REHABILITATION OF DEGRADED LANDS IN HUMID ZONES OF AFRICA

By

Dominic Blay
Forestry Research Institute of Ghana
University P. O. Box 63, Kumasi, Ghana

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SUMMARY

Rehabilitation of degraded forests, which is ever increasing in humid forests regions of Africa is very necessary because it has the potential to generate significant environmental and livelihood benefits.

In spite of this, rehabilitation of degraded forests does not feature in national nor regional debates on sustainable forest management in Africa nor has any document been produced on this important theme.

Global Forestry Information System (GFIS Africa) project therefore intends to produce a synthesis on rehabilitation of degraded forest lands for use by students, trainers, researchers, NGOs and others involved in land management and also form the basis for the production of popular press articles (brochures radios etc.) for other stakeholders.

This paper therefore aims at providing background information for discussion by identified scientists and other stakeholders in order to produce the synthesis.

The background information include the importance of the forest resource, the causes of deforestation and degradation, the rates of deforestation and degradation, rehabilitation techniques and strategies, policy, management and research constraints against rehabilitation as well as policy, management and research recommendations. It also includes suggestions on issues that the discussions should be centered on.

INTRODUCTION

Loss and degradation of forests, particularly in less developed nations, continues as a global environmental and social issue. A 1990 assessment on the subject by the Food and Agriculture Organisation (FAO) stated that "despite the massive efforts of the past decades to arrest deforestation, forest degradation and the non-sustainable conversion of forests to other forms of land use, these processes continue unabated" (FAO 1993a).

If restored or rehabilitated degraded forests have the potential to generate significant environmental and livelihood benefits. Under certain conditions they can contribute to mitigate pressure on primary forests. Furthermore they fulfill environmental functions and can play a useful role in bio-diversity conservation (ITTO, 2002).

In spite of this, rehabilitation of degraded forests does not feature very much in international conventions on forests. The Convention on Biological Diversity among others things, only encouraged the application of the ecosystem approach and noted the importance of supporting work on taxonomic, ecological and socio-economic issues for the restoration of forest ecosystems and forest resources. The Convention on Desertification has also only developed thematic programme networks, which focus on technical measures for desertification control and land rehabilitation.

The other conventions (United Nations Framework Convention on Climate Change, Convention on International Trade in Endangered Species of Wild Fauna and Flora, Convention on International Trade in Endangered Species of Wild Fauna and Flora, and Ramsar Convention) do not however make any direct reference to rehabilitation or restoration of degraded forests lands.

Rehabilitation of degraded forests lands do not also feature in regional and national debates either nor has any document on rehabilitation of degraded forests in Africa been produced.

This has therefore prompted Global Forestry Information System to produce a synthesis of on this theme for use by students, trainers, researchers, NGOs and others involved in land management and also form the basis for the production of popular press articles (brochures radios etc.) for other stakeholders.

OBJECTIVE

The purpose of this paper is therefore to provide background information on rehabilitation of degraded forests in humid Africa for discussion among scientists and other stakeholders in order to produce a synthesis on this theme which is intended to be used by students, trainers, researchers, NGOs and others involved in land management and also form the basis for the production of popular press articles (brochures radios etc.) for other stakeholders.

IMPORTANCE OF THE FOREST RESOURCE

The forests of Africa cover 520 million hectares and constitute more than 17 per cent of the world's forests. They are largely concentrated in the tropical zones of Western and Central, Eastern and Southern Africa. With more than 109 million hectares of forests, Congo Kinshasa alone has more than 20 per cent of the region's forest cover, while Northern Africa has little more than 9%, principally along the coast of the western Mediterranean countries, according to FAO. This still, however, makes Africa on of the continents with the lowest forest cover rate.

Forests play important roles in many African countries. These roles include biodiversity conservation, provision of NTFP’s. Enhancement of cultural values, Preservation of Ecological functions. as well as economic, and social services.

Biodiversity conservation:

Biodiversity poses a global, national and local heritage and resource. Tropical forests and other habitats are renowned for their rich diversity of flora and fauna. In Cameroon, for example, at least 8,000 species of higher plants are found, while over half of Africa’s bird and mammal species are reportedly within the country. Cameroon contains a variety of forest habitats ranging from montane forests, which are noted for their globally unique endemic species, to Atlantic coastal forests, which are rich in plants, to inland Cameroon-Congolese forests, which are renowned for their mammalian diversity. Habitat loss and poaching present a major threat to the country’s biodiversity.

Preservation of Non-timber forest products (NTFPs),

NTFP, s, including bark, tubers, leaves, flowers, seeds, fruits, resins, honey, fungi, and animal products, play an important role in the households of the urban poor and forest-dwelling communities. They are used as medicines, tools and building materials and for food, primarily within local villages and households. It is difficult to quantify the economic importance of these commodities, but a study by the Center for International Forestry Research (CIFOR) estimates that they are an important source of cash revenue for local communities. Bushmeat, bush mango, the bark and fruits of Garcinia cola, palm nuts, cola nuts, and the African pear were among the major cash suppliers. The trade in these commodities especially is an important source of income for women.

Cultural Values

Forests also represent immense *cultural values*. African tropical forests are home to a large variety of peoples and ethnicities, which originate much of their cultural value set from their physical surroundings. Among the oldest peoples in Central Africa are forest hunter-gatherers, pejoratively known as "pygmies,” who immigrated to the region several thousand years ago. These groups rely primarily on the tropical forests for their livelihood, medicine, and shelter. Their cultural identity is rooted not only in language, kinship, oral history, and traditional practices but also in their identification with a particular area of the forest.

Economic and Social Services

Forest products provide 6 per cent of GDP in Africa at large, the highest in the world. Forests provide a range of ecological, to humans, including protection of water and soil resources. Forests also act as storehouses of carbon, much of which is released into the atmosphere when they are cleared, contributing to the buildup of greenhouse gases. In addition, forests are the main reservoir of terrestrial biological diversity and are a vital resource for millions of local communities. Forest products also provide the foundation of many local and national economies.

Ecotourism is also providing a growing income for who have known to facilitate it. Before the Rwandan genocide and the conflict in Congo Kinshasa, the national parks in that zone containing mountain gorillas were a major tourist attraction. In Rwanda, traffic was high, that visits had to be reserved. In Guinea, before the conflict in neighbouring Liberia, the border mountain Mount Nimba, with its rich montane forests, was getting a tourist attraction. Several countries outside Africa now are attracting those tourists Africa could attract to its famous forests. Rainforest tourism is probably one of the least exploited resources in Africa, with great potentials.

Although the values of tropical forests are indeed high, only a few are visible in national budgets. Logging and timber exports give short-term cash income, visible in the GDP. Others are close to invisible, as revenues are not registered within the monetary sector. These include, to a certain degree, local use and revenue from fuelwood and non-timber products, and more clearly, environmental services such as soil and water protection and storage of carbon dioxide. Other values again, are partly "robbed" from the conserving society, as is the example of the use of the genetic industry's use of African endemic species. If "the cure for cancer" should be found in the Congolese rainforest, none of the billion dollar revenues would return to those societies, which are now maintaining biodiversity.

RATE OF DEFORESTATION AND DEGRADATION

Deforestation

Except for the Congo Basin, Africa's humid forests have largely been destroyed, primarily by loggers and by farmers clearing land for agriculture. The rainforests of West Africa are disappearing at a rate of some 5 per cent annually. Nearly 90 percent of the original moist forest is gone, and what remains is heavily fragmented and degraded. Today, The Ivory Coast, which once had 30 million hectares of tropical rainforest, is now reduced 4.5 million hectares. Thus West African unspoiled forests are restricted to one patch in Côte d'Ivoire and another along the border between Nigeria and Cameroon. During 1990-95 the annual rate of deforestation in Africa was about 0.7 per cent, a slight decline from 0.8 per cent during 1980-90, according to FAOSTAT. The highest rates were recorded in the moist western parts of the continent. During the 1980s, Africa lost an estimated 47 million hectares of forest. By 1995 another 19 million hectares had been lost, according to FAO, an area the size of Senegal.

Over the last 20 years, about 300 million hectares (six times the size of France) of mainly tropical forest have been converted to other land uses on a worldwide basis, such as farms and pasture or large-scale plantations of oil palm, rubber and other cash crops.. To the east, very little remains of Madagascar's once magnificent tropical forests.

The changes in changes in humid countries in Africa as result of deforestation for 1990-2000, according to FAO, 2001 is shown in Table 1.

Table 1:CHANGE IN FOREST AREA (1990-2000)

Country/area	Total forest, 1990 ('000 ha)	Total forest, 2000 ('000 ha)	Forest cover change, 1990-2000)	
			Annual change ('000 ha)	Annual rate of change (%)
Benin	3,349	2,650	-70	-2.3
Burundi	241	94	-15	-9.0
Cameroon	26,076	23,858	-222	-0.9
Central Africa Republic	23,207	22,907	-30	0.1
Comoros	12	8	n.s.	-4.3
Congo	22,235	22,060	-17	-0.1
Cote d'Ivoire	9,766	7,117	-265	-3.1
Dem. Rep. of the Congo	140,531	135,207	-532	-0.4
Equatorial Guinea	1,858	1,752	-11	-3.3
Gabon	21,927	21,826	-10	n.s.
Ghana	7,535	6,335	-120	-1.7
Guinea	7,276	6,929	-35	-0.5
Guinea-Bassau	2.403	2,187	-22	-0.9
Liberia	4,241	3,481	-76	-2.0
Madagascar	12.901	11,727	-117	-0.9
Nigeria	17,501	13,517	-398	-2.6
Rwanda	457	307	-15	-3.9
Sierra Leone	1,416	1.055	-36	-2.9
Togo	719	510	-21	-3.4
Uganda	5,103	4,190	-91	-2.0
United Republic of Tanzania	39,724	38.811	-91	-0.2

Land Degradation

The extent of soil degradation induced by human activity since 1945 was evaluated as ~2 billion ha, or 17% of Earth's vegetated land, in a recent study sponsored by the United Nations Environment Program (UNEP, 1990.). Of this, ~750 million ha (38%) are classified as lightly degraded (defined as exhibiting a small decline in agricultural productivity and retaining full potential for recovery); ~910 million ha (46%) are moderately degraded (exhibiting a great reduction in agricultural productivity; amenable to restoration only through considerable financial and technical investment); 300 million ha (15%) are severely degraded (offering no agricultural utility under local management systems; reclaimable only with major international assistance); and 9 million ha (0.5%) are extremely degraded (incapable of supporting agriculture and unreclaimable).

The percent of area affected seems regionally to be independent of ecological zone or economic status; for example, it is 22%, for Africa 20%, in Asia, and 23% in Europe, The direct causes of these forms of degradation (and estimates of the relative importance of each) are overgrazing (35%), deforestation (30%), other agricultural activities (28%), overexploitation for fuel wood (7%), and bioindustrial activities (1%). Global rates of change in soil degradation are unknown. The UNEP study constitutes the first standardized global assessment and is the baseline for planned future monitoring on a decadal basis.

CAUSES OF DEFORESTATION AND DEGRADATION

Direct Causes

Despite the significant importance of the forests, they are being degraded at a very fast rate. The causes of the ongoing destruction of tropical forest are extremely complex. Many different factors can be involved, and their combination, relative importance, and interactions vary not only from country to country and region to region, but also over the course of time, influenced by economic, political and social developments.

Activities that are treated as causes that directly and obviously contribute to degrading or destroying tropical forestland, and which strictly speaking should therefore be regarded as types or manifestations of forest destruction include:-

- Small-scale shifting cultivation for food production, predominantly to meet the cultivators' own needs (subsistence farming).
- Agro-Industrial land use for production of certain cash crops for export, such as fodder (soybean, maize) and products from plantation crops (coffee, cocoa, palm oil, and rubber).
- Fuelwood collection
- Felling of trees for timber
- Clearing of forestland to exploit energy and mineral resources (mining, construction of dams and reservoirs) with installation of the required infrastructure.

Expansion of agricultural land at the expense of the forest

Between 1900 and 1980 the world's total cropland doubled; in tropical Africa it even tripled during this time period, Even though new agricultural land is also being obtained at the expense of other ecosystems, it is nevertheless a good measure of the pressure that is being placed on the forests.

Agricultural land is continually being expanded. More and more virgin lands are being opened to agriculture: on the one hand because the increasing food needs of growing populations leave no alternative as long as productivity per unit of land area remains constant, and on the other hand because some land degraded by overuse is being withdrawn from agricultural production either temporarily or permanently.

Growing exports of cash crops like coffee, cocoa and fodder to the industrialised countries have also made a large contribution towards expanding agricultural land in the Third World. And the demand for these agricultural commodities in the industrialised nations is continuing to motivate the establishment of new croplands.

At the same time, the growing need for foodstuffs and agricultural land is also involving expansion into ecologically fragile tropical forests growing on soils that are poor in structure and in plant nutrients. According to the FAO, in the next 15 years the vast majority of the developing countries will be unable to keep the agriculturally utilised land area stable while

allowing marginal land to betaken out of agriculture by showing the growth in demand and applying improved farming methods to increase productivity.
The share of the destruction of closed tropical forests, i.e. humid forests, attributable to shifting cultivation is estimated to be more than 70% in Africa.
Large areas of forestland in the tropics are also lost when plantations are installed for growing cash crops like oil palm, cocoa, peanuts, or pineapples.

The impact of logging methods on tropical forest cover

The extent to which a forest is damaged or destroyed by logging operations primarily depends on the intensity of felling and on the methods that are used. The effects which initial logging of this kind can have vary from region to region, ranging from activities that cause minimal ecological harm to the forest all the way to degradation and even complete destruction of forests. The question as to whether or not the minimum conditions for continued sustainable use are met in any given case cannot be answered by applying general rules, but only on the basis of knowledge of the specific local conditions prevailing there. Moreover, either unintentionally or planned by the state, the opening up of primary forests by commercial logging operations often paves the way for their subsequent complete clearing by small farmers, and others.

In Western and Central Africa, much of the tropical humid forests have already undergone substantial commercial harvesting. The total volume of wood exploited annually in the sub-region is more than 200million cubic meters.

FUELWOOD NEEDS

Current fuel-wood needs

Deforestation caused by cutting and collection of fuel-wood is primarily a problem of the dry tropics. However in the moist tropics, fuel-wood needs primarily pose a threat to the forests in the vicinity of large African cities (Kinshasa, Brazzaville, Lagos),

The firewood requirements of the cities of the developing countries are steadily increasing as a result of the high birth rate and the continuous influx of population migrating from rural areas to urban centres. These are confronted with declining forest resources in surrounding areas, increasing fuel prices, and a lack of alternative energy sources.

The fuel-wood problem is being exacerbated by the increasing urbanization of the developing countries not just because of population growth, but also as a result of using charcoal instead of wood. Throughout Africa, there has been an increasing demand for wood products, especially firewood, and charcoal. Recent projections by FAO estimate that consumption will rise by another 5 per cent by 2010. More recently, new economic reform measures have removed subsidies on energy alternatives, which further increased the demand for firewood. FAO estimates that at least 90 per cent of Africans depend on firewood and other biomass for their energy needs.

Infrastructure and industrial activities

Infrastructural activities such as the construction or improvement of roads, railway lines, shipping channels, and harbours are intimately linked with settlement and industrialisation projects, the opening up of remote economic regions, the improvement of transport routes for products intended to be exported, and military interests such as frontier surveillance in remote areas. When previously untouched regions are opened up by building roads, particularly when they are paved to permit travelling on them year-round, this makes it easier for shifting cultivators, loggers and gold diggers to penetrate these areas, resulting in colonisation and fragmentation of formerly closed forestlands.

Large-scale oil exploration and mining in Western and Central Africa have also led to the loss of forest resources, especially in Cameroon, the Congo, Gabon and Nigeria.
(German Bundestag, 1990)

INDIRECT OR UNDERLYING CAUSES

The underlying causes of deforestation and degradation can be summarised as follows:

- Unjust distribution of land and the failure to implement land reforms.
- Unequitable distribution of benefits from forest resources
- Taxation policies that encourage destruction of tropical forests.

- Pressures to earn foreign exchange
- State settlement programs and uncontrolled migration
- Lack of technologies for efficient, sustainable and environmentally compatible Utilization of resources and raw materials
- Displacement of small farmers as a consequence of the mechanisation of agriculture.
- Military and national interests
- The interests of foreign and domestic companies
- Corruption and legalised destructive exportation - German Bundestag (1990)

IMPACT OF DEFORESTATION AND DEGRADATION

There are many consequences of deforestation that will hurt the land of Africa in the years to come. Deforestation leads to land degradation which takes a number of forms, including depletion of soil nutrients, salinization, agrochemical pollution, soil erosion, vegetative degradation as a result of overgrazing, and the cutting of forests for farmland.

- All of these types of degradation cause a decline in the productive capacity of the land, reducing potential yields. Farmers may need to use more input such as fertilizer or manure in order to maintain yields, or they may temporarily or permanently abandon some plots. Degradation may also induce farmers to convert land to lower-value uses. For example, farmers may plant cassava, which demands few nutrients, instead of maize, or convert cropland to grazing land. Farmland degradation can also have important negative effects off the farm, including deposition of eroded soil in streams or behind dams, contamination of drinking water by agrochemicals and loss of habitat.

- Another consequence is degradation is its impact on the carbon cycle. Forests act as a major carbon store because carbon dioxide (CO_2) is taken up from the atmosphere and used to make carbohydrates, fats and proteins that make up the tree. When forests are cleared, and the trees are either burnt or rot, this carbon is released as CO_2. This leads to an increase in the amount of CO_2 in the atmosphere, which in turn causes the dangerous greenhouse effect.

- The water cycle is also effected by deforestation. Trees draw groundwater up through their roots and release it into the atmosphere (transpiration). With the removal of part of the forest, the region cannot hold as much water.
- Bio-diversity preservation depends, in part, on increasing yields on human-dominated land to alleviate pressure to convert remaining natural habitat.

- Land is frequently a limiting factor of economic output, and its degradation threatens to undermine economic development in poor nations and social stability globally.

- Deforestation and degradation are also rapidly fragmenting landscapes and creating new conditions to which vegetation must adjust. Examples of these new conditions include different atmospheric gas concentrations, eroded soils, changing air temperatures, changed soil conditions such as nutrient status, texture, moisture and pH, changed levels of water tables, the possibility of accumulation of toxic substances, changed disturbance regiments and reduced supplies of plant propagules (cf. Knabe, 1965; Buschbacher et. al., 1992; Dale et. al., 1993; Ang. 1994).

REHABILITATION TECHNIQUES

Techniques for rehabilitating selected degraded areas will ultimately depend on the priorities and objectives of stakeholders, the costs and benefits associated with available rehabilitation techniques, and the economic, social, and environmental values of these land resources in their current and desired future states (Lamb, 1994).

The major techniques that have been used for rehabilitating degraded forests world-wide include:-

(i) Natural Succession;
(ii) Enrichment planting;
(iii) Assisted Natural regeneration;
(iv) Plantations; and
(v) Agroforestry planting.

Natural Succession

Experience in reclamation of degraded areas, although limited, indicates unequivocally that human intervention may be effective (even essential) in ensuring a path and rate of succession that would achieve substantive improvements at time scales relevant to society. The potential for accelerating recovery is difficult to assess, as most degraded areas with known histories have not yet recovered. Moreover, recovery is nonlinear (with respect to time), and intervention can only accelerate some phases of the process.

Where land is suited to direct human use and has not been stripped of topsoil, substantial recovery may be achieved in as few as 3 to 5 years with intensive management but more typically may take 20 years However, recovery of self-sustaining, mature ecosystems in areas unsuited for intensive agriculture may take 100 years or more.

The creation of foster ecosystems focuses on improving conditions for natural succession and overcoming barriers to regeneration. When land is degraded for a period of time, natural processes are disturbed and barriers are formed which block the natural pathways of forest succession.

Barriers to be taken into account are low availability of native seeds and other propagules on-site, seed and seedling predation, seasonal drought, root competition, and poor soil conditions. These barriers need to be ameliorated before a restoration project can be attempted.

Minimizing barriers to seed survival, germination, and growth-:.

A major barrier to natural regeneration of forests is that conditions in open lands are unfavorable to seed survival, germination, and growth of tropical forest species. Abandoned clearings are quickly overgrown by invasive grasses and shrubs, which in turn provide excellent habitat for seed predating ants and rodents. Nepstad (1991) found that predation of native seeds placed in abandoned clearings is very high, as is predation on germinants. This same study also found that root competition in such cleared areas is a serious deterrent to the development of seedlings. Young tree seedlings growing in open areas suffered dramatically stunted growth, mainly due to root competition from thick grasses, while the same kinds of seedlings planted in tree-fall gaps grew almost four times as quickly.

Plantation trees can be planted to alleviate the problems of seed predation and competition. Although tropical systems are complex and different situations may require different approaches, established trees shade out invasive grasses and shrubs under their canopies. Ant and rodent habitat are destroyed and thus predation is decreased. Because the ground vegetation has been reduced, root competition for emerging seedlings is also greatly reduced. This makes conditions for seed survival, germination and growth more favorable under the canopies of plantation trees.

Accelerating soil improvement and natural seed dispersal

Most of the nutrients and organic matter of a tropical rainforest are stored in aboveground biomass. When the trees are removed from a site, which is then grazed, or farmed, soil conditions can become degraded. Soil conditions can be improved by using plantations of selected tree species. Leguminous, nitrogen-fixing species grow well under difficult conditions and produce nutrient rich litter. In a plantation, nitrogen fixation and litter fall can increase soil nutrients and organic matter. In addition, trees can help by reducing the bulk density of soil with their roots, conserving moisture in their shade, and providing conditions favorable to a healthy population of soil microorganisms.

The last and probably most important factor in a successful regeneration is the availability and dispersal of seeds and other propagules of the native tree species. Many tropical trees can propagate by roots, by residual seeds, or by seeds disseminated from an adjacent forest. In the open conditions of a clearing, much of the residual propagative material is destroyed or is unable to germinate and survive. Rather than giving humans the work of disseminating native seeds, the presence of plantation trees can attract seed disseminating bird and mammal species to do the job of dispersing seeds naturally. Appropriate plantation species should provide perches and/or food for disseminating birds and bats. Fruit-eating birds and bats will be attracted to the tree to perch or eat its fruit. In the process, they disseminate seed from previously eaten fruit. Nepstad (1991) found 400 times more seeds under tree crowns than in open field conditions.

Enrichment Planting

Enrichment planting (also known as strip, - gap- and under- planting) is defined as the introduction of valuable species to degraded forests without the elimination of valuable individuals already present (Catinot, 1965 cited in Lamprecht, 1990; Weaver, 1987).

This practice is intermediate in intensity between natural regeneration and plantations. The objectives are the rehabilitation of cutter forests after selective felling of marketable trees and the assurance of full stocking, species control, crop uniformity, short rotations, and competitive yields.

Thus enrichment planting has been suggested as a technique for restoration of over-exploited and secondary forests as it can increase total tree volume and the economic value of forests (Weaver, 1987, 1993; Sips, 1993; Adjers et al., 1995; Korpelainen et al., 1995).

Variations of enrichment planting

There are several variations of enrichment planting.

Thus ‘’enrichment planting’’ is used when in forests containing most of the trees required for a future crop, individual trees are planted to fill small vacant areas. The main disadvantage is that uneven growth rates between the natural forest and the under-planted trees produce an uneven stand that is difficult to manage and harvest.

"Gap" planting of trees spaced at 2 to 3 m inside openings of 20 m or more in diameter is another variation. It seems to have the same disadvantage as enrichment planting.

"Group" planting is made up of closely spaced clusters of 9 to 25 trees in openings as small as 10 m in diameter. Only one tree per cluster is intended to survive.

Line planting: In forest stands with an insufficient number of trees to form a significant portion of the next crop, under-planting may be done systematically in rows or lines. This provides more tree/site selectivity and requires less planting stock.

Line planting seems to be the successor to most of the other under-planting techniques; however, it also has problems. Not only must overhead shade be removed initially but weeding must be so drastic that most of the former forest quickly disappears. Clearing lines and keeping them open until the new trees are well established also can be expensive. Since most failures in the past have been a result of competition with natural trees, self pruning tree species capable of 1.5 in/yr of straight growth are suitable . The list of marketable species that meet the growth requirements is limited. Also, line plantings typically are of a single species, producing a loss of stand diversity, even though natural regrowth may be permitted between and below the crowns of the planted trees. Finally, maximum yields to be expected from line plantings are about 12 me/ha/yr. The constraints may make line planting a risky investment.

It has also been said that it is difficult to provide optimal light conditions for each species planted within a transect (Weaver, 1987) and that introduced species are more exposed to pests than in undisturbed forest (Lamprecht, 1990). However, it may be possible to adjust the design and management of enrichment lines to avoid some of these problems. For example, light availability can be controlled by changing the width of the transect. Planting some species of the Meliaceae family, which contains may commercially important species, under a partial forest canopy has also resulted in a reduced incidence of the shoot borer (*Hypsipyla* spp.) which commonly attacks and severely retards the growth of these species when planted in the open (Newton et. al, 1993).

Control of surrounding vegetation is the most manageable factor in enrichment systems for secondary forests (Sips, 1993). Appropriate line width and light incidence requirements of each species could be determined in controlled experiments.

Management of enrichment plantings should be complemented by tending of natural regeneration within the lines. The weeding necessary for initial establishment and maintenance of the enrichment lines also tends to favour natural regeneration (Grance and Maiocco, 1993).

If regeneration in the enrichment lines is considered together with planted trees, enrichment planting may become a more economically attractive alternative. Therefore, silvicultural treatments should be designed to encourage the establishment and growth of line plantings and at the same time favour natural regeneration, especially of commercially important species (Sips, 1993). Once the seedlings are established, the whole forest should be tended throughout and not just along the enrichment lines (Dawkins, 1961). However, the need for trained personnel and the costs associated with tending may limit the widespread applicability of this approach, especially at large scale.

The success of enrichment plantings has been variable and its efficacy questioned and this silvicultural option has declined in the tropics. planting work is difficult to supervise; seedlings have to be regularly released from regrowth; a regular supply of seedlings is needed, and it is costly (labour demanding). In general, failures were attributed mainly to poor selection of species and/or the lack of adherence to sound planting and tending practices. Others include improper selection of planting stock, insufficient over storey opening prior to planting, insufficient follow-up tending and pest attack.

There are, however, biological, environmental and economic arguments in favour of enrichment planting. When compared to other artificial regeneration systems, enrichment planting has the advantages of mimicking natural gap dynamics, protecting the soil by maintaining vegetation on site. Necessary conditions for successful enrichment planting include the provision of adequate light conditions proper supervision and follow-maintenance (especially canopy opening treatments).

Important silvicultural characteristics for species ideal for enrichment planting include for instance:

- produce timbers of high value
- regular flowering and fruiting
- low crown diameter
- wide ecological amplitudes

- rapid height growth
- good natural stem from
- tolerance to moisture stress
- free of pests and diseases

Because of the relative management complexity of enrichment planting, some authors consider it economically viable only at a small or medium management scale (Ramos and del Amo, 1992). The high cost of establishing and maintaining plantings in initial years has been cited as one disadvantage of enrichment techniques (Sips, 1993). However, including species of medium and shorter harvest age could improve the economics of this technique, and enrichment planting could play an important role in the recovery of degraded forests (Chai, 1975; Cheah, 1978; Thang, 1987; Weaver, 1987).

Assisted Natural Regeneration

An alternative approach to the restoration of native forest is to accelerate regeneration by assisting the natural processes of succession. This is already practised in the Philippines, where it is labelled 'assisted natural regeneration' or 'ANR' (Dalmacio, 1987; Jensen and Pfeifer, 1989). There, ANR methods include cutting or pressing the weeds around existing naturally established seedlings, protecting the area from fire and interplanting with desired species if necessary. ANR as explained here differs from 'natural regeneration' as defined by Fox (1976) which allows some human intervention but precludes tree planting.

The importance of basing tropical forest restoration on an understanding of ecological processes is often emphasised (e.g. Lugo, 1988; Janzen and Vazquez-Yanes, 1`991). For the purposes of ANR, it is particularly important to know what specific factors limit the rate of regeneration of trees in deforested areas, so that minimum input strategies may be devised to overcome them. Several authors have focused on this, notably Fox (1976), Uhl (1987) and Nepstad et. al., (1990). A systematic approach to such a study is firstly to determine the stage of the life-cycle where population size is limited and then to isolate the factors responsible (e.g. Alvarez-Buylla and Martinez-Ramos, 1992).

The Potential Role of Plantations

There is increasing evidence that forest plantations can play a key role in harmonizing long-term forest ecosystem rehabilitation or restoration goals with near-term socio-economic development objectives (cf. Lam and Tomlinson, 1994). Recent studies have shown that plantations can facilitate, or 'catalyze', forest succession in their understories, particularly where silvicultural management was neglected, on sites where persistent ecological barriers to succession would otherwise prelude recolonization by native forest species. Lugo (1992), Parrotta (1992, 1993, 1995), and Lugo et. al (1993) for Puerto Rico; Guariguata et al. (1995) for Coast Rica; Vieira et al. (1994) and Silva Junior et al. (1995) for Brazil; Knight et al. (1987), Lubbe and Geldenhuys (1991), Geldenhuys (1993, 1996), and van Wyk et al. (1995) for South Africa; Fimbel and Fimbel (1996) for Uganda; Yu et al. (1994) for China; Bhaskar and Dasappa (1986), Kushalappa (1986), Soni et al. (1989), George et. al. (1993) for Malaysia; and Kuusipalo et. al. (1995) for Indonesia.

These studies suggest that, under certain circumstances, as already mentioned under natural succession, the catalytic effect of plantations is due to changes in under-story microclimatic conditions, increased vegetation structural complexity, and development of litter and humus layers that occur during the early years of plantation growth. These changes lead to increased seed inputs from neighbouring native forests by seed dispersing wildlife attracted to the plantations, suppression of grasses or other light-demanding species that normally prevent tree seed germination or seedling survival, and improved light, temperature and moisture conditions for seedling growth. In the absence of silvicultural management aimed at eliminating woody under-story regeneration, the mono-specific plantation system is replaced by a mixed forest comprised of the planted species and an increasing number of early and late successional tree species and other floristic elements drawn from surrounding forest areas. Eventually, if the planted species are short-lived and light-demanding (as are most of the commonly planted commercial species), they may disappear entirely from the system, leaving a floristically rich secondary forest. Alternatively, if the planted trees are gradually removed without also removing the woody understory regeneration, a secondary forest could develop quickly.

Plantation Strategies

When creating a foster plantation, steps may be taken to improve the speed and efficiency of native forest regeneration. The pattern in which trees are planted is important. The ideal method would be to plant trees evenly throughout the field, allowing disseminators to penetrate deep into the field from the forest edge. If funds are limited, forested strips (corridors) or islands may be effective and more economically feasible. Planted forest strips should extend from the edges of natural forest stands at intervals easily transversed by disseminators (20-30m). Plantation islands are trees planted together in groups. Islands should also be planted so they are 20-30m from forest edges and other islands. For both the strip and island methods, it is expected that as these systems develop, they will spread outwards and eventually overlap, creating a continuous forest.

Agroforestry Planting

Agroforestry plantings should not be considered a replacement for the conservation of native tropical forests, but agroforesters can play a key role in helping to conserve biological diversity (biodiversity) of species in degraded habitats. Agroforestry plantings can provide expanded habitat for a wide range of species, from soil microlife to insects to mammals. The value of agroforestry for biodiversity is especially high when agroforestry replaces or expands into farms or other establishments in degraded areas. A well designed agroforestry, modeled after healthy, diverse natural forests will spontaneously attract and support biodiversity. While most of us have productivity as a primary focus, there are some things we can do to optimize the positive impact of our plantings on biodiversity.

As a general rule, the more forest-like in form and diverse in species a planting is, the more kinds of life it will attract and support. The design tips that can help agroforestry planting become a safe harbor for biodiversity include:

- Create "wildlife corridors"--areas or zones of the planting that are not often disturbed or entered by people, leaving them to be colonized naturally. Ideally, connect these areas together to form safe corridors throughout the project, and connect them to neighboring habitats for wildlife.

- Plant many different kinds of species. Complex, multi-storied agroforests have much more benefit than just one or two additional species integrated with a monoculture.

- Encourage or actively cultivate native plant species as they are more likely to support native life, from soil fauna to birds. Also be aware of the exotic species that native wildlife may have become accustomed to as food or habitat that will also be of value. If you are near a native forest area, your chances of wildlife moving in spontaneously are greater than if you are isolated from natural areas.

THE STRATEGIES FOR REHABILITATING DEGRADED FORESTS

The general strategies for rehabilitating degraded forests have been summarised by Hadley and Shreckenberg (1987) as follows:-

- Maintain flexibility in the rehabilitation approach
- Be alert to environmental conditions
- Avoid specificity on the ultimate goals of rehabilitation
- Maximize vegetation cover
- Manipulate existing vegetation before attempting a substitution
- Use fallow to do most of the rehabilitation
- Restore tree cover as rapidly as possible
- Be aware that nutrient cycling strategies may change through a rehabilitation from phosphorus limitation to nitrogen limitation
- Develop species mixtures based on their 'ecological' combining ability
- Keep top soil moist, cool and shaded
- Couple ecosystems to maximize their value and accelerate rehabilitation (e.g. use treated urban sewage as irrigation water to accelerate tree growth)
- Maximize ecosystem complexity to optimize use of site resources, maximize protection from pests, and minimize risks
- Use exotic tree species to foster native species through site rehabilitation

- Use multiple seeding techniques when in doubt as to what to plant and let natural selection processes decided the best species combination for a site
- Create nuclei of biotic activity from which habitat rehabilitation occurs under the influence of biotic agents
- Use stressors to arrest succession at a desirable stage

CRITERIA AND INDICATORS FOR MEASURING THE SUCCESS OR FAILURE OF A REHABILITATION

How can rehabilitation be measured as either being successful or a failure ?

Ewel 1987 put forward five criteria for measuring the ecological success or failure of a rehabilitation scheme and these are shown in Table 2.

Table 2: Criteria for measuring the ecological success of a rehabilitation

Criteria	Query
Can the system be sustained?	Is the new system self perpetuating or must it be subsidized to maintain itself?
Vulnerability to invasions	Does the new community resist invasion by other species?
Productivity	Is the new system as productive as the original?
Nutrient retention	How efficient is the nutrient cycling?
Biotic interactions	Are all key animal and plant species present?

POTENTIAL INDICATORS OF SUCCESS OR FAILURE FOR A REHABILITATION MONITORING PROGRAMME

How can a rehabilitation programme be monitored ?

Indicators for measuring success or failure can be either biophysical or socio-cultural factors Lamb (1988(Table 3). In both cases it is necessary to evaluate the stability of the ecosystem that has been achieved, its efficiency, and its flexibility. Biophysical factors would include measuring the rate of erosion, the percentage plant cover (for which remote sensing might be useful), the complexity in terms of species diversity in the new community, the quality of water of rivers and lakes. It would also be important to determine whether rehabilitation required continued inputs in the form of planting, weeding or fertilizers among others.

Socio-cultural factors are particularly concerned with the stability of the ecosystem and its human component. This can be measured in terms of migration rates into and out of the area, the extent to which farmers cultivate cash rather than food crops, the increase or decrease in livestock numbers and quality. The question of who benefits from the rehabilitation is also important as, while the aim may be to help certain sector of the population, the actual result may be to promote the interest of quite a different group.

Finally, the rehabilitation scheme must be evaluated in terms of time and costs. In many degraded landscapes, nature alone would eventually rehabilitate the ecosystem but the time required can be reduced greatly by active human intervention. Such intervention costs money and it is necessary to check that rehabilitation efforts remain within proposed budgets and do not use up more resources than they are considered to be worth.
(Lieth and Lohman, 1993)

Table 3: Indicators for measuring success or failure of rehabilitation

Biophysical indicators	Socio-cultural indicators
Stability Stability of soil surface	Stable human population
Presence of adequate plant cover and growth	Stable market prices
Adequate crop yield	Adequate food
Appropriate plant species composition and structure	Stable land use pattern
Appropriate animal population	Stable land tenure system
Adequate regeneration or reproduction of preferred species	Appropriate balance between subsistence crops and cash crops
Acceptable water quality (surface and groundwater)	Stable rate of fuelwood consumption
Appropriate albedo	Stable rate of water use (in arid zones)
Efficiency Need for inputs of seed or fertilizer	Level of public in involvement or participation in the programme
Need for weed control	
Need for irrigation	
Flexibility Extent to which alternative or multiple uses can be made of land	Extent to which economic flexibility possible. Accumulation of economic wealth

CONSTRAINTS

There have been constraints which have prevented the successful rehabilitation of degraded forest lands. These constraints include: **-**

Policy and Institutional Constraints

- Degraded forests and degraded forest lands are insufficiently taken into account in International agreements. (Convention on Biological Diversity. Framework Convention on Climate Change, Desertification Convention, Agreements (ITTO) and Processes United Nations Forum on Forests)
- National Policies do not mention or consider degraded forest landscapes as priority when compared short term economic activities (e.g. intensive agriculture) In addition there are no clear definitions/classifications of the various conditions in resource assessment, policy planning, and legal frameworks.
- In addition forest policies and economics do not recognize the value natural
- Restrictive regulations for the use and harvesting of products from degraded forest landscapes a forest legislation often imposes high bureaucratic requirements and procedures a landowner must follow to obtain permission to harvest and market wood, timber and certain NWFP.
- Insecure land tenure or use rights
- High informality and corruption
- Lack of adequate data knowledge and expertise on the ecological, socio-economic, silvicultural and institutional dimensions of degraded affects and influences people's perceptions of the resource, masks its importance and potential, and often results in poor management/degradation and inappropriate rehabilitation
- In many cases, degraded forests have overlapping tenure claims involving the state, the private sector and local communities. As a result, conflicts over access rights are common, often resulting in unsustainable use and further degradation of the resource.
- Inadequate assessment and sharing of costs and benefits related to the management and use of degraded forest landscapes could result in resource degradation and inappropriate conversion.

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Management Constraints

- Agricultural use of degraded forest landscapes predominates, mainly to restore soil fertility as part of the fallow cycle in shifting cultivation systems
- Cultural practices contrary to the maintenance of forest (lack of a 'forest culture)
- Low levels of organizational and managerial capacity of local population
- Low negotiation capacity of main actors
- Lack of financial for rehabilitation of degraded forests and non recognition of specific situations of degraded forest landscapes in existing schemes (Global Environment Facility, Clean Development Mechanism, Climate change Adoption fund)
- Lack of real –scale models/demonstration of viability of management strategies
- for degraded forest landscapes
- Lack of documented experiences; as well as poor dissemination of information on experiences
- Lack of technical experience in the management of degraded forest landscapes
- Poor accession to information technologies and markets

Research Constraints

- Lack of interdisciplinary, integrative and participatory research on bio-physical, socio-cultural, economic and policy factors affecting rehabilitation
- Lack of better understanding of dynamic interactions between degraded forests landscapes and human livelihood and often conflicting conservation and development needs
- Research priorities and proposals not developed collaboratively with local population and local stakeholders

- Research results not widely disseminated and their practical application not incorporated into policies

Education and Training

- Knowledge about degraded landscapes is not sufficiently integrated in the educational system at both the technical and professional level.
- Capacity of local groups and institutions involved in rehabilitation of degraded forests not well strengthened.

RECOMMENDATIONS

To overcome these constraints the following recommendations are made:-

POLICY RECOMMENDATIONS

Degraded forest landscapes need to be seen as an integral part of the rural tropical landscape

They are affected by off-site conditions, particularly are affected by off-site conditions, particularly land uses. Restored and rehabilitated degraded forest landscapes can provide numerous benefits and services to society; at the same time they fulfil important productive and protective functions and need full recognition as an important land-use element. Within any given landscape, some degraded primary forests may need to be converted to other uses, but such conversion should be part of an overall land use plan that optimizes the allocation of land within the landscape.

- The value of degraded forest landscapes for all those people who depend directly or indirectly on forest resources for their livelihoods needs to be documented and formally recognized. Inadequate participation of local stakeholders in policy processes and inadequate consideration of local needs, site conditions, and land use practices may result in degradation and inappropriate conversion of degraded primary forests.

- Networking and communication is needed to promote collaboration in and validate commitment to the management of degraded forest landscapes.

- Networking and communication between forest users and interest groups is needed to reverse forest loss and degradation. Forest loss and the degradation of forests concern and affect people at the local, national and international levels. There is a need to address a range of policy, institutional, social and technical issues to make progress. As the number of issues and the size of the tasks are huge, policy-makers and forest services should encourage and promote participation of interest group networks so that they can share ideas and work towards a common agenda for change.

- Actions required to manage, restore or rehabilitate a forest ecosystem sustainably mean that people may have to change their perceptions, attitudes and behaviour. Unless the affected people and user groups appreciate the reasons for change, and the benefits they will derive from this, they will have little motivation to change.

- Quality of information about degraded forests and their social, economic and ecological contexts need to be improved since this will improve the quality of decisions made on the fate of degraded primary forests.

- Adequate policies focussing on degraded forest landscapes at the local, national and international levels need to be developed.

- Clear land tenure and property rights to guarantee sustainable management and use of degraded forest landscapes needs to be in place in order to prevent further degradation and inappropriate conversion to other land-uses.

- Policy decisions need to be based on a full cost-benefit assessment and identified transfer payment mechanisms for forest products and services.

- Forest services and other relevant species need to be strengthened in the management of degraded forest landscapes

- Extensive bodies of information and knowledge are available on the management of degraded forest landscapes but, in many cases, this in accessible to stakeholders and relevant institutions, information remains inaccessible for forest species. There is a need to clearly define units within national forest services that can play the role in the restoration of degraded primary forests, management of secondary forests and rehabilitation of degraded forest lands. These units should become centres of excellence that co-operate (ITTO, 2002)

MANAGEMENT RECOMMENDATIONS

The adequate land-use option for a given site needs to be carefully chosen

At the level of land-use planning, clear decisions need to be taken on which forest land will be used for agricultural production in the short and long term and which forest land will be devoted to conservation, managed for sustainable production of forest goods and services, or through a forest restoration process.

Planning of degraded forest landscape restoration needs to be participative

Participatory planning needs to be put into place wherever possible in order to determine the objectives of management and restoration or rehabilitation. Most planning concentrates on national needs, but in degraded forest landscapes particular attention needs to be paid to the needs of local communities because they will necessarily be heavily involved in the management, use and transformation of the degraded forests. Local people's participation must be encouraged at each stage of planning in order to find out local use preferences and to evaluate the full social costs and benefits of alternatives.

Relevant stakeholders should actively participate in planning and implementing management strategies for degraded forest landscapes and in sharing the responsibilities of decision-making:- An analysis of the needs, values and perspectives of local communities and stakeholders is fundamental to planning management strategies for degraded forest landscapes. Conflicts will be inevitable in decision over the strategies to be implemented in areas that are designated as multiple use.

The major technical planning tool to manage degraded forest landscapes is the forest management plan. The forest management plan is the major planning tool for the technical justification of activities to be carried in rehabilitation of degraded forest land. Management plans need to be precise, simple, clearly understandable by all practices, accessible to all interested parties and cost-effective in their implementation.

The management plan should be based on an adequate characterization of the social, cultural, economical and biophysical context in order to identify and describe the scenarios, the actors and their perceptions, the potentialities and needs.

Multiple-use management is the single most important management objective to apply in degraded forest landscapes

Degraded forest landscapes should be managed under the general principle of multiple-use management in order to derive a maximum of benefits from the resource. Planning needs to consider a dual purpose: on the one hand, management should boost the productivity of specified forest products, and, on the other hand, it should restore the protective functions of forest and soils. Restoration of degraded primary forests for timber alone is in many situations not a valid option, as forests are accessible to a variety of stakeholders, or fragmented, so that a single purpose of timber production is not sustainable in the long run.

The environmental risk and stress factors present in a degraded forest landscape must be assessed

The feasibility of forest restoration and rehabilitation of degraded forest land depends on the extent and nature of the existing environmental and socio-economic stresses. Sites with strong seasonal climate, low soil fertility and other environmental stresses are likely to be more difficult to restore than those that have more benign situations. Frequent periodic but unpredictable stresses and strains (e.g. fires, droughts), episodic climatic anomalities (e.g. ENSO) and the potential for long-term global climate change, may make restoration or rehabilitation is achieved, such improved stands may buffer some of the initial environmental stresses and episodic events (ITTO, 2002).

RESEARCH RECOMMENDATIONS

Status and trends of degraded forest landscapes – Reliable regional/country estimates of extent and productivity of degraded.

Decision making – A better understanding of the decision making processes and the driving forces behind land uses changes affecting the formation and dynamics of degraded forests and how these underlying causes can be influenced. This will allow the identification of appropriate strategies and intervention points and mechanisms for altering current dynamics and trends of different categories of degraded forest landscapes.

Ecological studies at the ecosystem and species level –Recovery process after disturbance. Reproduction patterns. Seed ecology. Regeneration, growth and yield

Management regimes and silvicultural techniques- Documentation and analysis of existing indigenous /local management practices. Species choice for restoration and rehabilitation. Auto-ecological information on key species used in rehabilitation of degraded areas. Restoration techniques for degraded forests to favour biodiversity.

Ecological response to management- A better management of the response (e.g. in terms of dynamics, biomass accumulation and loss productivity, soil properties of degraded forest lands to different management and silvicultural interventions.

Socio-economics of different management strategies – Costs and benefits of rehabilitating degraded forest under different management objectives and silvicultural options.

Policy analysis and formulation –How present policies including extra -sectoral policies affect land use decisions and what policy changes are required to remove obstacles to and or actively encourage sustainable management and rehabilitation of degraded forests.

Monitoring –Criteria and indicators for assessing suitability of management strategies for degraded forest landscapes. Development, implementation and analysis of monitoring systems for each broad category of degraded ecosystems with identification of indicators (silvicultural, or production ecological, and socio-economic) indicators, assessment methods and appropriate thresholds.

Adoption studies- Constraints and opportunities perceived by landowners, rural communities and relevant stakeholders for the adoption of different options for degraded forests. What incentives should be introduced for increasing adoption, which disincentives must be eliminated or reformulated in order to facilitate adoption (ITTO,2002).

EDUCATION AND TRAINING

Knowledge about degraded forests should be integrated in the educational systems hence there should be a change in the curricula used in forestry schools at the technical and professional levels.

The capacity of local groups and institutions should be strengthened by being involved in rehabilitation programmes.

ISSUES TO BE DISCUSSED

Based on the above information, the issues to be discussed should include the following:

- What are the causes of deforestation in the different countries?
- What is the extent of deforestation and degradation (per annum and the %rate of change)?
- What is the impact of deforestation and degradation,?
- What efforts has been made at rehabilitation and what techniques have been used?
- What has been the rates of success or failures and what has been the causes of these?
- What criteria has been used to determine the success or failure rates?
- What have been the constraints (Policy and institutional, management and research)?
- What recommendations can be made on the (Policy and institutional, management and research aspects to facilitate the rehabilitation of degraded forests?

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