include improved implements and equipment, improved animal breeds for traction power along with appropriate animal husbandry practices, improved and environmentally sustainable management practices for agriculture, and complementary institutional changes and arrangements.

3. Need for and Understanding APTP Approach

The possible justification or reasons for arguing in favour of animal power–based technological package are that it is : (a) appropriate for the geomorphological, topographical and hydrological features; (b) a realistic option for the small holders, pastoralists, urban and peri-urban settlers; (c) useful for the soil-water and forest conservation; (d) indispensable for the utilisation and distribution of energy, water and food items; (e) a sustainable means of transportation system; (f) a prerequisite for land-use and settlement planning; (g) a condition for alleviation of water contamination, poor sanitation practices and discharge of untreated sewage, resource-use and ethnic conflicts; (h) a condition for the production and distribution of sufficient foods; (i) a condition for the development and utilisation of risk-prone areas, and; (j) a condition for mitigation of unemployment problems. The above factors are elaborated below.

1. Physiographically, Ethiopia is a country of great geographical and geomorphological diversity, with high rugged mountains, flat topped plateaux and deep gorges. The rainfall, river, human and agricultural patterns follow the geomorphological features (Mesfin, 1972; Mengistu, 1999). The physical environment is one of the main causes for the spatial separation of farmland, small and irregular shape of plots and scattered settlements. To minimise risks, farmers

utilise different small parcels from different soil types and agro-ecological zones, but create long physical and social distances between and among settlements, farm sites and farmers (Mengistu, 1986; Mengistu and Sjöberg, 1994). The topographical features, settlement and land-use patterns are not conductive to tractor-based farming system either. It can also be argued that since fragmented plots and settlement sites are not connected by road nor by marketing systems, these and similar problems can be alleviated through the introduction of APTP rather than by mechanised technologies or traditional ones.

2. It is argued that the traditional farm tools could be modified and improved in such manner to contribute to sustainable land management and environmental protection. The present climatic phenomena can not be coped with the outmoded *maresha*. We have seen the effects of El-Nino and La-Nino phenomenon in abnormal floods, recurrent drought and the unusual spatial distribution of precipitation and the recent weather disturbance in the Horn of Africa that add to the complexity of food insecurity. Neither the traditional farm implements nor imported tractors provide adequate food to the rapidly growing population (about 3 % per annum) and nor are they appropriate to the biophysical and human environments. These inappropriate technologies and land-use changes have

brought not only reversible and irreversible environmental changes, but have also brought degradation of human ecosystems which pushes massive human migration from rural to urban areas (Mengistu and Sjöberg, 1999). This indicates that rural retention may not be as efficient as its dominant position in the literature would have us believe'.

3. It is also argued that APTP would be a realistic option for small farmers and pastoralists who produce fundamentally foods for the entire population. However, the present traditional tools, farming systems and means of transportation are not appropriate to the present unpredictable climatic changes nor can they satisfy the demand for food requirements. APTP-based development could convince farmers and pastorialsts to reduce their numbers of animals and to raise a limited number of energetic, healthy, well-fed, trained and productive animals.

4. One of the main problem of today's Ethiopia is too many poorly-fed and disease-prone animals. Livestock is considered by farmers as an indispensable asset and status, and they try to maximise the number of animals as much as possible. This phenomenon has already brought extremely poor-fed, weak and less productive massive animal species. Such stocks would aggravate environmental degradation and soil erosion through

over-grazing. Through free-grazing system and the concentration of too many animals on limited physical space, over-crowding, over-grazing and trampling would also damage the soil-water environment. Through the introduction of APTP, integrated technological development, and new methods such as carefully and systematically selected and limited number of animals, better breeding, training, provision of sufficient fodder and proper health-care, technical and environmental education and environmentally sustainable agricultural development can be enhanced. Each household or a small community can use the ammonia and urea rich animal wastes as source of manure and biogas. Thus, re-afforestation would be encouraged , increasing the supply of surface and ground water, decreasing sedimentation loads and adding nutrients to soils.

5. The present traditional farm tools not only affect the soil structure and texture, but also expose the soil moisture to evaporation. The traditional harvesting and threshing methods cause losses of a larger portion of harvests. Moreover, the operations are drudging both to persons and animals. Animals trample many hours a day, and men lose a lot of energy (Mengistu, 1986). On the other hand, the poor farmers can neither purchase imported technologies nor have access to knowledge to maintain tractor-based technology. Moreover, such

tractor-based technology is not appropriate for small (< one hectare/household) farms and plots of irregular shape. Consolidation of farm plots is required in order to apply tractor-based technologies. All these efforts have, however, brought environmental damage, requiring high costs to rehabilitate the damage.

6. One of the main reasons for the failure of many development projects is expensive technologies, which are also inappropriate to the bio-physical, economic and social, geography of the country. Such phenomena have been observed in the tractor-based farming system in many regions of the country. These systems have already been practised in commercial farms, resettlement schemes and villagisation programmes and producers' co-operatives. In the resettlement areas of Gambela, for example, out of 166 tractors that were introduced in the 1980s, only 40 of them were functioning in 1994, due to shortage of spare-parts and poor maintenance. Although each of the 35 resettlement sites in the same region, which were established in 1985, has its own water pumps, almost all of these pumps were out of function by 1991, due to (a) inadequate digging techniques, lack of and inappropriate spare-parts for the pumps and inadequately trained personnel; and (b) too many people at water-supply points).

7. Traditional technologists (e.g. artisans and lacksmiths) have been discouraged by the socio-political and ideological systems that have been considered as low cast peasants. Even though the situation has slightly improved following the 1974 Ethiopian Revolution and when co-operative farming systems were introduced, the efforts of the development of local know-how based improved technologies have not been given serious attention in the post-1991 period. Self-trained traditional technologists collect discarded metals, glassbottles, aerosol cans, plastic containers, etc. and convert them to valuable products, which are indispensable items for urban-rural dwellers and cottage industries. Even though this innovative technological development takes place at small-scale level in urban areas like Addis Ababa, the idea is: (a) compatible with the strategy of APTP development on local, regional and national levels; (b) one of the solutions to urban waste management problems; (c) a simple, humble and remarkable culture of recycling that gives hope for the future of the country; and (d) one of the measures to alleviate shortage of basic industrial goods and foreign exchange problems.

8. From a broader context of environmentally sustainable development, APTP is cost effective and can also be applied in soil and water conservation, water harvesting, land and energy saving techniques. Animal power-

based technology can also be used in: (a) construction of roads, earth dams, farm ponds, small-scale irrigation, drainae, artificial ground water recharge, rain water harvesting system and flood control; (b) conservation and development of watershed and bio-physical and human landscapes; (c) transportation of people and animals, building materials, goods, organic manure, compost, fodder and crops from a field to settlement sites or to grain stores or market sites and so on.

9. The rural-urban areas in Ethiopia lack improved agricultural technology, and such technological limitation and poor farming methods represent most serious bottleneck in all sectors of the economy and way of life. This means that the country has neither improved its own traditional technologies and means of transportation systems, nor imported modern technologies appropriate to the natural and human ecosystems. Ethiopia can, therefore, be classified as one of the most environmentally affected disaster areas and soil loosing countries in the world. As Tewelde Berhan (1989:65-66) argues, land is used 'as a mine rather than as a source of renewable resources that has caused the present Ethiopian ecological crises'. The absence of improved technology and 'well-planned natural resource management systems, high demands for agricultural production from the land, shortage of nutrient cycling and well-thought out policies of water

and soil conservation practices have aggravated poverty and hunger (Mengistu, 1987). Robert Lamb (quoted by Wijkman, 1984:38) noted the seriousness of the environmental crises in Ethiopia, thus ; the highland regions of Ethiopia 'have been so over farmed, overgrazed and deforested that efforts to scrape a bare living from this land threaten to destroy it permanently'. Due to lack of alternative energy (other than fire -wood and charcoal), rapid population increase and lack of alternative employment system (other than farming), extreme farm land fragmentation, deforestation, overgrazing, rain-induced soil erosion have occurred (Mengistu and Sjöberg, 1994).

10. Although Ethiopia is often seen as the potential water tower of north-eastern Africa, the country neither diverts its fresh water resources from her many rivers to water scarcity regions, agricultural fields and settlement sites, nor prevents them from carrying away the country's valuable natural resources such as precious top-soils across national boundaries (Mengistu 1996, and 1999). APTP would have important role in the utilisation of water resources as a source of drinking water, energy and means of drought mitigation. In the absence of such innovative thinking and programme, the natural, human and animal ecosystems are now exposed to drought, diseases, land-use and resource-use conflicts, shortage of clean and safe water and food.

11. Introduction of APTP in conservation strategy could facilitate effective protection and preservation of natural habitats and wildlife. Certain types of these wildlife species can be trained and used for farming, transportation and for other purposes. Ethiopia has always had the reputation of hosting great numbers of incredible wildlife (Ethiopian National Atlas and EVDSA, 1988). The utilisation of wildlife requires protected community-based wildlife ranching system as one of the best land-use option in the country. Wildlife ranching management techniques can:(a) encourage eco-tourism; (b) be one of the solutions to the environmental problems; (c) provide trained, energetic, disease and draught resistant working animals; and (d) supply local people with off-farm employment opportunity and protein; (e) contribute to minimising land loss in the country.

4. Some Considerations for APTP

Important conditions for effective implementation of APTP on regional and national scales include: (a) committed government institutions that can introduce awareness and capacity building measures and implement integrated technological development strategies, (b) promotion of indigenous technology and applied research, (c) full participation of the local communities in the development

process and (d) financial and logistic support from national and international organisations.

APTP components have to be first carefully designed and tested in view of (a) the types, stability, feeds, epidemiological conditions of animals and the needed training and accompanying implements, (b) the altitude, topographical, hydro-geological and agro-ecological features, (c) rainfall, land-use, settlement and crop patterns, (d) slope, soil types and moisture characteristics, and farming methods, and (e) historical and cultural contexts. Above all, implements need to be designed primarily to solve farmers' problems and serve farmers and not any other vested interest.

The research and testing processes must be multi-disciplinary, gender-sensitive, multi-cultural, and have to be based on detailed fieldwork and participatory observation. Environmental impact analysis, efficiency of the dissemination of technological know-how, manufacturing and supply of the package components and complementary inputs are also vital tools for effective and wider utilisation of the package and improvement of performance of farming systems, and for further refinement of the animal power-based technological package.

5. The Case of Animal-powered Improved Technology Package for Waterlogging Control

Several million hectares of vertisols are underused or not used at all due to water-logging in several Sub-Saharan African countries, especially in Ethiopia. On the other hand, thousands of farmers owning Vertisols are very poor and suffer from food security. Addressing this problem would help to solve food security problem in the country.

Farmers in some parts of Ethiopia use traditional techniques to manage Vertisols. An example is constructing handmade broadbed and furrows principally using human labour, including women and child labour (e.g. in Moretna Jiru *woreda*, in central Ethiopia), to expel excess water during planting season. These traditional methods are inefficient to utilise the full potential of such soils. Better technological options are therefore essential for effective utilisation of Vertisols in order to improve food supply and save household members from drudgery caused by back breaking and inefficient Waterlogging control methods. The technological options would also help farmers to improve their welfare and enhance their productivity.

A consortium of researchers and research organisation designed and tested during the 1980s one of the improved technological options, improved Broadbed and Furrow (BBF) technology package. The central component of this technology

package is the animal-pooled Broadbed Maker (BBM) to prepare raised seedbed and furrows to drain excess water. The BBM consists of two local *maresha* (animal drawn iron-tipped plow) tied with a chain that serves to cover seeds during planting. Other major components of the BBF technology package include improved fertiliser, seeds and dry (early) planting.

Modification of the local plow for land shaping and drainage would diversify the use and expand the utilisation capacity of draft animals thereby increasing their efficiency and productivity.

Compared to the situation in 1995, the level of adoption of the improved BBF package in the country is relatively high. The number of farmers applying BBM seems, however, declining over the recent years.

6. Common Constraints to BBM package

Since in many cases the furrows made are shallow, they can not drain-off high rain water effectively during heavy rain fall period, damaging the crops on the seedbed. Early seedbed preparation for dry planting on BBF is constrained by the dryness of the land and the fact that oxen are weak due to lack of feeds. In general, repeated plowing is required to control weeds on early-planted crop fields. On the other hand, however, repeated plowings would damage soil

structure and texture, and expose soils to erosion. If farmers delay planting for various reasons, the muddy soil makes it difficult for oxen to pull the broadbed maker. Other constraints include: expensive price of the broadbed maker, 200 Birr that is unaffordable by a farm household, heaviness of BBM; demand for extra labour; sensitivity of the package to land topography and the amount and distribution of rainfall, and social conflict among BBM users on upper side of a slope and non-users of BBM on the lower side of the same slope.

Nevertheless, the innovation has played an important role in the innovative behaviour of farmers, for there are farmer communities who have already developed a locally modified broadbed maker (e.g. Shanga in Oromia region). This is the positive impact of the research-based technology on adaptive innovation of farmers. This experience indicates the importance of participation of farmers in further development and refinement of the technology in order to resolve the constraints outlined above, solve local problems and fit the technology into local farming systems.

The fact that there is a considerable size of Vertisol area (more than 7 million hectares) in the country, the cumber beds made by tractor- drawn implements is unaffordable and less suitable for small-holdings and the less effective and drudging traditional methods of water-logging control methods reinforce the idea of developing improved animal-powered technologies. It implies also the importance of scrutinized Research and

Development (R&D) effort to address inherent constraints of the BBM and refine the implement, and the need for social and institutional changes and arrangements (e.g. collective and adaptive use and management of BBM) for sustainable Vertisol management.

7. Concluding Remarks

Hoe and animal-based technologies in Ethiopia have been in use since many centuries, while tractor-based technologies have been practised to a very limited extent in the last four decades. But, these technologies as such have not improved the living standard of the people. These technologies have rather aggravated environmental deterioration. APTP, integrated with well planned land-use and farming, transportation and conservation systems can reverse the deteriorated bio-physical and human ecosystems and preserve locally endangered indigenous plants, crops and animal species and knowledge. For effective implementation of APTP, appropriate policies that (a) provide incentives to local technologists and researchers; (b) encourage technological and environmental education, animal welfare, environmental impact assessment, capacity and awareness building measures; (c) introduce land-use, settlement and family planning, township and village enterprise programs, are

essential. These measures can play a significant role in freeing Ethiopia and other African countries from long-term dependency on aid.

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