DRYLAND AGROFORESTRY STRATEGY FOR ETHIOPIA

By: Kindeya Gebrehiwot

Assistant Professor, Head of the Research and Publications Office, Mekelle University
P.O. Box 231 Mekelle, Tigray Ethiopia, Telephone: +251 4 409019, +251 9 300076;
E-mail: kindeya@softhome.net

Paper to be presented at the Drylands Agroforestry Workshop 1st-3rd September 2004. ICRAF Headquarters, Nairobi- Kenya.

1. INTRODUCTION

The practice of agroforestry has been an age-old practice in the Ethiopian farming system. In the drylands of Ethiopia there are a number of indigenous agroforestry systems involving mixed cereal-livestock, agrosilvopastoral, and silvopastoral systems. The existence of these systems has a great potential for further development and the introduction of new agroforestry systems. However, except for a general description, the existing agroforestry systems have not so far been studied. In the last decades, agroforestry has emerged as a science to improve, and support traditional land resource management practices. In this regard, ICRAF, as an international body, has played a central role in directing and streamlining research at a global level. Some activities were also undertaken in Ethiopia in terms of research, education and organisation of workshops. These have been commendable effort but not enough. They need to be strengthened.

In Ethiopia, the drylands (including the arid, semi-arid and dry sub-humid areas) account for about 70 percent of the total landmass, and 46% of the total arable land (EPA 2000). In the desertification convention drylands are defined as areas which the ratio of annual precipitation to potential evapotranspiration falling between 0.05 - 0.65. The arid, semi-arid, and dry sub-humid areas (dryland areas) of Ethiopia as described by EPA (2000:14-15) fall in the following areas with the following characteristics:

1. The **arid zones** of the country encompasses about 40 percent of the Somali and some 30 percent of the Afar regions and a little bit of the north-eastern part of Wollo and some 5 percent of the Oromiya Region towards the southern tip which borders with the Somali Region. They are characterized by mean annual rainfall of between 100 - 800 mm, mean annual temperature of 21-27.5° C and mean annual potential evapotranspiration of between 1700 - 2600 mm.

2. The **semi-arid zones** of the country cover almost 90 percent of the Tigrai Region, some 20 percent of the southern, eastern and north-eastern part of Oromiya, more than 60 percent of Benishangul, some parts of the Southern Nations and Nationalities and People's Regional State as well as the extreme north-eastern part of the Somalia Region (including Jijiga) fall under this zone. Given the situation that all fall under the same umbrella of semi-arid zone, there are distinct differences in characteristics within the semi-arid zone, between the semi-arid plains, the semi-arid lakes and Rift Valley and the semi-arid mountains and plateaus. The areas in this zone have mean annual rainfall of between 300 – 800 mm, mean annual evapotranspiration of 1600 - 2100 mm and mean annual temperature of between 16-27° C

3. The **dry sub-humid zones** of the country are mainly the Oromia, Amhara, Benishangul, Gambella and some parts of the Southern Nations, Nationalities and Peoples Regional State. The area coverage, as compared to the total land surface of each region, Oromia, Amhara, Benishangul and Gambella and Southern Nations, Nationalities and Peoples Regional State, is roughly estimated to be 10%, 10%, 10%, 15% and 5%, respectively. Areas of the Oromia Region falling in this zone include some parts of Bale, Arsi and Wollega. The zone is characterized by mean annual temperature of between 16-28° C and mean annual rainfall ranging between 700 - 1000 mm.

The biggest challenge the drylands of Ethiopia face is environmental degradation aggravated by poverty, which in turn accelerates the environmental degradation process itself. Earlier estimates indicated that 1.5 - 2.0 billion tons of soil is lost annually as a result of erosion (Chadhokar 1988). The annual rate of deforestation in Ethiopia ranges from 100,000 to 200,000 hectares (FAO 1988). It has been accelerating in recent years due to unwise use mainly for subsistence and local economic activities, increased population and incidence of uncontrolled forest fires. The present human population is projected to be about 71 million with an average annual growth rate of 3.2 % (CSA 2001) as compared to 11.8 million in 1900, 36 million in 1960 and 47.3 million in 1988 (UN 1997). The wild fires in the year 2000 in the Bale and Borana Zones of the Oromia Region (Southern Ethiopia) alone caused more than US $ 39 billion damage (Dechassa and Perault 2001). In the early 1990's, only about 2.7 % of the land mass was covered by closed forests (EFAP 1994). If the present trend continues, all these remaining forests could be lost in 15 to 20 years time (Dechassa and Perault 2001).

As Ethiopia faces high rates of deforestation, knowledge on indigenous species is in the process of getting lost. In addition the use, management, and silviculture of the different indigenous species used within the agroforestry systems is not well known. Bekele and Berhanu (2001) list 23 priority species that are at present endangered. It is therefore mandatory that this information be collected and analysed to provide a basis for further research and teaching. It is believed that such knowledge will improve the training and education in agroforestry.

Prevailing deforestation in Ethiopia has resulted in serious ecological degradation and loss of socio-economic welfare (Hurni 1988; Tewolde 1989; Kindeya 1995; Getachew 2000). It has caused the disappearance of various indigenous wild animals and plants. Ensermu *et al.* (1992) listed 120 threatened endemic plant species. It is estimated that 12% of the 6500-7000 species of vascular plants in Ethiopia are endemic (Sebsebe 1993). According to the Environmental Protection Authority (EPA) of Ethiopia some two million hectares of land in the country has now become irreversibly barren as a result of the extensive deforestation (WIC 2002).

As a consequence, various forest products are no longer easily available. Their price has escalated. This has the greatest impact on rural communities, which depend primarily on forest resources for construction materials, farm implements, energy and fodder needs. More than 85% of the population of Ethiopia live in rural areas, and more than 90% of the energy requirement of the country comes from fuelwood (EFAP 1994). In the early 1980's, the annual fuel wood deficit in the country was estimated to be 18.7 million m^3 (Newcombe 1987). Forest products represent 2.5% of Ethiopia's GDP (Goerge and Mutch 2001). Considering that this income is generated from forested area that covers less than 3% of the country's land area, even a relatively small reduction of the forested land will have a serious impact on the GDP of the country (Dechassa and Perualt 2001).

1.1 Review scientific works done on Agroforestry in the drylands

One of the reasons for the decline of land productivity in many areas is the removal of forest and vegetation cover due to increased human population pressure (Beets, 1989; Skoupy, 1991). However, in drylands livestock rearing, which is the major stay of the economy (Shankarnarayan *et al.*, 1987), also bear a particular force in hastening the degradation process (Baumer, 1990). This is because; traditional practices of animal husbandry are based on keeping large number of stock and free access to arable lands after each crop harvest. This continuous grazing with the animal number more than the carrying the capacity of the land strips-off the ground cover plant and thus, leaves soil bare. Hence, the soil will be easily vulnerable to the prevailing erosive winds and torrential rains (Agrawala, 1989). As a consequence, many of the dryland areas are now characterised by food-, feed- and fuelwood-deficits, erosion problems and associated declining soil fertility (Jama *et al.*, 1989; Jansens, 1990).

The several sustained successful traditional agroforestry practices and the continued existence of the trees in farmlands of drylands for ages indicate the successfulness of indigenous conservation measures (Wilson, 1989) and ascertain the mentioned roles of trees. The intercropping of trees with millet and sorghum in the semi-arid regions of West African Sahel (Felker, 1978; Dancette and Poulain, 1969) and Eastern Ethiopia (Poschen, 1986), the rotational production system of Gum Arabic (*Acacia senegal*) combined with agricultural crops in Sudan (Amin, 1973), the stable bush-fallow system in Bougage, Niger, the peanut and Millet areas of Sahelian zone of West Africa (Nair, 1984) are outstanding examples. In many of these cases, crop growth was reported to be better in association with trees, indicating the effect of micro-site enrichment by the trees (Agrawal, 1980; Radwanski and Wickens, 1967; Virginia, 1986). This is especially important in difficult environments like drylands, where people must manage hillslopes, dry farmlands and fragile rangelands to survive and earn their livelihood (Rocheleau *et al.*, 1988).

Wood products such as fuel, timber, poles for construction purposes and fencing materials can be produced from trees on the farmlands. Poschen (1986), in his study of Harrerghe (Eastern Ethiopia) indicated that felling of *Acacia* trees found in farmlands provides 0.4 - 0.5 m^3 fuelwood per mature tree when about 20 - 30% of the total tree volume is removed. Another study in the same region also revealed production of 1.8 - 4.7 m^3 of harvestable wood $year^{-1}$ from 40 - 60 *Faidherbia albida* trees ha^{-1} (Miehe, 1986).

Provision of some "minor" products such as fodder, resin, gum, fibre, rubber, honey and myriads of other food stuffs play great role in low-input farming systems (Swaminathan, 1987). In Botswana, Sharrock (1981) estimated that 25% of the total annual diet for livestock comes from browse trees and shrubs. Paramount importance of trees as browse is that, they provide protein, vitamins and frequently mineral elements which are lacking in grassland pastures during the dry and/ or cold season and enable standing feed reserves to be built up. Hence, herds will be able to survive critical periods of shortfall or prolonged drought without losses (Le Houérou, 1980a).

Income generating opportunities have also been documented. In Sudan, Gum Arabic from *Acacia senegal* and other species generates an annual income of about US $ 4 Million (Amin, 1973). Though the extent of production is not well documented, farmers in the central and Western Tigray are known to fetch additional off-farm incomes from gums of *Combretum, Acacia*, *commiphora* and *Boswellia species* (Pers. Obser.). Hence, year round employment would be created. Furthermore, diversity of crop species in a cropland also reduces the economic risk of price fluctuations of any single crop or total crop loss (MacDicken and Vergara, 1990; Raintree, 1990).

Micro-site enrichment by trees which ultimately maintain or increase productivity of the land (Vergara, 1982; Nair *et al*., 1984), is reported to be the net effect of several factors, the most important being soil fertility improvement (Nair, 1984). The increased yields of agricultural crops observed under trees in African drylands have been correlated with the high amount of leaf litter added to the soil, increases in soil organic matter, nitrogen content, increased availability of micro-nutrient (Zn, Mn and Cu) and higher moisture availability in the surface soil layer and improved tilth (Felker, 1978, and Dancette and Poulain, 1969 in Senegal; Radwanski and Wickens, 1967 in Sudan; Virginia, 1986 in California; Poschen, 1986 and Dechasa, 1989 in Ethiopia; Verunmbe, 1987 in Nigeria). In some cases the crop yield was reported to reach the extent of 3 to 4 times more than the normal farming system (ICRAF, 1988). Kellman (1979) while reporting preferential enrichment of the soil below trees interms of Ca, Mg, K, P and N in highly weathered and infertile Ultisols of the Mountain Pine Ridge savanna of Belize, concluded that the gradual accumulation of mineral nutrients by perennial, slow-growing trees, and the incorporation of these into an enlarged plant-litter soil nutrient cycle was the mechanism responsible for this soil enrichment.

Similar results of substantial enrichment in P, K, N and increased availability of micro-nutrients (Zn, Mn, Cu) under tree species growing in drylands elsewhere were also recorded (Agrawal, 1980; Mann and Saxena, 1980; Shankarnarayan *et al*., 1987; Sharma and Gupta, 1989; Rao *et al*., 1990; Tomilinson *et al.,* 1995). Though in many of the reports was indicated that soil fertility improvement by trees in drylands is a slow process, it is extremely important in the fragile economic and ecological context of drylands (Vandenbeldt, 1990).

The influence of trees in soil physical properties is also very important in augmenting the overall capacity of the land to produce. The removal of the vegetative cover from the soil results in increases in bulk density, decreases in porosity and reduction in infiltration rate (Nair, 1984). This ultimately will dwindle land productivity. In line with this analogy, researches have demonstrated influence of trees in reverting this problem. Under *Prosopis cineraria* plantation in Semi-arid areas in India, silt and clay content of soil have increased up to a depth of 120 cm as compared to the surrounding open fields which are devoid of trees. These changes in soil physical properties resulted in the maintenance of soil moisture beneath the trees (Shankarnarayan *et al*., 1987). This effect was associated with the influence of tree roots and biomass return in terms of mulching or tree litter on the structure and texture of the soils (Young, 1989).

The use of trees as windbreaks and shelterbelts is a widespread practice in many dryland agricultural systems. In drylands, effects of winds on agricultural crops are often obvious from the physical deformation of plant parts and their growth forms. Indirect effects concern mainly the water balance of plants and moisture content, erodibility and other properties of the soil (Skoupy, 1991; Sheikh and Khalique, 1982). Trees can mitigate these ravaging effects of winds.

Decreased wind velocity by windbreaks results in higher air temperature and increased relative humidity in and just above the leeward canopy (Vandenbeldt, 1990). Markedly reduced rates of evaporation and lower temperature regimes and reduction of about 5-14% in evapotranspiration during April to July (Shankarnarayan *et al*., 1987 in India; Schoch, 1966 in drylands of Senegal) was recorded as compared with adjacent bare lands.

By reducing wind velocity, wind breaks cause the deposition of airborne soil particles and prevent them from becoming airborne again. This tends to reduce sand blasting, which can destroy or severely reduce yield when exposed far as little as 15 minutes (Fryrear, 1987). Skoupy (1991) referring to farmers interview presented an important instance in asserting the above analogy. In normal years, only one sowing of the crops is required to the leeward of the shelterbelts where as in the unprotected areas it is frequently necessary to sow seed two or three times each season because of blown surface sand burying or damaging the germinating seed (Skoupy, 1991). In *Cassia siamea* type of shelterbelt, the soil loss was averaged 184.3 Kg/ha, while in the bare soil was 546.8 Kg/ha (Shankarnarayan *et al.*, 1987).

Windbreaks also sieve wind driven rain, depositing moisture on the windward side to the benefit of crops growing close to the windbreak. In Niger, a 1-year study of the effects of two rows *Azadirachta indica* showed millet yields in the protected fields were 123 per cent of the yields outside the protected areas. This takes into account the loss of production caused by the proximity of the planted tree (Skoupy, 1991).

Role of trees in protecting soils of drylands against rainfall is also of paramount importance. Risks of soil erosion can be reduced by the combined cumulative effects of tree canopies, ground cover of annual crops or pasture grasses, legumes and shrubs, and a surface litter on rainfall erosivity (Wiersum, 1984). When the protective vegetation cover is removed, the structurally unstable soils are exposed to the beating action of rains. As a consequence, erosion immediately after land clearing are normally high. Soil loss of up to 120 t ha^{-1} in the 1st year of the land after land clearing was indicated (Lal, 1974). The double "armour" provided by the crown cover and the layer of litter fall protects the soil from splash erosion and surface or sheet erosion. Water infiltration is also enhanced by both the roots action and accumulation of absorbent humus on the soil surface, and significantly reduce the volume, velocity, and erosive and leaching capacity of surface run-off (Young, 1989).

Tree crowns lessen solar radiation on the soil, reduce soil temperature, and thereby reduce moisture loss through evaporation from the surface soil where most annual food crops draw their moisture and nutrient uptakes. Most of the data in assertion to this come from tropical forests (Wilkinson and Ania, 1976). More work remains to demonstrate in dryland agroforestry.

The protective role of trees in imparting stability to the whole system is also well known. The clearing of vegetation affects not only the farmlands in the immediate vicinity, but also destroys the water catchment areas, causing flooding of rivers and rapid silting of dams. This is important in drylands as there is inundation problem because of the torrential rains. Floods annually affect an area of about 8 million hectare of cropped land in India (Sharma and Gupta, 1989).

Generally, the indicated attributes of trees and their favourable influences and effect on soil conservation, physical properties, the hydrological balance, microclimate and shelterbelt effect are sufficiently large to indicate the beneficial role of trees in conserving and stabilising the ecosystem. These are in addition to the economic and social benefits. As a matter of fact, reports from CAZRI revealed that combination of trees with crops would yield better overall returns in comparison with separate plots of trees and crops whilst reversing the land degradation in drylands (Shankarnarayan *et al.*, 1987)

In Ethiopia, ICRAF (1990) undertook a survey on traditional agroforestry systems. The study found mixed cereal-livestock, agrosilvopastoral, and silvopastoral systems.

From previous and recent field surveys in region revealed that the above listed systems exist, with variations in some of the components. The following observations were made. The interpretation of the indicated agroforestry practices in the subsequent points, reference could be made to Rocheleau *et al*. (1988) and Nair (1990). All systems attempt to maximise overall production of the farming systems.

1. As dispersed trees in croplands

This agroforestry system is the most dominant agroforestry practice in the semi-arid and sub humid zones. The native tree species are widely scattered haphazardly, or according to some systematic patterns on bunds, terraces or field boundaries. Native tree species to be promoted for this purpose include:

A. abyssinica, A. bussei, A. etbaica, A. Sieberiana, A. tortilis, Acacia seyal, Balanites aegyptiaca, Faidherbia albida, Zizyphus spina-christi

The suggested species can provide fuelwood, charcoal, shade, construction materials and farming implements, and fodder for livestock. Furthermore, farmers in these areas also confirmed their role in soil improvement and conservation. Their other uses include providing bee fodder, traditional medicine (only *A. tortilis, B. aegyptiaca* and *Zizyphus spina-christi*) and human food (only *B. aegyptiaca and Zizyphus spina-christi*).

Integration for improvement in croplands may comprise of protection and management of selected mature trees of the native species already on the site, planting new trees or careful management of selected seedlings established on site through natural regeneration. The use of the species could also be integrated with the traditional soil and stone bunds.

Since all the indicated species are palatable by most of the livestock, protection must be made against browsing while the seedlings are very young. This could be done by fencing the seedlings in groups (which would be economical than individual tree fencing) or exercising social fencing. When pressure of roaming livestock is intense, it impedes the occurrence of natural regeneration in the sites. As drought is indicated to be the main constraint, some water harvesting techniques like microcatchements and microbasins around the young seedlings could conserve the limited rainfalls (in the dry spells) and hence increase their survival during some prolonged droughts.

Spacing depends on the size and requirements of the tree species, and intended primary objectives of the land user. In croplands, it has to make best use of any positive effects of the trees on crops. Hence, variations are expected with regards to species and accompanying growing agricultural crops. More study remains in this light. For *F. albida* 40 - 60 trees/ hectare (10 X 10m) can be used as a basis to start with (from experience in the Sahel, Rocheleau *et al*., 1988). Based on spacing observed during field work, 7-15m for *A. seyal*, 5-10 m for *Z. spina-christi, A. sieberiana, A. tortilis* and *A. etbaica*, and 10-20 m for *B. aegyptiaca* could be used as an embarking point.

Management of the trees is important to ensure sustained return of mulch or leaf fodder and light shade. Pollarding, topping and pruning are important in this respect. This should be done in early summer or at the end of the dry season.

2. Trees on soil conservation and reclamation structures:

Soil and water conservation has been practiced in many parts of Ethiopia, and it has been promoted by the governments (the past and present) for more than 20 years. It is thus increasingly becoming a culture in many areas. In this light, native tree species have a lot to contribute. Traditionally, they have been incorporated in many of the conservation earthwork structures - especially, soil and stone bunds. Furthermore, they can be grown on terraces, raisers etc. with or without grass strips for the purpose of reclamation of degraded soils, and sand dune stabilisation while providing various tree products. There exists a great potential in improving productivity and land use sustainability in sloppy farmlands. Native tree species to be promoted for this purpose include:

F. albida, A. seyal, A. tortilis, A. sieberiana, A. etbaica, A. abyssinica and *Z. spina-christi.* Where adequate moisture can be conserved to plant fruit and cash trees, the following species could be considered: *Musa spp., Cofea arabica, Persea americana, Carica papaya, Rsidium guajava, Mangifera indica,* and *Citurs* spp. could be planted.

These tree species have been indicated to have potentials in providing various tree products while stabilising the conservation structures found in farmlands. They make lost cropping space productive by using the surfaces of structures where other crops can't be grown. To maximise water availability to the growing seedlings in the bunds, microcatchments can be utilised. Cut-off drains could also be incorporated during wet seasons.

Protection against browsing will be necessary during the early establishment periods. Cut and carry could be used to supply fodder for livestock in a form of stall feeding. Trees should not be allowed to grow too high and cause shedding on the accompanying crops, in cases of croplands. Topping and pollarding need to be done to secure light shade for growing crops and this also maximises biomass production both for soil litter and fodder for livestock.

3. Livefence

This is often practised to keep out domestic or wild animals. The native tree species are planted around a compound, house, cropland, fodder lot and garden. Native tree species to be promoted for this purpose will be:

A. tortilis, A. bussei, B. aegyptiaca, A. seyal, A. tortilis, A. sieberiana, A. etbaica, Z. spina-christi, A., abyssinica and *F. albida.*

These trees have been revealed to provide fuelwood, charcoal, shade for human and livestock, fodder, etc. while serving the primary objective of fencing. Since they can be grown along the boundary in croplands, agreement to its installation is needed among all affected land owners and users.

Protection and management are crucial for success. Protection is needed for young seedlings till they will be large enough to protect themselves. As the trees grow, they will be trimmed, providing either mulch for the soil or fodder for livestock. The planting pattern is often in lines. This practice does not require substantial labour for planting and maintenance. It can also serve as boundary demarcation, and windbreaks in wind prone areas.

4. Shelterbelts and windbreaks

This involves planting and growing native tree species around farmlands and plots to protect them from wind and blowing sand or soil. This has potential in highlands, where farmers have revealed greater incidence of wind damage on agricultural crops. It can also protect sand blasting to croplands from surrounding bare lands. Native tree species to be promoted for this purpose will be:

A. abyssinica, A. etbaica, A. tortilis, Z. spina-christi, B. aegyptiaca and *F. albida*

They can reduce soil erosion, improve the microclimate for growing crops and shelter people and livestock. This is accomplished through decreasing moisture loss, speed of the wind and thus its ability to carry and deposit soil and sand. Planting is done in strips at closer spacing.

Protection of young seedlings is necessary for all the tree species Management has to be made to maintain sustained presence of the windbreaks. Topping and pollarding need to be done, for harvesting. All trees should not be felled at once, Shelterwood cutting can be utilised. This ensures that there will always be windbreaks left after each harvest, and adult trees can provide protection for seedlings and young trees being planted for replacement.

Since windbreaks often affect more than one farmland (especially where the farm lands are fragmented to about 0.25 hectares), agreement should be reached between neighbours. The native species can also be incorporated in this pattern to serve in fencing and boundary demarcation. In addition the windbreaks could be done along roads and paths if wind direction and the roads or paths run perpendicular to each other. The trees also provide other products and services.

5. Fuelwood production

Since there is severe fuelwood shortage in Ethiopia, promotion of this practice is very important. It involves inter-planting the tree species on or around agricultural lands with a main production objective, to produce fuelwood. This can be produced while fulfilling other objectives including fencing, shelterbelts and boundary demarcation. It is thus very important to plant tree species with high fuelwood value. Species that can be used for this purpose include:

A. abyssinica, F. albida, A. seyal, A. tortilis, A. etbaica, A. sieberiana, A. bussei, and *B. aegyptiaca.*

The tree species listed above have been indicated to have high calorific value and meet most of the requirements of a fuelwood species.

The trees will be managed on short-rotation basis in order to supply fuelwood in areas where there is severe shortage. Protection will be necessary. Selection and breeding is also needed to promote the relatively faster growing provenances of the species.

6. Trees on rangelands – silvopastoral systems

This involves the incorporation of the native tree species having high fodder values in rangelands. They can either be scattered irregularly or arranged according to some systematic pattern. Species that can be promoted include:

In the semi-arid and sub-humid areas: *F. albida, A. seyal, A. tortilis, A. sieberiana, A. abyssinica, A. etbaica, A. bussei, B. aegyptiaca and Z. spina-christi.*

In the arid areas there is the *Acacia - Commiphora* woodland vegetation with *Acacia misera, A. socotrana,* and *A. spirocarpa* species; and near wadis *Tamarix nilotica, Ziziphus mauritiana, Z. mucronata, Phoenix reclinata, Leptadenia spartium* and *Conocarpus lancifolius* becoming frequent (FRA, 2000). The agroforestry species of these areas need to be studied – as so far there is only a list of the kind of species that occur in these areas and no detail on their usefulness.

These tree species have had great potential in their fodder value for most of the livestock. Most of them produce leaf fodder and edible pods. Most have higher crude protein, mineral content and some higher dry matter density than the associated grasses, particularly during the dry season. Though the species will primarily be incorporated to produce fodder, they can also provide poles, fuelwood, pollen and nectar for bee fodder, or improve the soil. The paramount importance of the trees in this agroforestry practice is to meet wood and fodder demands throughout the year and maintain fodder through dry periods. They can also help to maintain the stability and fertility of grazing lands and reverse trends in land degradation and desertification.

Either planting or natural regeneration or both would be involved. This can be encouraged through rain harvesting with microcatchments, as well as protection from grazing animals. Especially in the arid areas, in the past extended periods of rest, where natural regeneration was encouraged used to be practiced. With the ever increasing pressure, these periods have become progressively shorter, now resulting in very minimum regeneration. A recent study done by the author in the Tekeze valley where *Boswellia papyrifera* grows revealed that continues extensive grazing has resulted in most species having near to no regeneration. This trend was however, basically reversed by establishing closed areas where no grazing was allowed. Some management schemes will be necessary to promote and enable the establishment of seedlings and saplings to ensure the future of these systems. To minimise the protection requirements, the trees could be planted in clumps. Because it is easier and economical to protect group of trees than the same number of trees planted in lines or dispersed throughout the pasture. In sloppy lands the planting pattern should follow contour lines.

7. Protein Banks

This involves growing the native tree species for the production of protein rich fodder on farm or rangelands for cut- and -carry fodder production. The fodder kept in this manner especially acts as a reserve supplement during the dry periods, when other sources of feed will be limited. This is feasible in areas where there is high population pressure and feed scarcity. The species that can be promoted include:

A. abyssinica, F. albida, A. seyal, A. tortilis, A. sieberiana, A. bussei, A. etbaica, B. aegyptiaca and *Z. spina-christi.*

These tree species have been proved for their forage value. In addition to the mainly intended fodder production, the tree species would provide other highly needed tree products such as fuelwood, poles and etc.

Mixtures of these different tree species would be planted around homestead or backyards as clumps. The trees could be closely planted where land is in very short supply. Protection against roaming livestock is essential. The practice is suitable to group fencing which is reasonably economical. As they are often near the home, the labour required could be combined with home and child care responsibilities. Topping, pollarding and pruning will be done to maximise production of biomass. Breeding and provenance trials will be needed to select provenances that produce maximum forage.

8. Multipurpose woodlots

This comprises establishment of the tree species in the form of woodlots in order to fulfil multiple objectives (wood, fodder, soil protection, soil reclamation, etc.). All the native species listed above have potential to be used in this respect. In summery they are:

F. albida, A. seyal, A. tortilis, A. bussei, A. sieberiana, A. etbaica, B. aegyptiaca, A. abyssinica and Z. spina-christi. Where there is adequate moisture suppliment possible through irrigation, or close ground water tables fruit and cash trees could also be added. The following species could be considered: *Musa* spp., *Cofea arabica*, *Persea americana, Carica papaya*, *Rsidium guajava*, *Mangifera indica*, and *Citurs* spp. could be planted.

These can be planted in common lands for the benefit of the community. It can involve mixture of the species. Management may vary depending on the predominant objectives. Production objectives will often be diverse. Since most of the tree species provide bee fodder, apiculture could also be incorporated. In sloppy lands, tree planting will follow contour in association with some conservation measures. In cases where communal lands are used, the rights in sharing benefits and responsibilities in protection and maintenance of each community member must be clearly defined before any work is done.

The successful colonisation of many of the native species in many of the degraded lands, underline their potential in wasteland reclamation. This could be in the form of woodlots. These would serve as sources of fuelwood, fodder (using cut- and - carry system) and other tree products while reclaiming the marginal lands. Its contribution in augmenting the high demand of tree products might be of paramount importance.

To maximise land outputs, some shade tolerant crops could be inter-planted within the woodlots till canopy closes. Management include topping, pollarding and pruning.

9. Improved fallow

Leaving croplands fallow is a common practice in many parts of Ethiopia. This is intended to allow the soil to rest and regain some of its fertility from the growing vegetation, usually consisting of naturally growing weeds and grasses. Some weeds may be leguminous, but most of the weeds and the grasses are not. Due to shortage of the fallow years (1 or 2 years in most cases) and the type of vegetation growing in the fallow period, the intended objectives are not often met.

This traditional practice can be more robust, productive and achieve its targets using improved fallow. This involves planting the native tree species which would speed up soil recovery during the fallow phase. This enables to meet the main purpose of soil fertility improvement while keeping the fallow phase minimum. At the end of the improved fallow period, trees will be harvested while leaving the debris to decay in croplands. Overall benefits from the tree species include soil erosion control, increase in the organic matter content of the soil, cycle and trap nutrients and improve soil tilth. In addition, there will be short-term economic gains. These include the highly needed tree products such as fuel, fodder, food, construction materials and farming implements.

However, due to scarcity of land resulting from population pressure in many areas, applicability of improved fallow may only be limited to some areas where shifting cultivation have been exercised recently.

For this purpose: *F. albida, A. seyal, A. tortilis, A. bussei, A. sieberiana, A. etbaica, B. aegyptiaca, A. abyssinica, Z. spina-christi,* could be used.

To maximise the overall production, apiculture can be incorporated during the fallow phase as the tree species produce flowers with nectar. Protection against browsing is needed during the early years when the trees are growing. Fencing is important. However optimum management and rotation of the tree species need to be studied.

10. Closed areas and hillside distributions

In many parts of Ethiopia, degraded lands that almost have no production potential are set aside for natural rehabilitation. These are called closed areas. In addition to these closed areas, hillsides where no farming is practiced, and livestock grazing is not productive are set aside for communal plantation or forested areas. In some places in Ethiopia these communal plantations or forests are being divided among young people who do not have land to farm, as land re-distribution has been stopped. These areas have very high potential for agroforestry, especially with cash earning products like fuelwood, fruits, honey, milk and milk products, and when there is good access to markets forage being produced. From the above mentioned practices, the multipurpose woodlots, protein banks, fuelwood production, live fence, and trees on soil conservation and reclamation structures.

Other practices:

The preceding points do not exclusively list where agroforestry is being practiced and can be improved. Only the main ones have been described. Other promising practices include along water ways/ riverine, plantation crops with pastures and animals, homesteads, apiculture, communal lands and in wasteland or degraded land reclamation.

Though the above listed species flourish in the many traditional agroforestry practices, their present situations does not allow the realisation of the maximum biological potential benefits in the needed quantity and quality. Using these systems as an embarking point, further improvements can be established. The improvements have to be able to maximise the potential benefits from the tree species without inflicting losses in other land use aspects, like crop- or livestock -production.

- **Emerging strategies in Ethiopia**

As has been noted above environmental degradation is a serious challenge in Ethiopia. Many highlighted the urgency of reversing the land deterioration in the region to halt the above mentioned socio-economic and ecological problems of the region (SEART 1994 cited in ANON 1994, ANON 1992). In a review of research gaps in the country, the Ethiopian Agricultural Research Organization (EARO 1999) identified among others the need for research on the diversity, biology, ecology, silviculture and economic importance of trees and shrubs. Having realised the seriousness of the problem, the government and the people in Ethiopia are trying to rehabilitate degraded lands in an effort to reverse the problem. To do this several approaches have been tired, and among these are area enclosures and hillside distributions that are discussed below.

- **Enclosures**

These days, efforts are underway to replenish the denuded vegetation of Northern Ethiopia in line with the need to cater livestock fodder and other tree products. To this effect, enclosing areas has been instrumental towards materialising the major goal; achieving conservation based sustainable agriculture. It is also a means to maintain biodiversity in the drylands of the region within the rural community (Kindeya 1997, Emiru 2002, Kindeya 2003, Sarah 2003). This alternative has gained wide acceptance, for two reasons. The first, the degraded lands had not produced substantial amounts of grazing, but had promoted erosion especially downstream. The land now produces some grass, though still not enough as compared to the fodder needs of the local community it has not been made totally unproductive. In addition it is protecting downstream areas from erosion while at the same time improving infiltration and ground water conditions, as a consequence there are springs re-emerging and providing water for longer periods of time down stream. The second reason is that this system requires lower investment as compared to community plantation areas, as it only needs a guard to protect the land, and the community to set rules and regulations though which trespassers will be punished (Mitiku and Kindeya, 1997).

Delineation of enclosures

Local people are highly involved in the delineation of the area enclosures. In the beginning, the Development Agents, Development Committee and the local Administration (*Baito*) identify sites for protection. The selected areas should not be close to settlements of the local people and used for grazing. The selected areas are then presented to the general community in a general meeting of community members. After thorough discussion and based on the interest of the local people, the socio-economic and ecological conditions to be considered and the means of protecting these area enclosures will be developed (Mitiku and Kindeya, 2000).

Protection of area enclosures

The guards for the protection of enclosed areas are usually nominated by the local people, and payment for the guards comes from contributions made by the local people. A person who can read and write, who has interest in development, and who has acceptance by the majority of community members is selected for the position. Most of the time, the local people contribute about 0.25-0.50 Birr per month, or in some other cases about a kilogram of grain per household per year. In some areas people stop contribution after 2-3 years. In some cases, where the local people have stopped their contribution, certain adjustments may be made. For example, the site guards were allowed to cut and use the grasses or to graze few livestock (3-4 cattle) on the protected area for some time. Another mode of protecting community forests include protection based on incentives for example food for work or cash for work (Ibid).

- **Hillside distribution**

In addition to the enclosures, there are also some communal hillside plantations. Some farmers in the Echimare village of the Eastern Zone of Tigray, in 1992 decided against prevailing government policy, to divide and allocate a community forest area for individual management. A relatively larger hillside with frequent boulders and stones extends from the sides of the village. At the foot of the hill, all the land is cultivated and relatively a larger area is set aside as a pastureland. The area that formed a part of a degraded hillside was communally planted with eucalyptus trees, but the village people witnessed low survival and poor establishment of the trees planted on the hillsides. Hence, the members of the community opened dialogue and consultation among themselves on the options available for managing the forested land (BOANRD, 1996) and decided to carry out tree planting individually rather than communally.

The farmers forwarded their idea of dividing the land to the *Baito* (local council). Although the local *Baito* was convinced and accepted the idea, it needed approval from the *Baitos* at *Woreda* (District Council) and Regional levels. Those farmers had set-up a committee to prepare rules, divide the land equally to all members, and administer tree planting as per the agreement. Accordingly, the hillside was divided into parcels of 3m x 6m. Each household was given two parcels, one from fertile area and one from low fertility. People were organized into groups of ten relatives. Such grouping was adopted to allow consolidation of these parcels into bigger plots. It was also better to prepare planting site in a group than individually. Allocation of plots to individuals was done through drawing of lots in order to avoid biases. People have planted in this arrangement for the last twelve years. This challenge from the farmers of Echimare area in Eastern Tigray was accepted as a framework for developing a policy to plan resource management at a local level with a foundation for application at a Regional level. Subsequently, the Regional government appreciating the initiative taken by the community, decided to formulate a policy through the Bureau of Agriculture and Natural Resources for the allocation of sloppy lands to landless members of the community where sloppy lands occur (Mitiku and Kindeya, 2000).

The criteria of inclusion of a beneficiary for obtaining land on a hillside include:

- Socio-economic situation and income sources
- That the farmer should be adult and not a participant in the last land distribution undertaken
- Someone who can develop the land on his own initiative
- Returnees from migration or settlement programs

The hillsides for distribution were initially barren lands with free grazing. A local bylaw (*serit*) on the management, rights, duties and responsibilities of the beneficiaries has been endorsed by the community (Annex 1). Since boundaries are clearly marked, disputes about borders were not raised as issues of contention (Ibid).

Through the guidelines, assumptions were made that the participation of farmers and investors in the development of hillsides would be enhanced, environmental protection would be strengthened and food security of the region through additional income generated from forest products would be ensured.

Similar distribution schemes are being considered on rehabilitated gullies and improved pastureland. The whole philosophy of such distribution of hillsides centres on the improvement of the environment and socio-economic welfare of the community and involvement of the beneficiaries in the implementation processes (Ibid).

Experiences from farmers of Echimare

The idea of managing common pool resources through individual ownership, that started in Echimare, challenged the whole idea of top-down land use planning at community level. As pointed out by Desalegn (1998) past efforts in soil and water conservation, community forestry and catchment rehabilitation failed because they were not participatory in their approaches. Beneficiary communities were not involved in the planning, implementation and utilization of the products. However, the case of Echimare is a clear message to policy makers, that if properly addressed and consulted, local communities have the capacity and institutions to plan land use in accordance to the expectations of beneficiaries. Experience in Echimare shows the fact that people prefer individual planting than communal planting. Farmers were tending their plots properly. Weeding, cultivation, and run-off diversion were practiced by many of the households in Echimare. The *serit* developed by the beneficiaries is respected by all and accepted by the judiciary. None of the farmers failed to plant their plot as it would otherwise be given to others - according to the byelaw. Eucalyptus trees planted in private plots performed well as compared to those in communal plantations. The diameter of trees grown in private plots was twice that of trees grown in communal plantations (BOANRD, 1996).

Local level training in resource management

Despite the well intentioned initiatives taken by the farmers in Echimare, Negash and Wuhdet the need for technical support for such initiatives should not be undermined. Technical support in selecting appropriate tree seedlings, providing guidelines on physical structures is important. Training of the beneficiaries in resource management with emphasis in integrated hillside development should be given periodically. Simple indicators of the changes in the rehabilitation and development of the distributed lands needs to be developed (Mitiku and Kindeya, 2000).

Attitudinal change

Through the initiatives taken at Echimare, attitudinal changes are observed on development agents, experts and policy makers with regard to the management of degraded lands. Previous emphases on area closures, although still prevailing, are now considering the distribution of the planned areas to beneficiaries. This is not a reversal on the policy of the area closures, but realization of the involvement of the beneficiaries to own and manage the land resources. People's involvement and participation is ensured if they consider themselves as decision makers on the land they owned. This invariably is a *modus oprandi* in Tigray (Ibid).

Sustainability

Farmers are not interested for the mere protection of natural resources such as forest, pasture and water resources but prefer their use in a sustainable manner and do not in a way accept the destruction of such resources if they know it affects their livelihood. Framers in these schemes emphasize management of resources through use, not just for the sake of conservation. They assert that traditionally such management was manifested in several ways. However, the farmers indicated that successive reforms and policies on agriculture and tenure have not taken into consideration the local initiatives. This particular scheme provides the beneficiaries with a title deed to the land ensuring sustainability and security (Ibid).

Management issues

Beneficiary farmers are aware about the need for the management of the distributed lands with regard to tending the planted trees, watering the seedlings and in meeting their social obligations for good land husbandry. This is expressed through the maintenance of terraces, broken bunds, weeding of seedlings and cutting grass to stall-feed livestock, since the *serit* prohibits free roaming and grazing. Conceptually the beneficiaries are moving from the conventional method of using the hillsides as free grazing areas to areas where biomass can be produced to be used elsewhere through cut-and-carry system (Ibid).

Intermediate and long-term benefits

Distributed hillsides have very high potential for agroforestry, especially with cash earning products like fuelwood, fruits, honey, milk and milk products, and when there is good access to markets forage being produced. In the long run, the beneficiaries anticipate benefits to accrue from the sale of wood for fuel and construction and fruit crops. However intermediate benefits from cutting grass for livestock feeding are being realized. Grass is harvested on cut-and-carry system and after seeds of grasses are already shaded on the ground. In some areas, a grass strip with 1 m width is deliberately left as seed sources. Some beneficiaries have started fattening sheep and goats for sale. So far the out-put is encouraging since beneficiaries have access to credit facilities for starting the initial purchase of the sheep and goats. Further plans are drawn by each community to integrate bee keeping as part of the long-term benefits. Bee keeping is a lucrative business in providing additional income to the beneficiaries.

2. STAKEHOLDERS AND THE ROLE THEY PLAY

The following are the stakeholders in attempting to improve agroforestry.

1. **Farming community:** is the most directly involved body. Any intervention would have to start with convincing the farming community of the benefits of agroforestry, and the systems intended to be implemented. They area also the direct beneficiaries of any improvement in the agroforestry system resulting in improved substance and economic powers.

2. **Regional and federal governments:** the government is at present trying to fight food insecurity and poverty both at the federal and regional level. The present government policy focuses on attaining economic development though improved agricultural and rural productivity. As the policy maker, the government is directly involved in preparing a conducive environment in which agroforestry can be improve and promoted.

3. **Bureau of Agriculture and Natural Resources:** The Bureau of Agriculture is the body implementing the government polices, and the most decisive player in undertaking national level change in any form of agricultural and natural resource management interventions all over the country. At present the bureau works by developing extension packages and ideas to implement. Most of these ideas are implemented nationally, yet some are region specific, as conditions in different regions are different.

4. **Other government offices**: the different bodies of the government that are involved in making decisions regarding what the bureau of Agriculture and Natural Resource Management implements, what kind of infrastructure is development where and when, and what services will be provided to the farming community are directly or indirectly involved in implementing and improving agroforestry.

5. **NGO's**: Apart from the bureau, it is NGO's that experiment on developing and implement different strategies, methods, and programmes to help with improving agricultural and natural resource management.

6. **Intellectual community**: the intellectual community is either, employed and active in Bureau of Agriculture and Natural Resource Management, or is involved in consulting NGO's and/ or the government, and debates about issues that require decision. It is thus directly or indirectly involved in improving and implementing agroforestry.

Within this category one finds the **higher education institutions**. As was seen from the outcome of the Workshop on Land husbandry in the highlands of Ethiopia (Kindeya, Temu, Mitiku 1997), the role these institutions have been playing in agroforestry and other land resource management practices has not been significant. The main reasons given for this were:

Lack of appropriate teaching materials, Need for re-training trainers, Lack of communication between institutions, Lack of adequate trained manpower, Poor link between research and education, Need for proper utilization of available staff, Gaps in research and knowledge on related subjects for example soil science, forestry, crop husbandry, animal husbandry, soil and water conservation, water resources, and socio-economics, Lack of appropriate organizational/institutional set-ups, Lack of appropriate research policy to address land husbandry, Lack of tools for collaboration, Poor research-extension-farmer linkage, Lack of incentives for researchers, and Inadequate research funds and facilities.

To overcome these shortcomings the following improvements were proposed:

Overall development of the resource base both with regards to human and infrastructure that are necessary for education, training, research, extension, networking, and information exchange, Creating a more conducive education, research, and extension related policies, Trying to procure more funds for research, education, extension and networking activities in the country, and Building up on the information and education base in all the related subjects. Most of the above-mentioned solutions can be undertaken by the higher education institutions themselves, yet some need to be undertaken at national and international levels.

3. AGROFORESTRY AND HOUSEHOLD FOOD SECURITY OF THE DRYLAND RURAL COMMUNITY

As discussed in the introduction, the environmental degradation in Ethiopia is one of the biggest challenges the country faces. The severity of the environmental degradation coupled with poverty expresses itself in the large proportion of the country's population lacking food security. Many countries in the world face drought, yet not all occurrences of drought end up with famine. The famine in Ethiopia is only an expression of the complex interrelated problems of environmental degradation, poverty and lack of alternatives.

The success of any land use intervention is determined in its capability to deliver the intended benefits. In order to attain food security, one needs to find a system that will not completely collapse when there is drought, and one that will provide the farming community with alternative income earning possibilities. In a prior study conducted by the author in 1995, several indigenous tree species incorporated in agroforestry systems were found to be sources of fuel, feed (during dry season), poles, farming implements, shade, live fence and other local uses like in traditional medicine, human food and bee-keeping. As these products were obtained from trees, it needs to be noted that they still produced during drought periods provided there were small showers and percolated moisture from previous years. Moreover based on soil analysis also undertaken at the same time, there was increased organic matter content in the soil where the trees were located. The increased organic matter content, and the sheltering effect of the trees help in combating crop failure when the rains stop too early. In addition to this effect, there was a significant increase in soil nutrients highlighting the species role in increasing crop productivity in croplands.

Hence, agroforestry to be a sound practice, has to meet the farmers' short term needs (fuel, feed, poles etc.) and provide service functions (maintain soil fertility, erosion control etc.) in the long-term. This largely depends on the ability of the incorporated multipurpose species. On these grounds, the study argued that proposed agroforestry options should have to start from the species to which farmers are accustomed to or in other words, native multipurpose trees.

In this line native species have quite a lot untapped potential to be used as agroforestry components in many of the farming systems. The realised benefits by farmers coupled with their age-old traditional experiences with the species gives an important point for intervention. Moreover, the success of these species in the traditional agroforestry systems for ages is an indicator in the possible prudent extrapolation of the species to a wider scale.

4. DIVISION ON THE OWNERSHIP, AND INVOLVEMENT PER AGE AND GENDER IN AGROFORESTRY

In the drylands of Ethiopia there are several cultures, with implications into ownership, and involvement per age and gender in agroforestry. Overall however, it is up to women to collect and use fuelwood. In most cases, the home gardens and all that grow in them are the responsibility of women and children. Thus providing women with the possibility to purchase basic necessities from sale of produce in the home gardens. On the other hand in most cases, the production and marketing produce from the farmlands and the rangelands belong to men and boys respectively. An exception to this, are the Afar people where all production and sale is under the control of women and children.

5. THE OPPORTUNITIES AND CONSTRAINTS FOR STUDYING, PROMOTING AND PRACTICING AGROFORESTRY IN THE DRYALNDS

As noted above agroforestry is a traditional system already known by farmers in Ethiopia. Even though it is a traditional system, it is not very widely implemented. In addition it is not well studied. Its full potential is thus not yet realised. To realise its full potential it will need to be studied, promoted and practiced. To do this the following opportunities and constrains will have to be met.

1. Opportunities:

- There are already on-going studies on the potential role of agroforestry in land degradation at EARO, higher education and regional governments level. From such on-going works, data on trees, soicio-econmics, extension, soils, erosion, and etc is being generated. Therefore, one can therefore build on already started work. This also shows that the government and some stakeholders are already interested in agroforestry.

- It is almost 10 years since the Ethiopian Forestry Action Programme has been put in-place. Following this, regional forestry action programmes (Amahara, Tigray, Oromiya, Afar, Somalia, etc) has been approved. This action programme gives special emphasis to practices that help attain food security, and combat environmental degradation. As shown above agroforestry is such a practice, and thus favoured by the programme. In addition the programme has laid down the basic foundation in human and institutional infrastructure to implement agroforestry and similar practices.

- There are successful indigenous agroforestry practices through out the country. There exist local initiatives by farmers for land used planning that integrates trees (e.g. hillside distribution). These will be very useful for extension and promotion of agroforestry in the farming community.

- There are initiatives to start up networking in Land Husbandry and agroforestry, which has involved all stakeholders in Ethiopia. This has been supported by ANAFE of ICRAF. This has lain down the foundation for ICRAF to start working with the various stakeholders in Ethiopia, and Africa.

Constraints:

- The continued existence of open grazing. As it is known for agroforestry to function, tree must be able to grow. Because of free grazing all tree seedlings that emerge in grazing, farming and communal lands are either grazed on and uprooted, or will be trampled on and die. Without the establishment of trees, practicing agroforestry will become very difficult. Due to the free grazing however, it is not only trees that find it difficult to establish, but also most of the other vegetation suffers form trampling. This leaves land unproductive and exposed to soil erosion.

- The high agroclimatic and cultural diversity in Ethiopia makes development of a specific overall applicable system difficult, thus each combination of agroclimatic and cultural combination needs to be addressed individually.

- Gaps in research and education in Ethiopia:

    - gap in studying traditional agroforestry systems and the indigenous knowledge associated with it to identify its potentials and ways of improving the existing systems,

    - lack of in depth understanding of subjects related to agroforestry for example soil science, forestry, forest breeding and genetics – especially on indigenous species, crop husbandry, animal husbandry, soil and water conservation, water resources, and socio-economic of the country,

    - lack of appropriate teaching materials,

    - poor link between research and education, especially concerning researcher-extension-farmer links, and

    - lack of public awareness raising and information dissemination, especially lack of means to bring to the farmers and the public the findings in research

- Shortage of options of in technologies. These need research, education and training, extension, awareness, policy and institutions.

- Very few universities and institutions have formal linkage for support and information exchange in agroforestry.

- Lack of communication between the different governmental and non-governmental institutions involved in agroforestry research and education

- There is lack of a forum for the exchange of information and experiences on land husbandry activities out of with agroforestry is one.

- Need for trained human resources and proper utilization of all the available resources.

- Little attention being given to traditional existing systems, especially to indigenous species.

- Historical changes in land tenure and the repeated land distribution efforts having discouraged investment in land in the past and creating security problems at present.

- Poor extension practices and lack of trained manpower to work in extension activities.

- There are several technological and institutional issues that we need to address while working to promote agroforestry such as:

    - What do our farmers expect from interventions, and in how can we provide them with what they expect?

    - The word agroforestry is being heard in each and every development intervention. Is it the same agroforestry intervention that we are thinking of?

Some failures have been witnessed on much-publicised species such as *Leuceana* and *Sesbania*. Do we need to change our approach, and focus on indigenous species?

6. GAPS IN THE SCIENTIFIC KNOWLEDGE SO FAR ACCUMULATED

The science of agroforestry in Ethiopia is very new, and efforts to study it have been scattered and disorganised. The level of knowledge available is at best very rudimentary. A lot still needs to be studied in the following areas:

- The detail of indigenous agroforestry systems are not well analysed and documented,
- Exotic species promoted so far have not been well accepted, the reasons for this need to be studied. In addition there is need to focus on local species, especially ones used in agroforestry. Yet the different provenances and production potential of these local species has not been studied.
- The silviculture, management and specific environmental requirements of the local species have not been studied.

The basic information on fields related to agroforestry such as soil science, hydrology, socio-cultural studies, and economics needs to be built up.

7. CONCLUSIONS AND RECOMMENDATIONS AND FUTURE INTERVENTIONS

The study, promotion, and implementation of agroforestry in Ethiopia will help the country address two of its basic problems, environmental degradation and lack of food security. There is great potential and justification to start with implementing agroforestry. Interventions need to focus on the following areas:

a. Short term interventions:

1. Undertaking detailed analysis of the policy environment and recommending the building of a more conducive policy environment,
2. Starting to build up a scientific knowledge base on agroforestry and its related fields,
3. Establishing a network for flow of information both nationally and internationally,
4. Analyse the different indigenous agroforestry systems
5. Survey and identify representative sites within the different agroclimatic and cultural settings to undertake detailed studies on improving existing and introducing new agroforestry systems.
6. In each agroclimatic and cultural environment identify local species with potential to be used in agroforestry. Survey the country and surrounding environment to look for different provenances to start a breeding programme to fulfil the different agroforestry objectives (fast growth, fuel, fodder, … production). As a point of entry, a literature review done by the author is attached in the annex.

b. Medium term interventions:

1. Sensitise the government on policy problem areas and work for the development of a conducive policy environment.
2. Build on, promote and implement the agroclimate and culture adapted agroforestry systems. In this regard a lot of work will be needed in strengthening the extension system in Ethiopia.
3. Further work on the provenance screening and breeding on local species.
4. Publicise information obtained both nationally and internationally.
5. Evaluate the effectiveness of the different interventions and undertake changes where needed.

c. Long term interventions

1. Work on the promotion and implementation of the different findings of the long and medium term interventions.
2. Publicise the different findings of the different interventions.

Evaluate the effectiveness of the different interventions and undertake changes where needed.

REFERENCE:

Abu-Al-Futuh, J.M. (1983). *Balanaites aegyptiaca: an unutilised raw material potential ready for agro-inductrial exploitation.* United Nations Industrial Development Organaisation Report. TF/INT/77/021, Vienna, 100pp.

Adams, M.E. (1967). A study of the ecology of *Acacia mellifera, A. seyal* and *Balanites aegyptiaca* in relation to land clearing. *Journal of Applied Ecology,* **4**: 221-237.

Agrawal, R.K. (1980). Physico-chemical status of soils under Kherji (*Prosopis cineraria* Linn.) In: H.S. Mann, S.K. Saxena (eds.), *Kherji in the Indian Desert*, pp. 31-36. Monograhp No. 11, Jodhur, CAZRI.

Agrawala, V. (1989). *Forests in India*. 2nd ed. Oxford and IBH Publishing Co: India.

Amin, H.M. (1973). *Sudan Acacias*. Forest Research Institute Bull.No. 1. Information Department, Khartoum**.**

Anon. (1980). *Firewood crops: shrubs and tree species for energy production.* National Academy of Sciences, Washington. 232pp.

Anon (1992). Report of the Syamposium on environmental degradation. Prepared by the organizing comittee. 15-20 April, 1992, Meklle, Tigray, Ethiopia.

Anon (1994) Study on resin bearing trees in Tigray. Addis Consultancy House PLC (ADCOH), Addis Ababa, Ethiopia. 109 pp. Unpub.

Baumer, M. (1983). *Notes on trees and shrubs in semi-arid regions.* FAO, Rome. 270pp.

Baumer, M. (1990). *The Potential of agroforestry in combating desertification and environmetal deradation.* Technical centre for Agricultural and Rural Co-operation (CTA): The Netherlands. 250pp.

Beets, W.C. (1989). *The potential role of agroforestry in ACP countries.* Technical centre for Agricultural and Rural Co-operation (CTA): The Netherlands. 68pp.

Bekele Million and Berhanu Leykun (2001) State of Forest Genetic Resources in Ethiopia. *Forest Genetic Resources Working Papers*: The sub- regional workshop FAO/IPGRI/ICRAF on the conservation, management, sustainable utilization and enhancement of forest genetic resources in Sahelian and North-Sudanian Africa, Ouagadougou, Burkina Faso, 22-24 September 1998. FAO, IPGRI/SAFORGEN, DFSC and ICRAF

Booth, F.E.M. and Wickens, G.E. (1988). Non-timber use of selected arid zone trees and shrubs in Africa. *FAO Conservation Guide***, 19:** 18-27.

Booth, G.A (1952). The forest of the upper Nile province, 1862-1950. *Sudan note and records.* In: **Hall, J.B. and McAllan, A. (1993).** *Acacia seyal*: a monograph. School of Agricultural and Forest Sciences, University of Wales, Bangor, UK. 88pp.

Brandis, D. (1921). *Indian trees.* Constable and Co., London. 767pp.

Breitenbach, F. (1963). *The indigenous Trees of Ethiopia.* 2nd ed. Addis Ababa. 305pp.

Burley, J. (1985). *Global needs and problems of the collection, storage and distribution of multipurpose tree germplasm.* ICRAF, Nairobi, 179pp.

Burley, J. and Von Carlowitz, P. (1983). *Multipurpose tree germplasm.* Proceedings of a planning workshop to discuss international co-operation. Washjington DC, USA. 298pp.

Chadhokar, P.A. (1988). *Silvopastoral systems in soil conservation in Ethiopia.* Community Forests and Soil Conservation Development Department, Ministry of Agriculture. Addis Ababa (Unpub.).

Charreau, C. and Vidal, P. (1965). Influence del' Acacia albida sur le sol nutrition minérale et les rendements des mils penesetum au Sénégal. *Agron. Tropical*, **67:** pp. In: **Dancette, C. and Poulain, J. F. (1969).** Influence of *Acacia albida* on pedoclimatic factors and crop yield. *African Soils*, **14**: 143-181.

CSA (2001)

Dechassa & Perault (2001)

Dechasa, J. (1989). *Evaluation of crop yield under A. albida shade and alley cropping in Semi-arid farms.* Proceedings IAR/ICRAF National Agroforestry Workshop, IAR, Addis Ababa.

Doran, J.C., Turnbull, J.W., Boland, D.J. and Gunn, B.V. (1983). *Handbook on seeds of dyrzone Acacias.* FAO, Rome.

Dougain, F. (1960). Rapport de Mission du Niger. Centre de pedologie de hann-Dakar, 22pp. (mimeo). In **Gupta, R.K. (1993).** *Multipurpose trees for agroforestry and wasteland utilisation.* International Science Publishers, New York. 562 pp.

EFAP (1994)

Emiru Birhane (2002) Actual and Potential Contributions of Enclosures to Enhance Biodiversity in Drylands of Eastern Tigray, with Particular Emphasis on Woody Plants. SLU (Swedish University of Agricultural Sciences), Sweeden.

Ensermu et al (1992)

EPA 2000

FAO (1988). *Report of the mission to the Ethiopia on tropical forestry action plan*. Rome, FAO.

Felker, P. (1978). *State - of - the art: Acacia albida* as a complementary permanent intercrop with annual crops. University of California.

Felker, P. (1981). Uses of tree legumes in semi-arid regions. *Econmic Botany,* **35:** 174-186.

Forest Products Research Laboratory (1968). Report on two consignments of talh (*Acacia seyal*) from the Republic of Sudan. *Reports on Overseas Timbers,* **8:1-8.** Forest Research Laboratory, Princes Risborough. In: **Hall, J.B. and McAllan, A. (1993).** *Acacia seyal*: a monograph. School of Agricultural and Forest Sciences, University of Wales, Bangor, UK.88pp.

FRA (2000) Global Forest Cover Map, Working paper 19. Rome, Nov. 1999.

Fryrear, D.W. (1987). *Wind erosion mechanics / measurements / control.* Draft paper presented at the workshop on soil, water and crop management systems for rainfed agriculture in the Sudano-Sahelian Zone, January 11-16, 1986, Niamey, Niger.

Gammadid, I.D. (1989). Study of growth rates of *Acacia bussei* (Harmes) ex. Sjostedt in the Bay region of Somalia. *Commonwealth Forestry Review,* **68**: 27-34.

Getachew (2000)

George & Mutch (2001)

Giffard, P.L. (1974). L' arbre dans le paysage sénégalensis: sylviculture en zone tropicale séche. Centre Techmique Forestier Tropical, Dakar, 431 pp. In: **Hall, J.B. and McAllan, A. (1993).** *Acacia seyal*: a monograph. School of Agricultural and Forest Sciences, University of Wales, Bangor, UK. 88pp.

Glover, P.E., Glover, J. and Gwynne, M.D. (1962). Light rainfall and plant survival in East Africa II. Dry grassland vegetation. *Journal of Ecology,* **50**: 199-206.

Gosseye, P. (1980). Introdcution of browse plants in the SudanoSahelian zonw. In: H.N. Houérou (ed.), *Browse in Africa: the current state of knowledge.* International Livestock Centre for Africa, Addis Ababa, pp. 393-397.

Gupta, R.K. (1993). *Multipurpose trees for agroforestry and wasteland utilisation.* International Science Publishers, New York. 562 pp.

Habish, H.A. and Khairi, S.M. (1970). Nodulation of legumes in the Sudan: cross-inoculation groups and the associated Rhizobium strains. *Experimental Agriculture,* **4**: 227-234.

Hall, J.B. and McAllan, A. (1993). *Acacia seyal*: a monograph. School of Agricultural and Forest Sciences, University of Wales, Bangor, UK. 88pp.

Hall, J.B. and Walker, D.H. (1991). *Balanites aegyptiaca:* a monograph. Bangor: School of Agricultural and Forest Sciences, University of Wales. 65pp.

Hocking, D. (1993). *Trees for drylands.* Oxford and IBH Co.Pvt.Ltd. New Delhi. 370 pp.

Hunde, A. and Thulin, M. (1989). Mimosoideae. In: I. Hedgberg and S. Edwards (eds.), *Flora of Ethiopia*, Vol.III. Addis Ababa, Ethiopia, PP. 71-98.

Hurni 1988

ICRAF (1988). *Newsletter and agroforestry review,* No 24, Nairobi, Kenya.

ICRAF (1990) Agroforestry: Potentials and Research Needs for the Ethiopian Highlands No. 21. D.A. Hoekstra, E. Torquebiau, and Badege Bishaw (editors), ICRAF, Nairobi, Kenya.

Jama, B., Nair, P.K.R. and Kurirs, P.W. (1989). Comparative growth performance of some multipurpose trees and shrubs at Machakos, Kenya. *Agroforestry Systems,* **9**: 17-27.

Jansens, J. (1990). Landscape development scenarios for planning and implementing agroforestry: a case study in the semi-arid lands of eastern Kenya, In: W. Budd, I. Duthhart, L. Hardesty and F. Steiner (eds.). *Planning for Agroforestry*. Elseveir Science Pub. Co: New York, pp.267-277.

Jung, J. (1966). É tude de l' influence de l' Acacia albida Del. sur les processes microbiologiques dans le sol et sur leur variations saisonniéres. Centre ORSTROM, Dakar, 49 pp. In: **Gupta, R.K. (1993).** *Multipurpose trees for agroforestry and wasteland utilisation.* International Science Publishers, New York. 562 pp.

Jung, G. (1967). Influence de l' *Acacia albida* Del. sur la biologie des sols Dior. Internal Report, Office de la Recharche Scentifique et technique Outre-mer, Centre ORSTM de Dakar -Hann. In: **Gupta, R.K. (1993).** *Multipurpose trees for agroforestry and wasteland utilisation.* International Science Publishers, New York. 562 pp.

Kaul, O.N. (1963). A prilimenray silvical study on *A. tortilis. Indian Forester***, 89:** 46-57.

Kellman. M.C. (1979). Soil enrichment by neotropical savanna trees. *Journal of Ecology*, **67:** 565-577.

Kindeya (1995)

Kindeya Gebrehiwot (1997) Area enclosures as an approach in the management of dryland biodiversity: a case study in Tigray region, northern Ethiopia. Proceedings of the Workshop on management of Dryland Biodiversity. 30 July – 1 August, 1997, Nairobi, Kenya.

Kindeya Gebrehiwot (2003) Ecology and Management of *Boswellia papyrifera* (Del.) Hochst dry forests in Tigray, northern Ethiopia. George –August Universität, Göttingen.

Le Houérou, H.N. (1980a). Introduction: Backgroud and justification. In: H.N. Houérou (ed.), *Browse in Africa: the current state of knowledge.* International Livestock Centre for Africa, Addis Ababa, p.3.

Le Houérou, H.N. (1980b). Chemical composition and nutritive value of browse in West Africa. In: H.N. Houérou (ed.), *Browse in Africa: the current state of knowledge. International Livestock Centre for Africa*, Addis Ababa, pp 261-290.

Le Houérou, H.N. (1980c). Agroforestry techniques for the conservation and improvement of soil fertilty in arid and semi-arid zones. In: H.N. Houérou (ed.), *Browse in Africa: the current state of knowledge. International Livestock Centre for Africa*, Addis Ababa, PP.433-435.

Leach, G. and Mearns, R. (1988). *Beyond the fuelwood crisis: people, land and trees in Africa.* International Institute of Environment and Development. London, pp.309.

MacDicken, K. and Vergara, N. (1990). Introduction to agroforestry. In: K. MacDicken and N. Vergara (eds.). *Agroforestry: Classification and Management.* Willey: New York, pp.1-30.

Mannn, H.S. and Saxena, S.K. (eds) (1980). Kherji *(Prosopis cineraria)* in the Indian desert**-** its role in agroforestry. CAZRI Minograph II. Jodhur, India: CAZRI, 77pp.

Michelson, A., Nigatu Lisanework, Friis, I.B. (1993). Impacts of tree plantations in the Ethiopia highlands on soil fertility, shoot and root growth, nutrient utilisation and mycorrhizal colonisation. *Forest Ecology and Management*, **61**: 299-324.

Miehe, S. (1986). *A. albida* and other multipurpose trees and shrubs on the Darfar farmlands in the Jebel Mara highlands, Western Darjar, Sudan. *Agroforestry Systems*, **4**: 89-119.

Mitiku Haile and Kindeya Gebrehiwot (1997) Opportunities and constraints for afforestation in Tigray: the case study of Dega Tembien. Paper presented at the 13^{th} International Ethiopian Studies, 13-14 Dec. 1997, Tokyo, Kyoto, Japan.

Mitiku Haile and Kindeya Gebrehiwot (2001). Local initiatives for planning sustainable natural resource management in Tigray, northern Ethiopia. *Ethiopian Journal of Natural Resources*, vol.3 (2) pp. 303-326.

Muthana, K. D. and Arora, G.D. (1973). *Study of Acacia tortilis: a fast growing tree species for Arid zone.* XI forestry Confererncе; Forestry Research Institute, Dehra Dun.

Nair, P.K.R. (1984). *Soil productivity aspects of agroforestry*, ICRAF, Sceince and Practice of Agroforestry No. 1. Nairobi, Kenya.

Nair, P.K.R., Fernandes, E.C.M. and Wambugu, P.N. (1984). Multipurpose leguminous tree and shrubs for agrofrestry. *Agroforestry Systems*, 2: 145-163.

Nair, P.K. (1990). Classification of agroforestry systems. In: K. MacDicken and N. Vergara (eds.). *Agroforestry: Classification and Management.* Willey: New York, pp. 31-57.

NASA (1979). *Tropical legumes: Resources for future.* National Academy of Sciences, Washington, USA, 331pp.

Newcombe, K. (1987). An economic justification for rural afforestation: The case of Ethiopia. *Annals of Regional Science*, **21**: 80-99.

Paddon, A.R. and Satti, K.M.O. (1986). *Charcoal and stove workshop.* A practical trianing course on the use of non-traditional methods of charcoal making and the manufacture of improved charcoal stoves. *FAP Fuelwood Development for Energy in the Sudan Project Field Document*, **24**: 1-26.

Palgrave, K.C. (1981). *Trees of Southern Africa.* CapeTown, South.Africa, 955pp.

Palmberg, C. (1983). FAO project on genetic resources of arid and semi-arid zone improvement of the rural living. Report on progress. For. Gen. Res. Inform., FAO, Rome, **12**:32-35.

Parkash, R. and Hocking, D. (1985). *Some favourite tree for fuel and fodder*. Society fo Promotion of Wastelands Development; Internationjal Book Distributors, Dehra Dun, India.

Piot, J. (1980). Management and utilisation methods for ligenous forages: natural stands and artificial plantations. In: H.N. Houérou (ed.), *Browse in Africa: the current state of knowledge*. International Livestock Centre for Africa, Addis Ababa, pp. 339-349.

Porteres, R. (1954). The improvement of agricultural economy in Senegal. *African Soils*, **3:** 13-51.

Poschen, P. (1986). An evaluation of the *Acacia albida*- based agroforestry practices in the Hararghe highlands of eastern Ethiopia. *Agroforestry Systems*, **4**: 129-143.

Radwanski, S.A. and Wickens, G.E. (1967). The ecology of *Acacia albida* on mantle soils in Zalingei, Jebel Marra, Sudan. *Journal of Applied Ecology*, **4**: 569-579.

Raintree, J. (1990). Theory and Practice of Agroforestry: diagnosis and design. In: K. Macdicken and N. Vergara(eds.), *Agroforestry: Classification and Management.* Wiley: New York, pp. 58-97.

Ramakrishna, Y. and Shastri, A. (1977). Micro-climate under *Acacia tortilis* Plantation. CAZRI Annual Progress Report. 1977, pp. 69-70; CAZRI, Jodhpur.

Rao, M., Sharma, M., and Ong, C.K. (1990). A study of the potential of hedgerow intercropping in semi-arid India using a two-way systematic design. *Agroforestry Systems*, **11:** 243-258.

Reed, J.D., Soller, H. and Woodward, A. (1990). Fodder tree and straw diets for sheep: intake, growth, digestibility and the effects of phenolics on nitrogen utilisation. *Animal Feed Science and Technology,* **30**: 39-50.

Rocheleau, D., Weber, F. and Field-Juma, A. (1988). *Agroforestry in Dryland Africa.* ICRAF: Kenya. 311pp.

Ross, J.H. (1979). A conspectus of the African Acacia species, *Memories of the botanical survey of South Africa*, No. 34. Pritoria

Saka, A.R., Bunderson, W.T., Itimu. O.A., Phombeya, H.S.K., and Mbekeani, Y. (1994). The effects of *Acacia albida* on soils and maize grain yields under small holder farm conditions in Malawi. *Forest Ecology and Management,* **64:**217-230.

Sands, M. (1989). Balanaitaceae. In: I. Hedgeberg and S. Edwards (eds.), *Flora of Ethiopia.* Vol. 3. The National Herbarium, AAU, Addis Ababa, Ethiopa, pp.433-436.

Schoch, P. G. (1966). Influence sue l' évaporation potentielle d'une strate arborée au sénégal et conséquences agronomiques. *Agron. Trop.* 21:1283-1290. In: **Wickens, G.E. (1969).** A study of Acacia albida Del. Mimosoideae. *Kew Bulletin* **23**:181 - 200.

Sebsebe (1993)

Shankaranarayan, K.A. and Harsh, L.W. (1986). *Agroforestry in the arid zones of India.* Contribution No. 22 of the series of agroforestry system descriptions under ICRAF's agroforestry system project (USAID), pp.1-22.

Shankaranarayan, K.A., Harsh, L.W.and Lathju, S. (1987). Agroforestry in arid zones of India. *Agroforestry Systems,* **5:** 69-88.

Sharma, S. and Tiagi, B. (1979). *Flora of North Easten Rajasthan*. Kalyani Publishers, New Delhi.

Sharma, B.D. and Gupta, I.C. (1989). Effect of trees cover on soil fertility in Western Rajasthan. *Indian Forester*, **115**:348-354.

Sharrock, C. (1981). A note on the *in vitro* dry matter digestibility determination of mixed herbage and browse samples collected with oesphalgeal fistulated steers. *Journal of Agricultural Science,* **98**: 483-485.

Sheikh, M.I. and Khaligue, A. (1982). Effects of tree belts on the yield of agricultural crops. *Pakistan Journal of Forestry,* **32**: 21-23.

Sinclair, F.L., Verinumbe, I. and Hall, J.B. (1994). The role of tree domestication in agroforestry. In: Leakey, R.R.B. and Newton, A. (eds.), *Tropical trees: the potential for domestication and the rebuilding of forest resources.* HMSO, London, pp 124-136.

Sinclair, F.L., Verinumbe, I., Retallick, S.J. and Adderley, P. (1992). The effect of leaf trimming, stem length and hormone treatment on the rooting of stem cuttings of *Acacia seyal* Del. In: *Vegetative propgation and seedling studies of tree species with potential for domestication and use of in dryland agroforestry.* Report of glasshouse experimentation in ODA Project Contract R4181. pp. 20-28. School of Agricultural and Forest Sciences, University of Wales, Bangor.

Singh. M.P., Jain, B.P., Srivastava, J.L. and Trivedi, R.N. (1991). *Nitrogen fixing and multipurpose tree species for afforestation.* Recent Researches in Ecology, Environment and Pollution - 7. Today and Tomorrow's Printers and Publishers. New Delhi. 279pp.

Skoupy, I. (1991) The role of trees in agroforetry. *Desertification Control Bulletin,* No. 9, pp. 38-35.

Snolnozi, T.W. (1985). *Food and Fruit trees of the Gambia.* Stifung Walderhafung in Afrilka/ Bundesforschung-sanstalt fur Forst-und Holzwirtschaft, Hamburg, 132pp. In :**Hall, J.B. and Walker, D.H. (1991).** *Balanites aegyptiaca:* a monograph. Bangor: School of Agricultural and Forest Sciences, University of Wales. 67pp.

TBNRDEP (1994). *Field assessement on development of agroforestry system in Tigray region* (unpub.). Tigray Bureau of Natural Resources Development and Protection, Mekele, Ethiopia.

Teel, W. (1954). *A pocket directrory of trees and shrubs in Kenya.* Kenys Non-governmental Organisation, Nairobi, 151pp. In Hall and Walker

Tesfaye Abebe (1994). Growth performance of some multipurpose trees and shrubs in the semi-arid areas of Southern Ethiopia. *Agroforestry Systems,* **26:** 237-248.

Tewolde (1989)

Tolsma, D.J., Ernst, W.H.O., Verweij, R.A. and Vooijs, R. (1987). Seasonal variation of nutrient concentrations in semi-arid savanna ecosystem in Botswana. Journal of Ecology, **75:** 755-70.

Toutin, B. (1980). The role of browse plants in animal production in the Sudanian zone of West Africa. In: H.N. Houérou (ed.), *Browse in Africa: the current state of knowledge.* International Livestock Centre for Africa, Addis Ababa, pp 261-289.

UN (1997)

Vandenbeldt, R. (1990). Agroforestry in the semi-arid tropics. In: K. Macdicken and N. Vergara (eds.), *Agroforestry: Classification and Management*. Wiley: New York, pp. 150-194.

Verinumbe, I. (1993). Soil and *Leucaena leucocephala* L. groeth variability under *Faidherbia albidaDel.* and *Ziziphus spina-cristi*. *Agroforestry Systems*, 21: 287-292.

Virginia, R.A. (1986) Soil development under legume tree canopies. *Forest Ecology and Management***, 16**:69-79.

Vollesen, K. (1989). Rhamnaceae. I. Hedgeberg and S. Edwards (eds.), *Flora of Ethiopia.* Vol. 3. The National Herbarium, AAU, Addis Ababa, Ethiopa, pp. 395-396.

Von Carlowitz, P.G. (1991) Multipurpose trees and shrubs: sources of seeds and inoculants. ICRAF: Nairobi. 328pp.

Von Maydell (1990). *Trees and shrubs of the Sahel: their characterstics and uses.* Verglaf Josef Margraf Sceintfic books, Germany. 525 pp.

Wanyancha, T.M., Mills, W.R., Gwaze, D.P. (1994). Genetic variation in *Acacia albida (Faidherbia albida)* and its agroforestry potential in Zimbabwe. Forest and Ecology management, 64: 127-134.

WIC (2002)

Wickens, G.E. (1969). A study of Acacia albida Del. Mimosoideae. *Kew Bulletin* **23:**181-200.

Wiersum, K. (1984). Surface erosion under various systems. In: C.L. O` Loughlin and A.J. Pearce (eds.), *Symposium of Effects of Forest Land Use on Erosion and Slope Stability*. Honolulu, Hawaii, USA: East-West Centre, pp. 231-239.

Wilkinson, G.E. and Ania, P.O. (1976). Infiltration of water into Nigerian soils under secondary forest and subsequent arable cropping. *Geoderma,* **15**: 51-59.

Wilson, K.B. (1989). Trees in fields in southern Zimbabwe. *Journal of Southern African Studies***, 15:** 369-383.

Young, A. (1989). *Agroforestry for Soil Conservation.* CAB International, UK