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## 1.0 GENERAL INTRODUCTION

### 1.1 The Dryland Environments of East and Southern Africa

The dryland environments in Eastern and Southern Africa and indeed in most of Africa, carry a variety of vegetation types with different growth habits and constitute vastly different proportions by area, of the various nations they occur in. On a continental scale, some attempts have been made by botanists to classify the dryland vegetation types of Africa (White, 1983) but this is made difficult by several factors, one of which is that such efforts have not been concerted. Hence, books on the flora of Southern Africa such as that of Palgrave (1983) will describe vegetation in the southern region without making reference to similar formations or to common or related species in East, Central and even West Africa. The dry regions are nonetheless generally characterised by an imbalance between precipitation and evapotranspiration. Hence, aridity is generally measured on the basis of an Index (UNESCO 1977) derived from the ratio of precipitation (P) to evapotranspiration (ETP). A ratio  $(P/ETP)$  of 0.03 is hyper-arid,  $0.03 < P/ETP < 0.20$  arid,  $0.20 < P/ETP < 0.50$  semi-arid and  $0.50 < P/ETP < 0.75$  is sub-humid. Except in the hyper-arid zones, the index does not necessarily predict vegetation type, growth habit and association because other factors such as temperature regimes including frost, drainage, other land use practices and population pressures come into play.

In eastern Africa, particularly Kenya and Somalia, dryland vegetation range from woodlands where trees can reach 15 metres in height and sometimes 20 meters in riverine systems, to hyper arid conditions with just a few shrubs in sight and more dense shrubs only occurring along seasonal river-beds and gulleys. In Tanzania, and in some parts of Zambia, Zimbabwe and Malawi one gets Miombo Woodlands with their characteristic indicator species of *Brachystegia* and *Julbernardia*. In South-Western Zambia, S-Eastern Zimbabwe and in the Northern parts of Namibia and Botswana occur different tree vegetation types growing in the often reddish Kalahari Sands, dominated by two commercially important tree species; *Baikiaea plurijuga* and *Pterocarpus angolensis*, in addition to other tree species such as *Burkea africana*, *Guibourtia colophosperma*, *Ricinodendron rautatennii* *Terminalia sericeae* and *Lonchocarpus nelsii*. In the flat water-logged and clayey soils almost pure stands of another traditionally important species namely; *Colophospermum mopane* (Mopane) can be found.

The dependence of humans and livestock on the woody and other vegetation in the dry lands, their interactions and resultant effects on the environment, is a phenomenon that is often not given due consideration even though this dependence represents a significant departure from classical forest practice. In these systems, the reduction or increase of livestock populations not to mention man-made changes can have significant ecological effects in the often fragile ASAL environment. Traditional land use practices include activities such as Extensive Pastoralism, limited riverine cultivation, some rainfed cropping in the alluvial floodplains and other areas receiving between 500 - 1000mm of rainfall per annum. The crops tend to be drought tolerant pulses such as pigeon peas, cow peas and quick maturing varieties of millet and sorghum.

It should also be appreciated that traditional systems of vegetation management have existed or do actually exist in most arid environments. However their institutional basis is often quite weak and not respected or adopted by policy and law in modern governments. This has made them easy to violate and vulnerable to socio-economic changes brought about by such factors such as immigration, wars, overexploitation by immigrants or short term traders. In recent years, traditional land use patterns are changing as a result of various factors

Among these, the rapid development without proper foundation of cash economies in much of Africa has been really disruptive especially to the people of the dry areas who generally practice extensive pastoralism which as both a cultural and economic activity. For some of them livestock rearing for purely commercial purposes is not an easily adopted practice. In certain areas with potentials for rain fed cropping, new permanent to semi-permanent settlement by land cultivators is replacing the nomadic systems of extensive pastoralism on the range. In addition, the sheer chronic lack of alternatives for income generation by shrinking African Economies leaves no options for rural people other than the exploitation of the natural resources which is often fiercely competitive, uncontrolled and inevitably leads to resource depletion.

Population increases brought about by immigration by land settlers, urban aggregations and land alienation; often by state proclamation have caused both widespread and localised degradation of natural resources. In fact, land

privatisation which leads to practices such as fragmentation and fencing have reduced free ranging of livestock and even cut "game corridors" or "migration routes" thus causing problems such as overgrazing, crop raiding by game and the displacement of small scale pastoralists. All these coupled with drought has made populations poorer.

In most African countries, electricity is often too expensive for the majority of urban dwellers to use for cooking. This situation is exacerbated by the routine mismanagement of government-owned energy companies and run by people appointed more for political allegiance rather than by their management acumen or economic prudence. It turns out that the demand for energy in urban areas has often led to mainly localised and sometimes extensive deforestation for charcoal production or for the supply of raw fuel wood. Furthermore, the technically inefficient conversion or carbonization techniques often employed in charcoal production, lead to wastage of available wood and means that larger areas than necessary are cut regardless of available more efficient technology. It is also an irony that much of the deforestation in the arid and semi-arid regions for fuel wood supply is for consumption in the more enlightened but still relatively poor urban populations in high potential areas, rather than the arid regions themselves.

Lack of incentives to manage tree vegetation is yet another factor which often leads to degradation. For this reason, it is worth pointing out that there should be programmes which by their very nature will encourage the sustainable management of tree vegetation especially along the rivers on floodplains and on upland areas which provide grazing and harbour harvestable volumes of vegetation.

## **1.2 The Status of Dryland Forestry Programmes in East and Southern African Countries - A Brief Overview.**

In most of the eastern and southern African regions, dryland forestry is usually a special case often lagging behind industrial plantation forestry for a number of reasons starting from colonial legacies to the very legitimate needs of a number of countries for industrial timber and for a significant but informal manufacturing wood-based industry. It is therefore quite common to find that the management of indigenous forests or woodlands which is outside the mainstream of industrial forestry has largely been ignored or received little or no government support. Dryland forestry which for the most part depends on the management of natural vegetation rather than the creation of plantations has therefore lagged behind plantation forestry and the situation has so far not changed despite recent policy changes in Kenya, Tanzania, Malawi, Zimbabwe with respect to the management of their natural forests in the arid and semi-arid regions.

Countries such as Namibia and Botswana whose environments did not permit economically viable industrial plantations and therefore would have been expected to lead in the scientific management of dryland vegetation unfortunately still not leaders in dryland management. This is because of a colonial legacy which never invested in vegetation management but concentrated on mining and cattle ranching and the exploitation of highly valuable timber species in the dry woodlands without due regard to management for proper renewability. It can however be expected they will, given time, be leaders in the management of dryland forests. It is reassuring that the forest policies and some programmes of countries such as Zimbabwe, Botswana, Namibia and Malawi favour the management of natural forests.

The widespread and traditional system of extensive pastoralism in sparsely populated Botswana can be said to be an ecologically sound practice in the arid country even though localised cases of overgrazing, stocking and fodder provision in lean years have to be planned for. It is also interesting that the traditional villages in Botswana in which people congregate has tended to limit the move towards land fragmentation which would destroy expansive grazing grounds necessary in arid range. It also makes it easier for the government to provide central services and roads. It is however quite important that forests for energy and amenity near the villages must be given special attention. The promotion of non-timber forest products especially traditional medicines is rapidly gaining popularity and recognition. This is quite positive therefore, policies and legislation to manage these resources sustainably ought to be rearticulated.

Despite current efforts in dryland forestry, a number of features call for attention. The wise, planned and systematic use of fire in forest or range management is still largely lacking. Furthermore, in all these arid areas, the development of industrial gums and resins, medicines and other non-wood or non-timber products still needs a lot of work. Even from a purely forestry viewpoint, formalised management regimes for dryland natural forests has not been properly established. In this regard, recent resource assessment projects in Botswana, Zimbabwe and the impending one for Namibia are noteworthy especially if they are aimed at being the forerunner to management planning and the control

of exploitation. Another common gap is the lack of "issues searching" techniques for serious policy analysis to advice governments and associated with this is that guidelines for substantive community participation in management and the drawing of responsibilities have yet to be made in most of the arid countries.

The role of non-governmental organisations in mobilising dry land communities to manage their resources sustainably by way of institutionalising the harvesting of non-timber resources and by trying to influence government policy to make them more sensitive to local needs, ought to be built upon. Some of the issues such as land tenure or ownership rights as they affect the use or abuse of natural resources must be seriously revisited.

## 2.0 DRYLAND FORESTRY IN KENYA

The arid and semi-arid lands of Kenya are estimated to cover some 80 - 88 % of the total land area and by carrying one quarter of her population and 60% of her livestock it can no longer be ignored in national development planning. Using the classification of aridity by UNESCO (1977), the ASAL Districts of Kenya can be divided into four major agroecological zones from zone IV to VI in order of increasing aridity.

The physical and demographic factors which have affected the ASAL environment in Kenya are many. Among these, frequent droughts such as the 7-year drought of 1974-1981 is notable. There have also been population changes in some areas chiefly by way of immigration by land searching populations from the crop-cultivating cultures of the densely populated high potential areas. Associated with this have been the gradual displacement of pastoralists, the conversion to cultivation agriculture and the disenfranchisement of pastoralists who have lost their livestock in droughts and or land. The increased availability of central services such as education, health, water and veterinary care has lead to sedentarisation of a large number of these pastoral societies. Areas surrounding the settlements have been severely overgrazed and other associated resources such as water and woody vegetation unsustainably exploited resulting in severe environmental degradation. These factors have bred land use conflicts which have been exacerbated by until recently, lack of policy guidelines on ASAL management. Without such guidelines, the interests of the increasingly poor pastoral communities can easily be overlooked with their further impoverisation.

## 2.0 WOODY VEGETATION IN THE ASALS AND CURRENT MANAGEMENT.

The woody vegetation of the arid and semi-arid lands (ASALS) of Kenya range from riverine forests, dry woodlands, to high elevation evergreen to semi-evergreen forests, woodlands or bush. In the vast woodlands, the vegetation can vary from dry woodland to semi-desert dwarf shrub land, stunted deciduous bushland, deciduous bushland to grasslands, depending on physical conditions of the soil, moisture and even elevation. For purposes of forest practice, emphasis is put on the riverine forests, the open to semi-open woodlands, bushlands or thickets and evergreen to semi-evergreen bushlands or woodlands occurring within dryland zones but usually at high elevations. These are important for survival in the dry lands (Barrow 1987, Gachathi 1993). The classification of vegetation given below has been adopted largely from three publications by Amunyuzu (1988), Herlocker (1992) and White (1983.)

### 2.1 Riverine Forests

Riverine forests are exemplified by those occurring on the Turkwell, Kerio and Tarach river systems in Turkana District while in the eastern half of Kenya are the Tana, Athi, Galana, Uaso Nyiro and Voi river systems.

On the Tana, Galana and Uaso Nyiro rivers, the forest vegetation forms a three-storied vertical structure. The dominant canopy measures some 15-20 m in height and provides from 40 to 60 % ground cover. Tree species such as *Acacia elatior*, *Acacia robusta* (*A. clavigera*), *Populus ilicifolia*, *Trichillia emetica* (*T. roka*), *Newtonia hildebrandtii*, *Garcinia livingstonei* and *Diospyros mespiliformis* occupy the top canopy. The middle canopy has *Spirostachys verenifera*, *Kigelia africana*, *Tamarindus indica*, *Mimusops fructicosa*, *Sorindea madagascariensis* and *Ficus sycomorus*. Along the Voi River in Tsavo East, the dominant tree species include *Acacia robusta* subsp. *usambarensis* (*A. clavigera*), *Albizia glaberima*, *A. zimmermannii*, *Ficus sycomorus*, *F. ingens*, *Kigelia Africana*, *Newtonia hildebrandtii*, *Tamarindus indica* and *T. sambesiaca*. In Turkana district, the dominant riverine tree species include *Acacia tortilis*, *A. elatior*, *A. mellifera*, *Cordia sinensis*, *Hyphaena coriacea*, *Salvadora persica*. *Hypheana coriacea* (the doum palm) becomes more dominant; accounting for more than 60 % of total cover along the Kerio and Turkwell rivers. Upstream, *A. tortilis* accounts for more than 50% of total vegetation cover. Other important species include *Mauria oblongifolia*, *Indigofera spinosa* and *Acacia albida*.

The riverine vegetation is crucial for **dry season grazing** in all of the ASAL districts of Kenya and is connected with the often wildlife-rich transition zone between itself and the relatively dry more open woodlands. The proper management of these zones are therefore necessary and important for traditional pastoralism, ecosystem conservation and wildlife tourism. Traditional management exists in Turkana and to a lesser extent, among the Rendille on the eastern shores of Lake Turkana. The Turkana have developed a system of "tree ownership" or "user" rights by way of a system which allocates segments of vegetation along their major rivers; Turkwel, Kerio and Tarach which are conservatively managed for grazing, fruits, fuelwood gathering and even cultivation. This system is known as "Ekwar" (Barrow, 1987). In addition to these, there are communities who still keep livestock but are also sedentary riverine crop cultivators along the Turkwell, Kerio, Tana and Ewaso Nyiro rivers. To such cultivators, a cash economy may destroy the traditional and environmentally-friendly methods of cultivation and should therefore be assisted to adopt appropriate farming practices.

The "Ekwar" of the Turkana demonstrates that "ownership" is an important factor for resource conservation and use. Ekwar owners recognise the need to sustainably manage their trees, hence hardly any vegetation resources are depleted despite introduced forces which have led to numerous cases of land degradation in other areas of the ASALS. The felling of live trees is rare, not encouraged and instead, only dead trees are harvested for fuel wood and charcoal making. Government projects must recognise these systems and the traditional leadership and decision-making systems which underpin it.

With respect to cultivation, intercropping trees with smaller crops should be encouraged. The upper tree canopy, shelters the smaller crops from excessive heat and provides microclimate amelioration which protects soil from excessive evaporation. In West and East Africa, we have *Acacia (Faidherbia) albida* - Millet configuration used whereas in the Sudan, *Acacia senegal* -Millet is preferred and in the Mediterranean regions Olive grove-cereal configuration is practised. Should there be need for tree cutting, high stumping is recommended as it is likely to stimulate coppicing which aids in restoring soil cover. It is noteworthy that experiments with stumping heights have been initiated in West Pokot. High stumping is a well used system in some parts of Southern Sudan (Sharland, 1991). In addition, windbreaks and shelterbelts should be incorporated into cropping systems for their useful biological effects on an environment by increasing biological diversity and aid bee-keeping, pole and even timber production. Crop production in these areas can be improved by as much as 30% (Ben Salem, 1991).

Some afforestation is possible along the river but must be geared more towards fodder, fuel wood and fruit needs than timber. Advantage should be taken of floodwater (Kowsar, 1992), furrow irrigation and microcatchment possibilities in tree planting. Species such as *Acacia albida*, *A. tortilis*, *Zizyphus mauritiana*, citrus fruits, mangoes, bananas could be grown intercropped with agricultural crops.

Burning along the riverine must be strictly controlled for it can depending on several conditions, adversely affect livestock fodder and regeneration potential. Ordinarily it is one of those arid land ecosystems that have the highest regeneration potential (Oba, 1990).

## 2.2 Stunted Deciduous Bushland, Bushlands Woodlands and Thickets

The stunted deciduous bushland type is intermediate between bushland and shrubland. The woody cover is formed by *A. reficiens*, *A. mellifera* and *Commiphora spp.* *A. mellifera* tends to be restricted to the wetter sites and can be killed by prolonged droughts like the 1974 - 1981 drought which hit North and Northeastern Kenya. *Commiphora* prefers the shallow but well drained sites. Other species include *A. senegal*, *A. nubica*, *Calotropis procera* and *Balanites orbicularis*. *A. nubica* is common on degraded lands just as *C. procera*, being pioneer species, though *C. procera* also grows on newly deposited alluvium. *B. orbicularis* is not a pioneer species but its predominance tends to indicate degradation since it is normally spared for its edible fruits when other species are being cut.

Deciduous bushlands are taller than both the semi-desert shrubland and the stunted deciduous bushland, has scattered short trees as represented in Marsabit District on the rocky slopes of Nyiru, Ol Doinyo Mara and Ndotu mountains at elevations of 665 to 1335m and also on the lava derived soils on Mt. Kulal. The dominant species are *A. mellifera*, *A. reficiens*, *A. senegal*, *A. tortilis*, *Balanites aegyptica* and *Commiphora spp.*

Woodlands are carry tree vegetation standing at heights of 5-15m with a dwarf shrub understory. These woodlands

occur at high elevations and also on low-lying sandy alluvial soils and on seasonal floodplains. The upland woodlands have *Combretum molle*, *A. etbaica*, *A. nilotica subsp. subalata*, *A. drepanolobium*, *A. seyal* and *A. tortilis*. *Combretum* is dominant on the wetter sites and below 1000m, *A. tortilis* is dominant. The understory woody vegetation is mainly *Duosperma eremophilum* and *Indigofera spinosa* while *Leptothrium senegalense* is a perennial grass.

An alternative form of classification based on the temporal spectral characteristics from satellite imagery taken over a whole year to show phenological changes (Ryan and Openshaw 1991), recognises types described as Dry Acacia - Commiphora Bushland and Thicket (Class 41), Moist - Acacia Commiphora Bushland and Thicket (Class 43) and the Acacia Woodland Mosaics (Class 51). The type denoted by Class 41 appears to cover both the stunted and deciduous bushland types discussed above. These two types cover about 36 % of Kenya's total land area (214,312 km<sup>2</sup>). The Moist Acacia - Commiphora Bushland and Thickets cover 6.5 % or 38,836 km<sup>2</sup> of Kenya and the Acacia Woodland Mosaics cover some 3.4 % of Kenya.

The woodland areas can be quite extensive and carry biomass which, under a planned and careful exploitation, can yield substantial amounts of fuel wood and charcoal on a sustained yield basis. A number of the woodland species are also quite hardy and are capable of coppicing after cutting, browsing and even burning. The coppicing ability after disturbance and the recently observed rates of bush encroachment in former grass pastures has revealed a vegetation productivity that was hitherto ignored or underestimated (Herlocker 1992).

In Kenya the majority of fuel wood or charcoal to the urban areas come from the ASALS. Charcoal is produced quite inefficiently (Gathaara, 1992), thus a lot more wood is cut than would be the case if the best technology were applied. Such harvesting should be based on reliable resource assessment techniques. It is possible to assess available fuel wood but one also needs biomass equations to be able to set estimates of allowable cut. Such has been tried in woodlands in Bura in Kenya (Pukkala 1993). Efforts outside Kenya include Hellden (1987) in Ethiopia and Chidumayo (1988) and Stromgard (1985) in Zambia.

Their management is based on a system of extensive and migratory grazing or browsing and the collection of fuel wood and poles for construction work. To improve pastures, some cutting or burning of woody species are used. However, there have been little or no attempts at a planned harvesting for fuel wood or charcoal making, pasture improvement, degraded hillsides are not collectively protected for purposes of natural recovery. Management must address the needs for the natural vegetation by planned and controlled harvesting, protection of young natural regeneration when necessary and the protection of sites already degraded or in danger of degradation. Some knowledge on the dynamics and the responses of particular vegetation types to continuous browsing, wildfires and clearing is an interesting and crucial research area. Systems of Deferred Grazing to manage range is a practical issue.

### 2.3 Evergreen and Semi-evergreen Bushland

These are restricted to the upper elevations such as the Hurri Hills and Mt. Kulal. The vegetation comprises of *Carrisa edulis*, *Dovyalis abyssinica*, *Euclea racemosa*, *Grewia spp.*, *Olea africana*, *Pappea capensis*, *Pisatacia lentiscus*, *Rhamnus sp.*, *Rhus vulgaris*, *Teclea simplicifolia* and *Turea mobassana*. *Juniperous procera* occurs on disturbed sites.

At lower elevations Aloes and Euphorbias and scattered deciduous species such as *A. etbaica* predominate. Fire and overgrazing leads to the predominance of *Dicanthium insculptum*, *Themeda triandra* grassland and further degradation leads to the occurrence of unpalatable vegetation such as *Eragrostis tenuifolia*, *Chenopodium spp.* and *Solanum incanum*. When protected from fire, the grasslands are invaded by *Ocinum spp.*, *Pavonia urens*, *Lippia ukambensis* and it eventually reverts to bushland. This is one of the interesting vegetation succession studies reported from the ASALS.

### 2.4 Evergreen Forest and Scrub Forest (High Elevation or Mist Forests)

These forest formations occur on the caps of mountains in the ASALS and are in themselves, interesting unique "islands" surrounded by desert. These mountain tops is where rainfall is higher, have more extensive cloud cover and the potential evapotranspiration is much lower than in the plains (White 1983). Since rainfall amounts range between 800 to 1000 mm only, the explanation for the occurrence of such high rainfall forests suggests the interception of

moisture from clouds and mists. Hence these forests have been termed "Mist Forests" by some authors.

The mountains and associated species are as follows:

! Loima Hills, Turkana - *J.procera*, *Lawsonia inermis* floristic community. Other species include *Combretum molle*, *Tamarix nilotica*, *Vangueria apiculata*, *Rhamnus staddo*. In the upper and drier slopes, bushlands of *Euphorbia nyikae* and *Pappea capensis* occur associated with *Commiphora africana*, *Tamarix nilotica*, *Ormocarpum trichocarpum*, *Plectranthus igniarius* and *Eragrostis spp.* In the lower and drier slopes, soils change and the floristic tree community is dominated by *Acacia senegal*, *A. tortilis* and *C. africana*.

! Mt. Kulal (Summit 2335M), Mt. Marsabit, in Marsabit District - The top are dominated by *J.procera* a fire induced pioneer and at lower altitudes, 9-10 M scrub forest with *Olea capensis*, *O. africana*, *Diospyros abbyssinica*, *Teclea simplicifolia* and *Strychnos mitis* are the major species. Further up and in sheltered places a 15 - 20 M canopy of *Cassipourea congoensis*, *D. abbyssinica* and *O. capensis* develops.

! On Karissa Hills, Ndoto and Oldoinyo Lenkiyo (Mathews) Ranges and Mt. Nyiru, Samburu District - *Juniperus procera*, *Podocarpus falcatus* (*P. gracilior*), *Olea africana* and *Croton megalocarpus* are dominant. Burning the evergreen forest yields an evergreen bushland dominated mostly by shrubs such as *Carissa edulis*, *Euclea divinorum*, *Rhus natalensis* and *J. procera* and *O. africana*. Trees grow up to 15m and shrubs reach 5 M and providing about 5 % and 20-25% of the cover respectively. The grass *Themeda triandra* constitutes 55% of the ground cover.

Their importance in dry season grazing and conservation value should be considered in management. The use of fire should be carefully studied as repeated use transforms the cedar forests into bushland thickets no good for grazing or pole production. Being mountains surrounded by desert, their geographical isolation may lead to interesting developments of land races and provenances useful for future genetic work on these valuable tree species and for conservation and biodiversity purposes.

## 2.5 Discussion

It is clear that the management of the riverine and high elevation forests and natural woodlands are the key issues other than afforestation. Despite this some afforestation can be done where possible, using species such as; *A. tortilis*, *A. senegal*, *A. elatior*, *A. robusta*, *A. nilotica*, *H. coriacea*, *Z. mauritiana*, *Melia volkensii*, *T. brownii*, *T. spinosa*, *T. brevipes*, *T. pruinooides*, *C. sinensis*, *Delonix elata*

The problems of afforestation using indigenous species should be looked into in view of the value of maintaining the ecologically adaptable indigenous species. However such efforts are likely to be confronted by problems associated with, seed viability, dormancy and flowering periodicity (Milimo, 1987). In most African *Acacias*, hot water soaking and boiling generally improves germination. However, a number of species such as *Cadaba rotundifolia*, *Boscia coriacea*, *Sterculia stenocarpa*, *H. coriacea*, *Populus ilicifolia* and *M. volkensii* have exhibited germination problems (Milimo, 1987). To complement regeneration by seed, methods of vegetative propagation including micropropagation should be explored and where possible, be made operative to overcome seed related problems. Furthermore, exotic dryland species should be used where appropriate. It is noteworthy that the two species of *Prosopis*; *P. juliflora* and *P. chilensis* have shown lots of promise in Tana and Turkana Districts respectively. It demonstrated that the species could be used to provide fuel wood to the local populations and reduce the cutting pressure on the ecologically valuable riverine vegetation (Pukkala, 1993).

As a special case for the promotion of the industrial uses of dryland vegetation, the management of *A. senegal* stands is of special interest. *Acacia senegal* or the "gum arabica" tree or shrub thrives in some of the drier and rockier parts of Turkana District. It occurs naturally and sometimes in almost pure stands from Kakuma down to Lokichar in Southern Turkana then stretches to the east to Marsabit and Isiolo Districts. It is however in Isiolo where some organised management of this species has been started (Parantai, 1993). The tree produces a valuable gum with the potential of providing an alternative cash income. It is used in the food industry as a stabiliser and emulsifier, in pharmaceuticals as a coating agent, in lithographic printing and variously in textiles, cosmetics and paints. In addition to *A. senegal*, other species such those of *Boswellia* and *Commiphora* have valuable oleoresins and gums which have commercial potential. The interest on gum arabic should be extended to such species which are naturally hardy and can be easily propagated. Species of *Commiphora* are propagated quite easily by vegetative means and for this reason

they are used as live fences.

### 3.0 DRYLAND FORESTRY IN NAMIBIA

Namibia, a country in South Western Africa with a total land area of 830,000 Km<sup>2</sup> and a population of 1.5 million people is the most sparsely populated but also the driest of the southern african states. Formal forestry began in the early 20th Century but these early efforts virtually collapsed under changing colonial governments. This changed in 1990 with the creation of a Directorate of Forestry with a new mandate to look beyond the white-owned commercial ranches covering most of the savannas in the central parts of the country, into the mostly northern and southern communal lands bearing 70% of the population on merely 25 - 30 % of the land area. Since then, the first formal national forest policy was approved by cabinet in 1992 and the old forest ordinances and act of 1952 and 1968 respectively are currently under active review with a new draft legislation is expected by the end of 1996. The notable major strategies of the 1992 policy document include:

- (a) promotion of community participation in forest management through a system of incentives,
- (b) revision of the policy and legislative framework to provide for community participation in forestry, joint management of forests between government and communities, community rights and revenue sharing. Also, aspects of trade in wood and wood-products from, public, communal and private farms will given special attention,
- (c) the protection and management of forests on communal or trust lands will be clearly defined and mutually agreed upon or recognised by government and communities,
- (c) to assess and compile the quantity and quality of the available forest resources in the northern part of the country,
- (d) harmonization of policies and regulations with those of related ministries or institutions such as wildlife, agriculture & water affairs.
- (e) support for agro-forestry through strong policy guidelines and laws requiring minimum tree cover in the most threatened or fragile cultivated areas,
- (f) provision of adequate funding, staffing and training for the Directorate of Forestry.

A number of factors which have a significant impact on forestry development in Namibia are the social problems such as poverty, population growth, traditional land ownership systems, traditions and culture and lack of knowledge and participation local communities in forest management.

Poverty obtaining in many rural communities has increased the possibility that forest resources would be subject to indiscriminate exploitation for fuel wood, fruits, livestock fodder and cultivation. The fact that more than 60 per cent of the population still live in rural areas and primarily engaged in agriculture and that the annual rates of population growth at 3% in these areas far exceeds the rates of local economic growth has led to a *shortage of available land for cultivation*. Environmental degradation and rising unemployment is a now a reality in the communal areas. As a result, the traditional systems of conservative use of natural resources have broken down. Therefore, *communities must be encouraged to manage forests that grow in their vicinity*.

Problems of an institutional nature affecting the directorate of forestry include, shortage of trained nationals, an underdeveloped forestry infrastructure. Related to this is an outdated legislation does not match with the changed social-economic circumstances and the new emphasis on agroforestry, social and community forestry and the enhancement of community participation. However, recent advances in legislation are noteworthy.

The new legislation which started with a well attended "issues searching" and "public sensitisation" inception workshop basically set the agenda for the legislative process. The issues ranged from the need to have protected areas to conserve representative forest types to legal empowerment of communities to actively involve in forest management. The workshop agreed upon and endorsed the concept of "linking rights" of forest use to communities to "responsibilities" for the sustainable management of forests as a major driving principle worthy of enshrinement in

law.

However before giving a brief overview on current forestry practice, it is important to give a description of the major vegetation types of Namibia with special emphasis on tree vegetation.

### 3.1 An overview of Namibia's forest sector today

As has been described earlier, it is clear that the management of forests in Namibia must contend with her harsh biophysical conditions in addition to its political and demographic history. Since the country is largely arid or semi-arid as has been described, pastoralism or cattle ranching as a system of production occupies a large portion of the country's total area. In the north and north-eastern parts of the country, settled cultivation also takes place. In addition to several riverine or mountain forests in other parts of Namibia, it is mostly the north eastern region where extensive forests and open woodlands exist. In the southern parts of the country, extensive scrubland dominate with livestock ranching as the traditional and viable form of production. Far from what would be expected of a forest industry, large plantations requiring neat sustained-yield management regimes are virtually absent. All the same, the local populace still uses forests for a variety of purposes such as; timber for joinery, carving, traditional implements, poles for construction, fuel and so-called "Veld Products". At present, emphasis must be necessarily put on the management of forest and woodland formations for the sustainable supply of the above products and services. Forest management must also recognise and take into account, the importance of the woody vegetation of Namibia in livestock production, soil and water conservation (Agriculture), tourism and wildlife management, ecosystem conservation and the conservation of biological diversity.

The tree vegetation which occurs in semi-closed forests, other forms of woodlands and wooded thornbush savannas support a relatively small local timber industry. Logging is done by a selection system from the Ohangwena, Okavango, Tsumkwe and Caprivi regions in the north and north-eastern parts of Namibia. The principal tree species are *P. angolensis* (Kiaat), *B. plurijuga* (Zambezi Teak), *B. africana* and *G. colophosperma* (False Mopane). The allowable cut in the timber concessions in Okavango, Kanovlei and Caprivi regions are 8,000, 900 and 500 cubic metres of sawn timber per year. It is important at this point to note that the allowable cut figures for the above concessions are not based on any inventory of the total growing stock and that no authoritative figures on growth increment of the commercial species exist. The sawn timber is sold locally in addition to the traditional markets in South Africa. Some wood is also consumed by an expanding local carving industry but the annual volumes of wood involved has not been estimated.

The majority of utility timber for construction and general joinery are imported mainly from South Africa and recently from Zambia. Records of quantities imported are kept by the Ministry of Trade and Industry or the Central Statistical Office. In addition to the commercial timber species, dead roots of *C. mopane* (Mopane) and *O. paniculosa* (resin bush) have been harvested for export to South Africa where they are sand blasted to produce a relatively smooth surface and exported mainly to European destinations for domestic ornamentation. The Directorate of Forestry has stepped in to stop this exportation of unprocessed forest and woodland produce in late 1994, and before then it is estimated that up to 120 metric tonnes per month of these roots were exported. In 1994, The Directorate has encouraged companies to establish in Namibia to create local employment and add value to the products and export directly to external markets. Another aspect of wood utilisation is based on thorn bush which encroaches on to commercial and communal pastures. The woody species involved is mainly *A. mellifera* or sickle bush. The produce is exported to South Africa as firewood or converted into charcoal which is mainly exported to Europe. Only negligible amounts are sold locally. Many important traditional non-timber forest products have not been officially accounted for in this report for the mere lack of data on their demand and supply but there are plans for documentation.

Despite the apparent importance of forest products in the economy of Namibia, forest practice was virtually dormant for at least half a century till the creation of the Directorate of Forestry in its current form in 1990. This new organisation operates within a statement of mission; "to play a leading role in forestry by practising and promoting activities aimed at the sustainable management of forests and other woody vegetation to supply various products and services to meet the basic and industrial needs of Namibians in a manner that is economically sustainable and maintains or enhances the other environmental and conservation functions of trees and other woody vegetation".

### 3.2 THE VEGETATION TYPES OF NAMIBIA.



The vegetation or flora of Namibia has been the subject of much scientific curiosity because of some unique regions of endemism in areas such as the Waterberg Plateau in the central part of the country and in the north and central Namib Desert along the west coast. The Namib carries quite interesting desert species (Giess 1968, 1969 and 1971, Kers 1967, Logan 1960, Breitenbach 1968). From a forestry viewpoint, the paper by Giess (1971) is a phenomenal attempt at the botanical mapping of the flora of Namibia. Giess (1971) recognised three groupings namely Desert (1), Savanna (2) and Woodlands (3) which constitute 16, 64 and 20 % of Namibia's land area respectively. These three major groups are divided on the basis of rainfall, temperature and characteristic vegetation though rainfall seems to be the driving force. The desert, savanna and woodland types are further subdivided into 5 (1A - 1E), 8 (2A - 2H) and 2 (Savanna Woodland and Riverine Woodland) subdivisions respectively.

### 3.2.1 Deserts

The desert vegetation types are probably not important from a forestry perspective but it is important to mention their botanical importance and the support to other forms of life, mainly wildlife and livestock. The five subdivisions are the northern (1A), central (1B) and southern namib (1C); the desert and succulent steppe (1D) and the saline Desert with Dwarf shrub Savanna Fringe around the Etosha Pan (1E). The Namib forms a belt along the west coast of Namibia from the orange river in the south to the Kunene River by the Angolan border. In the Northern Namib *Balanites welwitschii* is common in the river beds as a shrub and grasses include

*Eragrostis cercoides*, *Stipagrostis* spp and *Kaokochloa nigrirostis*. The Central Namib has hummock colonised with *Zagophyllum clavatum*, *Psilocaulon salicornoides* and *Salsola* species. *Acacia reficiens* occurs as a shrub and white annual grasses, *Stipagrostis* are common. The unique and famous primitive conifer *Welwitschii mirabilis* occurs in the Central Namib from the Kuiseb River to the Angolan Border in the North. The Desert and Succulent Steppe covers the winter rainfall area in the southern coastal region. The saline desert with dwarf savanna fringe are found around the Etosha Pan, a famous National Game Park. *Acacia nebrownii*, *Monechma tonsum*, *M. genistifolium*, *Leucospora bainesii*, *Petalidium engleranum* and *Salsola tuberculata*. A Mopane savanna occurs on the southern side and a transitional savanna woodland on the eastern side with *Terminalia prunoides*, *Acacia* spp. and *Lonchocarpus nelsii*.

### 3.2.2 Savannas

The Savannas are subdivided into, Mopanne Savanna (2A), Mountain Savanna (2B), Thornsbush Savanna(2C), Semi-desert and Savanna transition (2D) Highland Savanna(2E Central Mountain Region), Camelthorn Savanna (2E Central Kalahari) and Mixed Tree and Shrub Savanna (2G Southern Kalahari) and Dwarf Shrub Savanna (2H).

The Semi-desert and Savanna Transition, Dwarf Shrub Savanna and Mopane Savannas in the Eastern Part and the Southern Parts of the country are floristically interesting but contain mainly shrubs which support important populations of grazers and browsers; livestock and game. The **Semi-desert and savanna transition** which borders the Namib Desert to the east carries several endemic species such as *Euphorbia guerichiana*, *Cyphostema* spp and *Moringa ovalifolia* and two species of *Acacia*; *A. montis-ustii* and *A. robysiana*. From Brandberg to southern Kaokoveld is found *Acacia senegal* subsp. *rostrata* and *A. tortilis* subsp. *heterocantha*. Several species of *Commiphora*; *C. virginata*, *C. Saxicola*, *C. anarcadrdifolia*, *C. glaucascens* and others also occur here.

In the **Mopane Savanna**, the species *Colophospermum mopane* occurs as a shrub and towards the Namib Desert, it grows together with *Balanites welwitschii* in a 50-100 mm rainfall zone. In the higher rainfall zones receiving 500 - 600mm toward Grootfontein and Owambo in Northern Namibia, species of *Sosamonthamus* and *Commiphora* (*C. africana*, *C. anarcadrdifolia*, *C. crenato-serrata*, *C. discolor*, *C. mollis* and plants in the family *Acanthecea* occur. It is noteworthy that *C. mopane* turns into a larger and larger tree toward the 500 - 1000 mm rainfall areas to the north and north-east up to Caprivi.

The **Dwarf Shrub Savannas** in the south carry interesting shrub vegetation species such as *Parkinsonia africana*, *Acacia nebrownii*, *Boscia foetida*, *A. karoo*, *A. erioloba* and *Tamarix usneoides* are also found here. The Mountain Savanna in the Tsumeb area are characterised by tree species such as *Kirkia acuminata*, *Berchemia discolor*, *Croton gratissimus*, *Cyphostema*, *M. ovalifolia*, *Olea africana*. Flats between the mountains carry species such as *Combretum apiculatum*, *Dicrostachys cinerea*, *Croton* and *Acacia* shrubs. Tree species in the flats include important ones such as *Sclerocarya birrea*, *Spirostachys africana*, *Ficus cordata*, *Combretum imberbe* and on the sandveld are

! There is much scope for indigenous fruit production.

! There is definitely a place for the application of modern scientific techniques or tools for research in dryland systems. In this regard a special case of biotechnology should be made.

! A number of problems of degradation of forests and woodlands cannot be solved by forestry practice alone and that **policies and incentives** that promote industrial uses and other cash-generating opportunities must come to play.

! The case for policy development for dryland development requires **economic techniques of valuation** or quantification of benefits that can demonstrate to policy makers why public spending in research and practical natural resource management projects are important. One major issue to be seriously considered is ability of foresters to articulate these uses to politicians from the point of view that such programmes promote the stabilisation of rural communities through income generation; a major and cross-cutting national development objective relevant in most of Africa.

! In a number of cases, there exist **traditional leadership systems** which govern the allocation and rights to resource use which is often quite conservative but whose sustainability have been destroyed by recent events. Within these leadership systems **gender roles and relationships** have a bearing on resource management.

! It is essential to bring dryland **forestry into the political arena** as a development issue common to most African Countries. It is probably going to solve half of the problem.

## 5.0 THE CHALLENGES OF FORESTRY PRACTICE IN DRYLAND SYSTEMS

The above cross-cutting issues can be presented as challenges as enumerated below:

- (1) The description both culturally and scientifically of dryland systems in order to obtain baseline socio-economic and bio-physical data for management planning.
- (2) The use of the data so gathered for attempts at the sustainable management of the woody vegetation for the supply of the traditional products and services and augment existing management techniques with appropriate research.
- (3) To place forestry and vegetation management as a major component in land use planning in an attempt to control unplanned deforestation or exploitation and provide for the other services such as fuel wood, fodder and ecosystem and gene conservation.
- (4) To institute a system to regularly monitor the status of dryland woody vegetation with a view to sensitizing communities and working together with them to recognize indicators of environmental degradation, resource depletion and be able to deal with or call for remedies.
- (5) To promote chiefly by research, activities which will increase the tangible and non-tangible values of maintaining tree vegetation
- (6) To promote the Social and Cultural Uses of Dryland Forests
- (7) To set policy guidelines to back up dryland development taking into consideration, the need to accommodate socio-cultural needs and practices and at the same time instill the virtues of responsible environmental governance. Prohibitive legislation is still quite common.

## 6.0 RESEARCH NEEDS

The pertinent research programmes can be derived from the above mentioned and described cross-cutting issues and the above enumerated challenges. It is also quite interesting to note that, the issues are quite similar in most of the arid

countries.

In order to back up several possible research programmes in the dry lands, baseline data such as the mapping and quantification of important resources is crucial. Systems of resource assessment for dry lands should therefore be adopted where technology is available. It is evident that satellite imagery is an indispensable tool in dry land resource assessment studies and countries must test which technologies and techniques of image processing and interpretation would suit their needs. Early warning systems on range quality using NOAA satellites is already in use in Namibia and its application to fire behaviour in the dry forests is currently being explored. This is very much in line with Kenya's Rangeland Ecological Monitoring Unit.

With respect to the important riverine ecosystems described herein, several research programmes or projects can be envisaged.

! Research on riverine intercropping systems is needed along the Uaso Nyiro and Tana River Systems in Kenya and on the Okavango, Zambezi, Kwando and Orange rivers is crucial. Tree crops cover should particularly be restored along the Kavango and Zambezi provided that such trees will contribute to food security.

! Trials using floodwater spreading and furrow irrigation combined with different agroforestry designs using the important indigenous fruit and fodder trees is a clear necessity.

Where cropping is not traditional like along the rivers in Namibia's namib desert and along much of the Turkana and the Turkwell Rivers in Kenya, studies of the vegetation ecology should be done with a view to understanding the reproductive behaviour of major species, their responses to fire, browsing and coppicing capacity. This of course be coupled with autecological studies of chosen species.

The question of seed related problems with several dry land *Acacias* and other species such as species of *Terminalia*, *Pterocarpus angolensis*, *Melia volkensii*, *Populus ilicifolia* and fruit trees such as *Dobera glabra*, *Salvadora persicae*, *Cordia sinensis* and many others which show dormancy and viability problems, naturally require seed collection, extraction and pretreatment research coupled with techniques for vegetative propagation which should include modern methods of micropropagation.

It has now been widely accepted that tree planting as a dominant form of management in the ASALS is impractical. This means that research should aim at ways of enhancing the natural processes of regeneration and development. Research should also be directed toward the supply of wood energy and on special products such as gums, resins, fruits and medicines. Some of these are briefly described in the following paragraphs.

Concerted efforts to carry out research on the growth or biomass yields of important tree species. Such growth studies should be based on different sites since some of these trees such as *A. tortilis*, *A. mellifera* and *A. reficiens* and *A. erioloba* can be widely distributed. Biomass equations could be derived for these species to be used in the estimation of wood fuel stocks, exploitation levels and policy decisions. Other examples are *A. nilotica*, *A. elatior*, *A. albida*, *Combretum* and *Commiphora spp.*

The current research efforts on *Acacia senegal* in Kenya should be strengthened and diversified to include biotechnological methods in selection and breeding and techniques of regeneration. Biotechnological methods should also be applied to threatened species such as *Populus ilicifolia*. The same efforts are needed to develop a gum industry based on *Acacia karoo* in Namibia.

The management of dry woodlands for timber, poles, grazing, wildlife and other non-timber products such as industrial gums, resins ought to be strengthened. Today there are no formal management regimes for the timber concession areas in Namibia *Baikea - Pterocarpus* and even *Mopane* Woodlands despite their importance. There is no information on regeneration treatment of stands, cutting cycles and proper allowable cut calculations. Namibia's current efforts to quantify stocks of Mopane Roots and on Mopane Woodland Management Research are commendable. Non-timber forest products are important in the informal sector but some such as traditional medicines, bee-keeping and industrial gums and resins ought to be developed with a view to increasing the value of maintaining the integrity of dry land vegetation.

### **The Importance of Biotechnological Techniques in Dryland Forestry Research.**

A number of growth or agronomic traits or characteristics have been shown to be genetically controlled and that it is important to select for and even develop the desired ones. In this respect the potential utility of biotechnology is important as a technique to identify, preserve, modify and utilise plant traits. The available techniques range from basic tree micropropagation to genetic transformation of trees to express desired traits or characters.

It is important in the arid areas that plant biodiversity be maintained and also enhanced. It is quite possible that cases of overgrazing and soil erosion and other processes of land degradation may lead to the extinction of certain species. Such germplasm can be stored in the form of tissues through freeze drying or cryopreservation (Burley 1989), through the production of artificial seed (Bapat and Rao, 1988). Through this, ASAL species which frequently have recalcitrant seeds or have dormancy problems leading to germination failures can be stored and regenerated at the desired time. Another advantage is that this practice can be used to store many genotypes of a species which is clonally propagated because such species risk genetic erosion.

In the dry areas, a number of fodder, fruit, fuel wood and medicinal tree species especially within the riverine or riparian ecosystems quickly come to mind. Practical applications include the selection of *Acacia senegal* and *A. karoo* which produce **gum arabica** used in the cosmetic and pharmaceutical industries of the west.

The effective collection and utilization of valuable germplasm of such species require fast and reliable methods of identifying and characterizing them (Gudu and Kojwang 1993). Several methods are in use for identification and characterization of plant germplasm. These techniques utilize morphological, cytological, biochemical and molecular variations inherent in the germplasm. In the dry lands however, there are erratic weather conditions which may drastically affect phenotypic expression of some morphological traits, one would require selection methods which are phenotypically neutral, free of environmental and epistatic influences. The methods should provide numerous genetic markers capable of tagging all the available agronomic traits even at seedling stage because this might speed up selection process in tree breeding programs. These reasons justify the application of molecular techniques for the often important need for characterisation. Molecular techniques which have been used for characterization of plant germplasm include restriction fragment length polymorphisms (RFLPs), random amplified polymorphic DNA (RAPD) and tandem variable repeats (Williams et al., 1990, Frohman, 1990)

The random amplified polymorphic DNA (RAPD) method is preferred over RFLPs since it is rapid, precise and a large number of samples can be evaluated simultaneously to identify useful molecular markers for agronomic traits. Only small samples are taken for DNA analysis because it is sensitive (Gudu et al., 1992). Besides, it is versatile and can utilize even crude DNA samples from leaves, roots or seeds thereby allowing screening at early stages in plant development. The RAPD technique provides numerous molecular markers. It does not require specialized laboratories and highly skilled personnel to operate. Owing to its simplicity and modest operational cost, it may be a method of choice for developing countries. In this respect marked genotypes can be used in genetic improvement. Along with this, "anther culture techniques" can also be attempted to produce haploid individuals which can be used to make specific crosses for maximum heterosis for gum production. Salt and drought tolerance are traits which can be similarly be screened for possible germplasm use and improvement.

Furthermore, biological nitrogen-fixation in agroforestry could benefit from advances in biotechnology. In some agroforestry trees and in agronomic crops the inoculation of plants with specific strains of nitrogen-fixing *Rhizobia* bacteria is a well known and practised way of improving crop production and also maintaining and improving soil fertility. A most recent possibility is in the actual process of nitrogen-fixation itself. The fixation process is a reversible reaction in which the forward reaction leads to fixation whereas the reverse reaction fixes oxygen. Scientists are looking for ways of genetically engineering, probably by mutagenesis, to block the reverse reaction. The result will be an increased yield of fixed nitrogen with its obvious advantages.

From these examples and many others, the need for the application of biotechnological techniques in dryland research especially for countries such as Namibia, Botswana and Kenya not to mention the Sahelian belt is obvious.

### **Socio-Economic Research**

In view of the coming to prominence of non-timber forest products, it is essential to develop or apply economic techniques of analysing the economics of their use. In addition to this, it is important to conduct research on management regimes that will promote their sustainable utilisation, taking care that other values are not obliterated in the process. In fact, one of the difficult issues is to convincingly demonstrate to politicians by economic means, to invest in the development of non-timber forest products, because relevant economic tools and valuation techniques are not well developed.

Alongside bio-physical research, social and policy research concerning resource management and use is important. As of today, there is a lot of rhetoric regarding the involvement of communities in natural resource management. However, proponents have to find out what policy and legal means will be necessary in each socio-political setting to get communities to link their "rights to resource use", to their obligations to responsible management. Such research is quite important.

There is also an urgent need for policy research on issues such as land tenure systems, diversification of economic activities in the ASALS, planned grazing to conserve range quality, just to mention a few areas.

## 7 SUMMARY

Forests or woodlands in the dry or arid and semi-arid regions of Africa are an important economic resource on which a large number of African human populations depend for their basic needs. In addition, it carries a large proportion of livestock and game which are crucial to food security and the valuable tourism industry. However issues such as government policies, socio-political and demographic changes have led to cases of severe degradation in some of these regions putting a number of people at risk. Furthermore, forestry or any other form of organised vegetation management for multiple benefits has been given little more than "lip service" by most countries and supportive policies, incentives and even laws guiding their development have been largely lacking.

A brief look at the woody vegetation reveals crucial riverine forests, woodlands and high elevation forests whose ecological characteristics are still poorly understood and could easily be destroyed. The need to understand these systems with a view to increasing the value of dryland vegetation is clearly needed. The potential for the industrial development of timber and non-timber products such as ornaments, gums, resins and valuable fruits and medicines is still largely untapped. In the endeavour to develop these resources, the application of traditional scientific tools and the recent advances in areas such as biotechnology must be brought into the picture. A system for regular monitoring of these resources to guard against destruction is also an imperative.

The development of economic methods for resource valuation to aid in policy making, the setting up of policy analysis systems and "issues searching" and the empowerment of communities to responsibly participate in resource management are paradigms which require new approaches to socio-economic research. The question on traditional leadership systems and gender relations with respect to the management of natural resources should be areas of research for "application" rather than the generation of research theses.

Countries like Kenya, Somalia, Tanzania, Namibia and Botswana should share their experiences in the management of dry lands since a number of socio-economic and scientific issues or gaps, are cross-cutting.

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