**Manual on Deforestation, Degradation, and**

**Fragmentation**

1. ***Introduction***

 Considerable uncertainty remains in our knowledge of deforestation, degradation, and forest fragmentation. Important research and management questions such as what is the rate of forest conversion, what is the age structure of forest re-growth, and what is the area impacted by forest degradation, selective logging, and fragmentation, are unknown in many parts of the world. Answers to these questions are critical to understand biogeochemical cycles (e.g. Carbon and Nitrogen Cycles, Nutrients), hydrological cycles (Energy/Water Balance and Climate, Sediment Transport, Erosion and Runoff), and ecological cycles (Ecosystem Health, Biodiversity (fragmentation)).

1. ***Basic Concepts of Deforestation, Degradation, and Fragmentation***
2. **Deforestation**

 Deforestation is the conversion of forested areas to non-forest land use such as arable land,

urban use, logged area or wasteland. According to FAO, deforestation is the conversion of forest to another land use or the long-term reduction of tree canopy cover below the 10% threshold. Deforestation can result from deliberate removal of forest cover for agriculture or urban development, or it can be an unintentional consequence of uncontrolled grazing (which can prevent the natural regeneration of young trees). The combined effect of grazing and fires

can be a major cause of deforestation in dry areas. Deforestation implies the long-term (>10 years) or permanent loss of forest cover.

 Deforestation defined broadly can include not only conversion to non-forest, but also degradation that reduces forest quality - the density and structure of the trees, the ecological services supplied, the biomass of plants and animals, the species diversity and the genetic diversity. Narrow definition of deforestation is: the removal of forest cover to an extent that allows for alternative land use. The United Nations Research Institute for Social Development (UNRISD) uses a broad definition of deforestation, while the Food and Agriculture Organization of the UN (FAO) uses a much narrower definition.

 Definitions can also be grouped into those which refer to changes in land cover and those which refer to changes in land use. Land cover measurements often use a percent of cover to determine deforestation. Land use definitions measure deforestation by a change in land use. This definition may consider areas to be forest that are not commonly considered as such. An area can be lacking trees but still considered a forest. It may be a land designated for afforestation or an area designated administratively as forest.

1. **Forest Degradation**

 Forest degradation is a process leading to a ‘temporary or permanent deterioration in the

density or structure of vegetation cover or its species composition’. It is a change in forest attributes that leads to a lower productive capacity caused by an increase in disturbances. The time-scale of processes of forest degradation is in the order of a few years to a few decades. For the purpose of having a harmonized set of forest and forest change definitions, that also is measurable with conventional techniques, forest degradation is assumed to be indicated by the reduction of canopy cover and/or stocking of the forest through logging, fire, windfelling or other events, provided that the canopy cover stays above 10%. In a more general sense, forest degradation is the long-term reduction of the overall potential supply of benefits from the forest, which includes wood, biodiversity and any other product or service.

 Any in-depth understanding of the processes of forest degradation has to be based on an

accurate monitoring of the degradation over large areas, for at least a decade. The detection of inter-annual changes in landscape spatial structure is more likely to reveal long term and long lasting land cover changes, while spectral indicators are more sensitive to fluctuations in primary productivity associated with climatic fluctuations. Different monitoring systems may be optimal for different ecosystems. A long time series of observations is always required with seasonal, annual and decadal changes. The monitoring of the spatiotemporal distribution of biomass burning may also give indications of open forest degradation.

1. **Forest Fragmentation**

 Simply defined, forest fragmentation refers to any process those results in the conversion of formerly continuous forest into patches of forest separated by non-forested lands. The definitions of fragmentation are as diverse as the subject itself. For instance, a definition which uses habitat as the qualifier is "The splitting or isolating of patches of similar habitat, typically forest cover, but including other types of habitat...Habitat can be fragmented naturally or from forest management activities, such as clear-cut or logging". In another example, the definition is empirically linked to population growth, "Fragmentation is a complex phenomenon resulting from dynamic interactions between the natural landscape and society's ever-increasing demands on the land, creating a mosaic of natural and human-modified environments." However, the single tie that links these two definitions together is the idea of fragmentation referring to the process of a contiguous land base being divided into smaller pieces. In one definition the author sums this idea, "Fragmentation has been defined as the conversion of large areas of contiguous native forest to other types of vegetation and /or land use leaving remnant patches of forest that vary in size and isolation".

 To better understand deforestation, degradation and fragmentation, it is important to revisit three additional terms that are often used to highlight positive changes in forest areas. These three terms are afforestation, reforestation and forest improvement.

1. **Afforestation**

 Afforestation is the conversion from other land uses into forest, or the increase of the canopy cover to above the 10% threshold. Afforestation is the reverse of deforestation and includes areas that are actively converted from other land uses into forest through silvicultural

measures. Afforestation also includes natural transitions into forest, for example on abandoned agricultural land or in burnt-over areas that have not been classified as forest during the barren period. As for deforestation, the conversion should be long-term, that is areas where the transition into forest is expected to last less than ten years, for example due to recurring fires, should not be classified as afforestation areas. The concept “long-term” is central in this definition and is defined as ten years. Local climatological conditions, land use contexts or the purpose of the analysis may however justify that a longer time frame is used.

1. **Reforestation**

 Reforestation is the re-establishment of forest formations after a temporary condition with less than 10% canopy cover due to human-induced or natural perturbations. The definition of forest clearly states that forests under regeneration are considered as forests even if the canopy cover is temporarily below 10 per cent. Many forest management regimes include clear-cutting followed by regeneration, and several natural processes, notably forest fires and windfalls, may lead to a temporary situation with less than 10 percent canopy cover. In these cases, the area is considered as forest, provided that the re-establishment (i.e. reforestation) to above 10 percent canopy cover takes place within the relatively near future. As for deforestation, the time frame is central.

1. **Forest improvement**

 Forest improvement is the increase of the canopy cover or stocking within a forest. For the

purpose of having a harmonized set of forest and forest change definitions, that also is measurable with conventional techniques, forest improvement is assumed to be indicated by the increase of canopy cover and/or stocking of the forest through growth. In a more general sense (cf. forest degradation) forest improvement is the long-term increase of the overall potential supply of benefits from the forest, which includes wood, biodiversity and any other product or service.

1. ***Causes and consequences of Deforestation, Degradation, and Fragmentation***
2. **Causes:**

 Deforestation has been attributed to socio-demographic factors, such as population growth

and the political economy of class structure, and specific exploitation activities like commercial logging, forest farming, fuel wood gathering, and pasture clearance for cattle production. Deforestation from logging operations, particularly in stands of tropical moist forest, is often claimed to occur in a two-step sequence. First, loggers build roads into primary or old-growth forest and remove selected trees. In many places of the world, it was observed that the logging operation destroys 45-74% of the residual trees. The logging damage, however, is compounded once the loggers have left. Then, forest farmers are likely to follow the logging roads in search of new areas for cultivation. Thus, a substantial portion of worldwide deforestation might be explained by the logger/farmer interaction.

 In developing countries, high population growth coupled with rapidly expanding agriculture, and over-exploitation of forest resources is believed to be responsible for accelerated rate of deforestation. Similarly, in many parts of the world, wood production was found to be a significant contributor of deforestation. Causes of deforestation can be divided into two categories: direct causes and underlying causes.

1. **Direct causes of deforestation**

 The most important direct causes of deforestation include logging, the conversion of forested lands for agriculture and cattle-raising, urbanization, mining and oil exploitation, acid rain and fire. In other countries, clear-cut logging practices have been the main reason for forest loss. In the early nineties, Canada and Malaysia were famous examples of countries where logging companies ruthlessly cleared mile upon mile of precious primary forests. Here too, the historical perspective should not be overlooked. Countries like Ireland and Scotland used to be almost entirely forested, but were nearly completely cleared under British rule to provide timber for English shipbuilders.

1. **The underlying causes of deforestation and forest degradation**

 During the last few decades, the forest crisis has prompted many international, regional and national preservation initiatives, yet many have had little success. There is general agreement that this is due to the fact that these strategies were too focused on the immediate causes of deforestation, and neglected the underlying causes which are multiple and interrelated. In some cases they are related to major international economic phenomena, such as macroeconomic strategies which provide a strong incentive for short-term profit-making instead of long-term sustain ability. Also important are deep-rooted social structures, which result in inequalities in land tenure, discrimination against indigenous peoples, subsistence farmers and poor people in general. In other cases they include political factors such as the lack of participatory democracy, the influence of the military and the exploitation of rural areas by urban elites. Over consumption by consumers in high-income countries constitutes another of the major underlying causes of deforestation, while in some regions uncontrolled

industrialization is at the heart of forest degradation with widespread pollution resulting in acid rain. The causes of deforestation are many and varied. Here are few interesting findings:

* **Market failures:**
* unpriced forest goods and services
* monopolies and monopolistic forces
* **Mistaken policy interventions:**
* wrong incentives
* regulatory mechanisms
* government investment
* **Governance weakness:**
* concentration of land ownership
* weak or non-existent ownership and land tenure arrangements
* illegal activities and corruption….
* **Broader socioeconomic and political causes:**
* population growth and density
* economic growth
* distribution of economic and political power
* excessive consumption
* toxification
* global warming
* war
1. **Consequences:**

 The social consequences of deforestation are many, often with devastating long-term impacts. For indigenous communities, the arrival of "civilization" usually means the destruction of their traditional life-style and the breakdown of their social institutions. Individual and collective rights to the forest resource have been frequently ignored and indigenous peoples and local communities have typically been excluded from the decisions that directly impact upon their lives. Many of the indigenous peoples of the Brazilian states of Amazonas and Rondônia have been encroached upon by slash-and-burn farmers, ranchers, and gold miners, often resulting in violent confrontations. The intrusion of outsiders destroys traditional life styles, customs, and religious beliefs.

 Watersheds that once supplied communities with their drinking water and farms with irrigation water have become subject to extreme fluctuations in water flow. The loss of safe, potable water puts communities' health at risk for a variety of communicable diseases.

 In economic terms, the tropical forests destroyed each year represent a loss in forest capital valued at US$ 45billion. By destroying the forests, all potential future revenues and future employment that could be derived from their sustainable management for timber and non timber products disappear.

 Probably the most serious and most short-sighted consequence of deforestation is the loss of biodiversity. The antiseptic phrase "loss of biodiversity" masks the fact that the annual destruction of millions of hectares of tropical forests means the extinction of thousands of species and varieties of plants and animals, many of which have never been catalogued scientifically. How many species are lost each year? The exact figure is not known, a consequence of our limited knowledge of tropical forest ecosystems and our inadequate monitoring systems. Some estimates put the annual loss at 50,000 separate species but this is an educated guess at best. Fragmented stands of trees left during deforestation are usually not large enough to be self-perpetuating in terms of maintaining even an altered balance of biodiversity. Deforestation is eroding this precious resource of biodiversity.

 Although there is some debate about the rate at which the atmosphere is warming, there is general agreement that it is warming. The currently accepted models predict a 0.3 degree Celsius increase per decade in global temperatures over the next century. This is due to the increase in the amount of carbon dioxide present in the atmosphere, which has risen by about 25 per cent in the last 150 years. Although it is less than 1/20 of one per cent of the earth's atmosphere, carbon dioxide has a high capacity to absorb radiant heat.

 The negative consequences of global warming are catastrophic -- increasing drought and desertification, crop failures, melting of the polar ice caps, coastal flooding, and displacement

of major vegetation regimes. The amount of carbon currently in the atmosphere is estimated

to be about 800,000 million tons and is increasing at the rate of about 1 percent annually.

Deforestation is an important contributor to global warming, however, its contribution relative

To the other factors is not precisely known. The principal cause of global warming is the excessive discharges in industrialized countries of greenhouse gases, mostly from the burning of fossil fuels. Annual discharges from burning fossil fuels are estimated to be about 6,000 million tons of carbon, mostly in the form of carbon dioxide. It is thought that an additional 2,000 million tons or about 25 percent of the total carbon dioxide emissions are a consequence of deforestation and forest fire. At the regional level, deforestation disrupts normal weather patterns, creating hotter and drier weather. Unfortunately, efforts to find solutions to the deforestation crisis have not been as success in capturing investment money as have improvements to automotive exhaust emissions.

 The long term impact of deforestation on the soil resource can be severe. Clearing the vegetative cover for slash and burn farming exposes the soil to the intensity of the tropical sun and torrential rains. This can negatively affect the soil by increasing its compaction, reducing its organic material, leeching out its few nutrients available, increasing its aluminum toxicity of soils, making it marginal for farming. Subsequent cropping, frequent tillage, and overgrazing by livestock accelerate the degradation of the soil.

 In the dry forest zones, land degradation has become an increasingly serious problem, resulting in extreme cases in desertification. It affects about 3,000 to 3,500 million hectares, about one-quarter of the world's land area, and threatens the livelihoods of 900 million people in 100 countries of the developing world. Desertification is the consequence of extremes in climatic variation and unsustainable land use practices including over cutting of the forest cover. Growing populations are making ever-increasing demands on the land to produce more, leading to an intensification of use beyond the carrying capacity of the land.

 By 2050, two billion people, or 20 per cent of the world's population, will suffer from water shortages. Most of these people will be living in developing countries. Once denuded, the same watersheds lose their capacity to regulate stream flows and experience rapid fluctuations in stream and river levels, often resulting in disastrous downstream flooding. Water shortage is a major health risk in terms of inadequate sewage disposal, poor personal hygiene, and insufficient potable water. Food security is threatened as irrigation water becomes scarcer. Without the protection of the tree cover, soils are exposed to the rigors of severe tropical climates and are rapidly eroded. Freshwater and coastal fisheries are devastated by the high sedimentation loads carried by the rivers, as are wildlife-rich wetlands. Sedimentation from degraded watersheds is also one of the principal causes of the decline of coastal coral reefs. The economic and environmental costs are staggering.