An overview on the distributions, status, uses and research needs of selected indigenous tree and shrub species in the Highlands of Ethiopia

Deribe Gurmu Benti

Forestry Research Center, EIAR, P.O.Box: 30708, Addis Abeba Ethiopia.
Email: deribe12@yahoo.com

Abstract

Available literatures indicate that the history of the Ethiopian forest is intimately associated with the domestication of agricultural crops and expansion of agriculture that started ca. 5000 years ago. During the "green age" the Ethiopian highlands were almost completely covered by high forests of various types and densities with a cover percentage of approximately 35-40% of the total area. It is stated that with the inclusion of the savanna woodlands, some 66% of the country was endowed with forest and woodland until the late 1800's.These forest resources comprised the natural high forests, with trees of *Podocarpus*, *Croton*, *Olea*, *Schefflera*, *Hagenia*, *Pouteria*, *Aningeria adolfi-friederici* at higher altitudes. The lowland woodlands included species of *Acacia*, *Boswellia*, *Commiphora*, *Balanites*, *Euphorbia*, *Combretum* and *Croton*. The mountain woodlands consisted of *Acacia abyssinica*, *Hagenia abyssinica*, *Protea*, *Erica arborea*, *Hypericum* and poor stands of *Juniperus prococera*, as well as the bushlands, shrublands and wooded grasslands representing woody vegetation types. It is also documented that in the early 1950's 16% of the landmass was forest land. However, in the early 1980's the coverage was reported to be 3.6%. By 1989 it was estimated to be only 2.7%. Some five million hectares of savanna woodlands remained, giving a total forest and woodland area of about 7.5 %. The loss of forest resources is severe in the Ethiopian highlands (1500m). Today, remnants of these forests are seen only in the south and southwestern part of the country and around churches, where, by tradition, the trees are not cut. Despite the destruction, forests and forest products will continue to be central to the households' economy, as well as to food security and health through a number of traditional practices in the years to come. It is reported that currently, the entire rural population and the majority of the urban households rely on forest resources for their energy needs. The National Energy Balance for 1989/90 also accounted for about 88% of the total energy consumed coming from forest products, with rural households sharing about 93%. Between the years 1981/82-1991/92 alone, forestry accounted for about 5.5% of the agricultural sector and 2.5% of the total GDP. Forestry industry employment amounted to about 2.2% of the total workforce and contributed 2.8% to employment in the agricultural sector in 1988/89. The cycles of events of forest destruction are many, but most of them are initiated by the rapid growth of population. With the current rate of forest destruction (200,000 ha on average) the remaining forests will be removed within 15-20 years and with them the valuable trees/shrubs and the soil, unless the destruction is abated through good forest management supported by a multidisciplinary research approach.

1. Introduction

Breitenbach (1963) describes the vegetation types of Ethiopia as mountain steppes, mountain-savannahs, mountain woodlands, highland-forests, lowland woodlands, lowland savannahs and lowland steppes. Sebsebe and Edwards (2006) identify these vegetation cover types as afroalpine and sub-afroalpine, dry evergreen montane forests and grassland complex, moist evergreen montane forest, evergreen scrub, *Combretum-terminalia* woodland and savannah, *Acacia-commiphora* woodland, lowland semi-evergreen forest, desert and semi-desert scrubland. FAO (2000) identifies them as shrubland, shrubland/grassland, savannah, deciduous broadleaf forests, deciduous needle leaf forest, evergreen broadleaf forest, evergreen needle leaf forest and mixed forest. The current trend is to broadly classify these vegetation types as: natural high forests (both heavily disturbed and undisturbed), lowland woodlands, bushlands, shrublands, wooded grasslands, plantations and trees on farm (EFAP 1994).

The natural high forests are recognised as those lands covered by a closed stand of trees with a more or less continuous canopy rising 7-30m, and a sparse ground cover of few grasses. Lowland woodlands are areas covered by an open stand of trees taller than 5m and up to 20m in height and a canopy cover of more than 20%. Bushlands are lands covered by an open stand of trees and / or taller shrubs of 2-5m and a canopy cover of more than 20%. Shrublands and wooded grasslands represent a variety of woody vegetation types (Melaku 2003, Demel 2004). The geobotanical maps and the surface cover equations developed by each descriptor and the approaches to the description of the vegetation types deserve their own respective academic merits. The aim of this presentation, however, is not to rate these merits, but rather to provide an overview of the distributions, status, uses and research needs of some selected indigenous tree and shrub species in the highlands of Ethiopia, based on the mix of the information generated by these descriptors.

2. Vegetation distribution

2.1. Closed broadleaved forests

The closed broadleaved moist forests of the south-west correspond to the “humid lower highland forests” and the “humid upper highland forests” mentioned by von Breitenbach. They are found only in the most humid parts of the south-west central Ethiopian plateau where the annual rainfall is more than 1400mm and sometimes exceeds 2000mm, with a fairly uniform distribution throughout the whole year and only one or two dry months. The temperature is relatively warm, since the altitude rarely exceeds 2500m. Some smaller blocks of this type also occur in the southern Rift Valley.

High density and a great variety of species characterise broadleaved moist forests. The dominant storey is rather open, the large trees being mostly scattered, growing to heights of 40 to 45m with branchy canopies often standing out in isolation. The most frequent and characteristic species are *Syzygium guineense*, *Cordia africana*, *Olea spp.*, *Mimusops kummel*, *Ficus* spp, *Manilkara butugi*, *Aningeria* spp, *Pouteria ferruginea*, *Albizia schimperiana*, *Morus mesozygia*, *Bosqueia phoberos* and *Clausenopsis angolensis*. Beneath is a much denser middle storey with a closed canopy 15 to 25m high. The prominent species are *Eckebergia rueppelliana*, *Bersama abyssinica*, *Apodytes acutifolia*, *Croton macrostachys*, *Schefflera abyssinica*, *Polyscias ferruginea*, *Erythrina abyssinica* and *Prunus africana*. The understorey, composed of shrubby trees and bush, is relatively dense, comprised of *Galiniera coffeoides*, *Cyathea manniana*, *Coffea arabica* and *Randia malleifera*. The herbaceous ground cover is rich in ferns. The trees of the middle storey carry numerous lianas, such as *Landolphia*

spp., epiphytes, principally mosses and ferns, are very abundant and sometimes cover entire trunks. Some boles have a magnificent shape and size, but many are twisted, with buttresses high up on the trunk or with large, low branches. Big trees are very scattered and considerable area is stocked with specimens of small diameter and poor growth that can be explained, without doubt, by earlier forest clearings.

Broadleaved semi-humid highland forests are well represented in semi-humid regions at altitudes from 1700m to 2500m, forming the lower and upper portions of the coniferous forests they enclose. While the upper storey reaches heights of 25 to 35m at lower elevations, frequent devastation and climatological and edaphic factors limit heights in the upper highlands to 10 to 20m. Cold northern and eastern exposures are characterised by *Celtis kraussiana*, *Sideroxylon oxyacantha*, *Prunus africana* and *Olea* spp in the dominant canopy while intermediate and lower storeys are occupied by *Trema guineensis*, *Bersama abyssinica*, *Catha edulis* and *Vernonia amygdalina*. Prominent members of the upper storey in warm southern and western exposures are *Polyscias ferruginea*, *Galliniera coffeoides*, *Prunus africana* and *Croton macrostachys*. Only the lower highland type possesses an intermediate storey composed of *Albizia isenbergiana*, *Ficus* spp, *Euphorbia candelabrum* and many others. The relatively dense understorey consists mainly of shrubs and small trees (*Maesa lanceolata*, *Lobelia gibberoa*). In the transition zone with the coniferous forests occasional *Podocarpus gracilior* or *Juniperus procera* can be found emerging above the broadleaved upper canopy.

The dense Acacia forests are the sole forest type of the semi-arid highlands between 1800 and 2500m and are prevalent in southern and western exposures. The comparatively poor habit is produced by the absence of an upper storey of big trees. The sparse, broken canopy formed by the spreading flat crowns of the dominant *Acacia xiphocarpa* is only 15 to 25m high (10 to 20m in the upper parts). Under this canopy a lower storey of small trees and big shrubs develops with species such as *Cassia didymobotrya*, *Dombeya multiflora, Maytenus senegalensis*, *Osyris abyssinica*, *Harrisonia abyssinica*, *Olea africana*, *Schrebera alata* and *Vernonia amygdalina*. The forest floor is scarcely covered. Trunks and branches of the higher trees are densely clothed with lichens, ferns and climbers.

The mountain woodlands extend from 2400 to 3400m altitude. Their physiognomy is very similar to that of the lowland woodlands and upper canopy formed by trees 5 to 12m high above a thicket of shrubs 1.5 m high. Poor specimens of *Juniperus procera* occur on all sites. On dry, stony and rocky mountain slopes *Protea gaguedi* is characteristic, accompanied by small- and medium-sized trees and shrubs of *Acacia abyssinica*, *Erica arborea*, *Rhus vulgaris* and *Pittosporum abyssinicum*. Semi-humid southern and western exposures show a relatively high frequency of the already mentioned *Juniperus procera* mixed with *Cussonia holstii*, *Maytenus ovata*, *Heeria insignis* and many other tall shrubs and medium-sized trees. The same conditions on eastern and northern exposures sometimes lead to almost pure stands of *Hagenia abyssinica*, the latter accompanied by *Olinia usambarensis*, *Dombeya* spp, *Ilex mitis* and the bamboo *Arundinaria alpina*.

The mountain savannas lie at very high altitude above the zone of the mountain woodlands. While their upper limits are, in drier regions, situated around 3500m, they are able, in more humid regions, to extend up to 4000m. Their lower limits are blurred on account of extensive land clearing and grazing in the area of the mountain woodland and upper highland forests where, on abandoned cultivation and pastures, they spread as secondary vegetation. Thus, this formation, originally

confined to comparatively small areas at very high altitude, occupies now the major part of the Ethiopian Plateau. Its secondary character, however, is easily recognizable by remnants of the former forest or woodland, such as *Acacia xiphocarpa*, *Juniperus procera*, *Hagenia abyssinica*, *Olea europaea*, *Apodytes dimidiata*. A blanket of tufted *Cyperaceae* and *Gramineae* covers these vast savannas, interrupted and dotted with isolated specimens or scattered groups of shrubs and small trees. The so-called semi-arid shrub savanna has large but broken thickets of *Erica arborea*, accompanied by some crooked *Protea gaguedi*, *Hypericum lanceolatum*, *Rhus vulgaris*, *Acacia abyssinica* and *Rosa abyssinica*. Of less arid aspect, the shrub-savanna is characterized by isolated or small groups of small trees and tall shrubs of *Erica arborea*, *Acacia abyssinica*, *Hypericum lanceolatum*, *Echinops steudneri* and *Hypericum* spp., while the more humid tree-savanna is usually marked by trees and shrubs of *Olinia usambarensis*, *Argauria salicifolia*, *Philippia trimera*, *Cassipourea malosana* and *Maytenus undatus*. Toward the upper limits of the mountain savanna, on alpine plateaus, stands of more or less scattered tall specimens of *Lobelia rhynchopetalum* can be found.

2.2. Closed coniferous

The Juniperus forests formerly covered wide areas of the high plateaus of Ethiopia. Cultivation, grazing and fires, as well as exploitation have progressively taken their toll and today only remnants exist, for the most part localised in Central Ethiopia, on the eastern escarpments of the plateau and on the upper slopes of the north-western side of the Arsi-Bali plateau. They generally grow at high elevations (2500 to 3200m) in areas where the climate is relatively cold and sometimes very dry. Some blocks are found at lower altitudes, between 1800 and 2000m, on cold northern exposures of the southwestern parts of the same plateau.

The upper storey of *Juniperus* forests is formed by large, up to 30 to 45m high trees of *Juniperus procera*. A middle storey of an average height of 20m comprises in general *Prunus africana*, *Olea chrysophylla*, *Hagenia abyssinica*, *Cussonia* spp, *Apodytes acutifolia*, *Eckebergia rueppeliana*, *Milletia ferruginea* and *Pittosporum abyssinicum*. The undergrowth is poorly developed. Almost pure *Juniperus* stands are often found. The trees and bushes generally have rather coriaceous foliage, which is fine and shiny. In some less favorable places, *Juniperus* trees are much shorter, have thicker boles and the undergrowth becomes dense, forming an impenetrable thicket. In the most humid regions and at the lowest altitudes the vegetation changes toward a semi-humid highland forest. The juniper may then be mixed with *Podocarpus gracilior*. At the highest altitudes the evolution is very often towards a park-like formation, where the trees are confined to isolated clumps appearing in the grassland (mountain savanna). Characteristic of the juniper forests is lichens, hanging everywhere from the branches of the trees.

Podocarpus forests do not have a well-defined geographical distribution. They are found in relatively humid climates where rain is well distributed throughout the year but is less abundant than in the zone of the broadleaved rainforests. They are mostly located in the west of Ethiopia and on the western slopes of the Arsi-Bali plateau, between 2000 and 2400m altitude. The large trees normally form a continuous and closed canopy. They reach a height of 40 to 45m and more on the most favorable sites. The upper storey contains *Podocarpus gracilior* (dominating), *Prunus africana*, *Eckebergia rueppeliana*, *Celtis kraussiana*, *Olea hochstetteri*, *Polyscias ferruginea* and *Apodytes acutifolia*. The large *Podocarpus* can grow in a closed mix with broadleaved trees, but more often they form small, almost pure stands, and may even exclusively occupy the upper storey, suppressing their companions

into the relatively open middle and lower storeys. Where the forest has been left untouched, the undergrowth is very open. There are some suppressed trees, few shrubs, except in the clearings, and the ground is fairly clean. Epiphytes (ferns) are abundant, but creepers are few. These forests are less heterogeneous than the broadleaved moist forests and the semi-humid highland forests. Although great variations occur from one place to another, under the best conditions the volume of the almost pure stands can reach 500 to 600 m^3 ha^{-1}. However, these forests have too often been subjected to thoughtless clearing that has greatly reduced their area and created numerous and sometimes large openings covered by herbs and grasses in the remaining stands.

The mountain scrub steppe is found on lower mountain sites and also in wind-protected locations at altitudes of 3500 to 4500m. This shrub steppe is formed by a continuous grass blanket and scattered shrubs of *Erica arborea* and *Lobelia rhynchopetalum*, pioneering species under less extreme montane conditions.

2.3. Bamboo and palms

Arundinaria alpina stands take the form of scattered but large and compact concentrations at very high elevation above the *Juniperus* forest (2500 to 3400m). They are mixed with single trees or groups of trees such as *Hagenia abyssinica*, *Juniperus procera*, *Prunus africana*, *Milletia ferruginea* and *Schefflera polysciadia*. Typical representatives of the lower shrub storey are *Rubus erlangeri* and other *Rubus* spp. Occasional stands are found at high altitudes in the broadleaved moist forest, sometimes reaching a height of 18m with some diameters reaching 12cm. The main bamboo areas in the highlands, however, occur where ecologically the humid montane woodland would find its habitat.

3. Forest status

Although there are limited empirical evidences on the extent and cover of the Ethiopian forests, available literature indicate that some 35-40% (27.5 million ha) of the land mass was covered by forest vegetation of varying types and density around 1800 (Last 1962, EFAP 1994). In the early 1950's, this coverage reduced to about 16% of the landmass. In the early 1980's, the coverage was reported at 3.6%. By 1989, it was estimated to be only 2.7%. Some 5 million hectares of savanna woodlands were remaining giving a total forest and woodland area of about 7.5 %. The loss of forest resources is severe in the Ethiopian highlands where part of the vast mountain massif in the heart of the country lie above 1500m. These highlands cover about 44% of Ethiopia's land area, accommodate 88% of the total population and contain about 95% of the cultivated land. More than 67% of the national livestock herd is also concentrated here (EFAP 1993). Big trees and shrubs such as *Syzygium guineense*, *Cordia africana*, *Olea welwitschii*, *Haginia abyssinica, Aningeria adolfi-friederici*, *Albizia schimperiana*, *Bersama abyssinica*, *Croton macrostachys*, *Prunus africana*, *Podocarpus gracilior*, *Olea hochstetteri*, *Juniperus procera, Milletia ferruginea*, *Mimusops kummel*, *Rosa abyssinica* and *Rubus* spp are very scattered. A considerable area is stocked with specimens of small diameter and poor growth. This can be explained by earlier forest clearings. Today, remnants of these forests are seen only in the south and southwestern part of the country and around churches, where, by tradition, the trees are not cut (Figure 1).

The cycles of events that lead to the deforestation process involve many varying factors. However, most are ultimately initiated by the rapid growth of population (FAO 1985a). Figure 2 elucidates these events.

4. Uses

Despite the destruction, trees and their products will continue to be central to the households' economies, as well as to food security and health through a number of traditional practices in Ethiopia. For example trees such as *Mimusops kummel*, *Cordia africana* and shrubs such as *Rubus* spp, and *Rosa abyssinica* provide assurance against drought and crop failure and also provide a buffer during hardship period and 'lean seasons'. In areas where livestock is limited, the forest and tree products also play major roles as good source of protein. The products of trees such as *Haginia abyssinica*, *Croton macrostachys*, *Prunus africana*, *Podocarpus gracilior, Milletia ferruginea* have also been and are still being used for the prevention and treatment of parasitoids, communicable diseases and pests. This is indirectly related to the household's income: it provides good health to people and the livestock as well as crops. The trees/ shrubs such as *Vernonia amygdalina* serve as animal fodder.

Figure 1: Map showing the current distribution of the Ethiopian forest resources (FAO 2000).

Practically all of the species listed above and those not indicated in the short list including the tree species like *Syzygium guineense*, *Olea welwitschii*, *Aningeria adolfi-friederici*, *Albizia schimperiana*, *Bersama abyssinica*, *Olea hochstetteri*, *Juniperus procera* are used as sources of building/construction materials, energy and bee forage. These in turn provide materials for business such as, timber, crafts, honey etc., which in turn provide cash for use in purchasing food items and cover other dues. Generally, forests and trees and their products provide the critical support to the national GDP, agricultural production, in terms of food, fuel, direct cash income and employment. If properly managed, the presence of forest and trees maintain the ecology. Good soil fertility and conservation with improved rainfall availability are partly a function of forest and trees. However, these trees and shrubs have been subjected to thoughtless clearing that has greatly reduced their area and created numerous and sometimes large openings covered by herbs and grasses in the remaining stands. The current deforestation rate ranges around 141,000 ha yr^{-1} (FAO 2007). At the current pace it is estimated that all the remaining high forest of Ethiopia will be finished within 15-20 years time. What is remaining will be the very few remnant forests localised in the most inaccessible part of the country and with them these valuable trees and shrubs (EFPA 1993). In fact trees/shrub species such as *Juniperus procera*, *Prunus africana*, *Ocotea kenyensis*, *Dombeya aethiopica*, *Dombeya longibractata* are among the species listed as the most vulnerable in the IUCN red list of threatened species (IUCN 2006). The Ministry of Agriculture has also recorded the following four species i.e *Hagenia abyssinica*, *Podocarpus gracilior*, *Cordia africana*, and *Juniperus procera* as highly threatened tree species and has proclaimed those trees no to be cut (MOA, 1994).

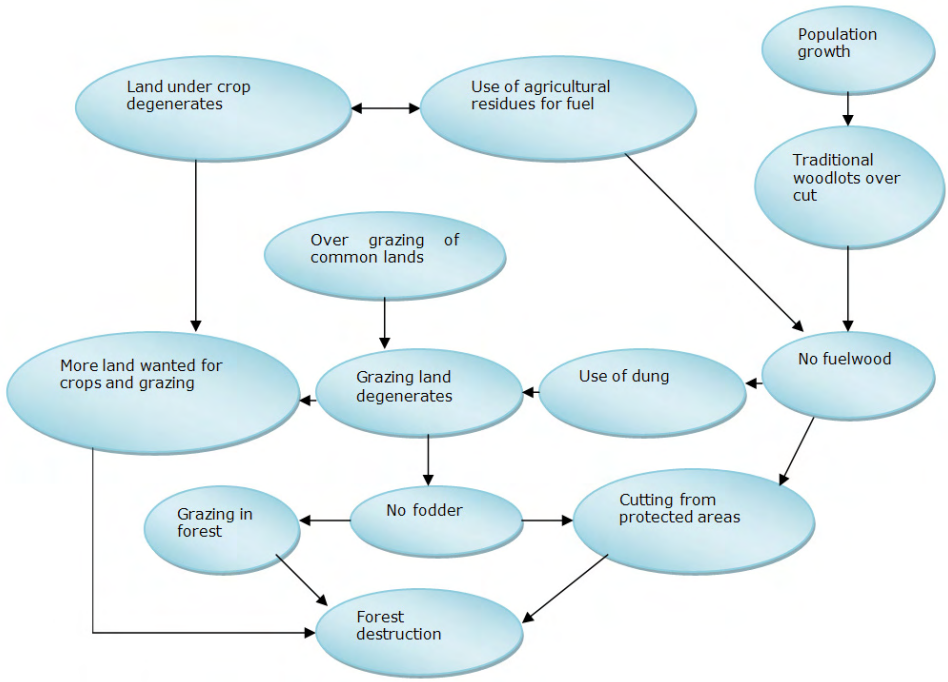

Figure 2: The cycles of events that lead to forest destruction.

5. Research needs and factors affecting forestry research

Institutions involved in forestry research in Ethiopia have achieved significant milestones in seed technology and physiology, seedling production and implementation techniques, and modest exotic species adaptation trials and management in plantations and utilisation. Improved ecological study results have also been achieved to assist in the development of sites for better tree growth and the processes associated with this. The adaptation, development and implementation of agroforestry technologies have also contributed to accelerated tree planting on farms. However, very limited success has been recorded in the development, management and expansion of knowledge for sustainable management of the highly valuable indigenous trees/shrubs species. Neither is there an intensive silivicultural and screening trial of indigenous tree/ shrub species in place to contribute to their increased development, utilisation and entry into processing and markets; nor are there studies avalaible on the roles of trees/shrubs in social and economic development and environmental amelioration including ecotourism. The ethnobotany and economic botanical study of the most important tree/shrub species is also ignored. It appears that emerging science and technologies in areas like cloning, genetic engineering and geomantic have eluded forest researchers, largely due to lack of know-how and facilities. Application of geographic information systems and remote sensing has not received enough support to generate the expected knowledge necessary for resource planning and management. Key areas like socio-economics are marginally handled. On the other hand, the number and diversity of these pristine forests that comprise these trees/shrubs are rapidly declining at a faster rate than ever imagined due to the increasing public demand for tree/shrub products. These developments call for responsive research and development programmes. Contrary to this, the forest research institutions have remained quite small, and programmatically frozen to classic structures and paradigms that cannot effectively address the rapidly growing research needs. The reasons to this are embedded in both internal and external factors.

5.1. Internal factors

5.1.1. Ineffective structure

The national forestry research center is established as a quite small unit which is subdivided into classic forest research programmes and projects such as natural, plantation, farm forestry, tree seed improvement and technology, timber, panel and fiber board and non-timber forest. Each of these projects are too weakly staffed and resourced to make a significant contribution.

5.1.2. Inefficient utilisation of available capacity

Available research capacity in the universities is not strongly linked to that of research institutions. Thus, the enormous research capacity of graduate students remains untapped. They seem to work independently, often addressing theoretical problems. Despite the weak staffing at research institutes, there is a relatively high rate of staff attrition for various reasons: e.b. some leave the institutions to join better paying organisations. Staff replacement often takes longer time due to government recruitment procedures. Besides, senior researchers are engaged in meetings and extra-consulting services, eating into their research time, and severely limiting the time they could spend mentoring young researchers.

5.1.3. Lack of synergy or coordination

The projects identified above operate as semi-autonomous units, independently

identifying and addressing research issues. In addition, there is little articulation of their research with research carried out in agriculture and other natural resource sectors (hydrology, wildlife management etc.). Thus, forest research appears to be isolated, truncated and not responsive to the real needs of society.

5.1.4. Weakly linked to development

Due to the nature of research issues addressed, the outputs are loosely directed at the public. There are no clear processes for research institutions to generate a research agenda from interactions with stakeholders and to share their findings with the general public, and this does not seem to be their focus or modus operandi.

5.1.5. Lack of interaction with end users

Forest research scientists seem to be content with their own understanding of research issues. Most research institutions do not have regular mechanisms for capturing research agenda from the public. This leaves them free to address priority issues that are not necessarily current or contextualised in the public domain.

5.1.6. Leadership and coaching difficulties

There is a need for the development of mid and long-term research strategies and plans and effective management of research resources. For instance, the private role seems to play a very limited role in supporting research, despite the great potential. Research managers do little to “market” forest research services. This could be partly due to the fact that they operate as civil servants, only waiting for clients to come to them.

5.2. External factors

5.2.1. Policy and legislation

Shortage of fund is the major constraints of forestry research and more often forestry is not among the most priority list in the development options, policy set up and legislative actions

5.2.2. Unattractive career path

Forest researchers are poorly remunerated and are working in very difficult circumstances. They are under constant criticism for being obsessed with trees and forests, hiding from the real needs of the society. The research, or generally forest career path becomes less and less attractive.

5.2.3. Costly international partnership

Opportunities for partnering with international bodies come at a cost. In many cases, the international partner has the resources and determines the agenda. This pulls researchers out of their national commitments and plans to address issues that are sometimes irrelevant, but personally rewarding

6. Recommendations

There is an urgency and need for major changes in forest research approach and prioritization of research agendas if current research efforts have to be more effective in delivering quality and relevant products and services. Among the key changes proposed are:

6.1. Establish a self-reliant independent institution

The number and diversity of forestry stakeholders have been rising very rapidly due to the increased public awareness of the role of forests in social and economic development and environmental amelioration. But the forest research

institution has remained quite small, and programmatically frozen to classic structures and paradigms that cannot effectively address the rapidly growing research needs. This calls for major changes in the institutional arrangement and research approaches if research efforts have to be more effective in delivering quality and relevant products and services to all stakeholders.

6.2. Paradigm shift to address relevant issues

Forest researchers need support and training to work with society in identifying research issues and solving development problems. This will bring them into currency with the dynamic social, cultural, technological and economic conditions. This would not only make research saleable, it would also promote the role of forestry in social and economic development and raise the profile of the researcher in society.

6.3. Improved access to resources

Forest researchers have to be prepared for a competitive research funding environment to access global resources and reduce dependency on public funding to effectively run this costly venture.

6.4. Networking and partnership

Forest researchers need to learn how to better work together, beginning with internal and national collaboration among scientists to build up inter-institutional networking and peer linkages. This in turn necessitates the building of a National Forest Research System and Forest Research Forum. This will help to overcome some of the problems that the forestry research sector is currently facing and provide the opportunity to rescue these vanishing forests along with these valuable trees species right in front of our eyes.

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