Review Article

CONCEPTUALIZING DIFFERENT FOREST DEGRADATION DRIVERS WITH SPECIAL REFERENCE TO INDIA

ABSTRACT

Forest deterioration has been a global issue in the 21st century as one of the most serious environmental issues. The costs of forests degradation is in reducing productivity and natural resources such as water, land, grassland etc. deforestation effect the whole globe but it is of main concern of developing countries of Tropics. Any change in forest structure or species composition is not always indicative of deterioration; it could, on the contrary, indicate that the forest is improving. Forest deterioration and deforestation are caused by a variety of factors that vary depending on the location. The main aim of the review is to analyse various forest degradation drivers and to establish keys to estimate the level of degradation. The various direct and indirect drivers of forest degradation are Excessive mining, Selective logging, population explosion, climatic-change, forest fires, Biological invasion, agricultural land expansion and weak forest administration. One sort of sustainability in a managed forest is the system of several landowners, each with a modest multifunctional, multispecies plot. Other plan for sustainable development is Eco-development programme, is an inter and multi-stakeholder method for connecting the conservation benefits of protected areas with community people's livelihoods and development practices in the environments around them. A shift toward whole-landscape management is required, with a focus on places with high levels of usage mixed with areas principally maintained for conservation, recreation, and water catchment. Some guidelines are being created, but more interactions between ecologists, foresters, social scientists, and economists are urgently needed.

KEYWORDS

Forest degradation,Degradation drivers, Biological invasion, Sustainable development, Community forest management, Natural forest management, Forestry.

1. INTRODUCTION

Forests act as biodiversity hotspot which cover around 31% of land area, with a total forest area of 4.06 billion hectares (ha), or 0.52 ha per person, currently. However, forests are not distributed fairly among the world's inhabitants (107). Approximatly, 25% of global land area is facing extensive rate of degradation by salinization, soil erosion, wetland and peatland drainage [34].

With 809 million hectares of forest, or 20.1% of the world's total forest area, Russia is the nation with the greatest proportion of forests. Brazil comes in second with 520 million ha of forest, or 12.2% of the world's total forest area (Fig: 1). Canada 310 Mhac, United States of America 304 Mhac, China 207 Mhac, Australia 149 Mhac, Indonesia 94 Mhac, Sudan 70 Mhac, and the Democratic Republic of the Congo 154 Mhac, India 68 Mhac, and others 1347 Mhac (Global Forest Resources Assessment 2010 Main report)

1.1 INDIAN FORESTS: A BRIEF ACCOUNT-

India is located between 8°4 N and 37°6 N latitude and 68°7 E and 97°25 E longitude. Its whole geographic location is in the northern hemisphere. India has a geographic size of 3,287,263 square miles, making it the seventh-largest country in the world. India makes up 2.5% of the planet's surface yet produces roughly 7% of the biodiversity worldwide, making it one of the top ten countries in terms of forest cover. Together, these nine nations and India make up 67% of the world's total forest area.

India is one of the world's six mega-biodiversity regions and the source of many cultivated plants, including cotton, sesame, pigeon pea, and egg plant cucumber. Due to its great biodiversity, high endemism, and highly vulnerable status globally, India has two of the world's 36 biodiversity hotspots. The two hot regions recognised worldwide are the Western Ghats and the north-eastern Himalaya. India ranked fourth in Asia and tenth, worldwide in terms of plant variety [18].

With about 45,523 plant species, including over 17,500 angiosperms, 4,950 of which are unique to India, India accounts for 11.8% of the world's forests. In the nation's numerous isolated regions, new plant species are constantly being studied and found. For instance, in 2007, the Botanical Survey of India (BSI) and other researchers found 41 new plant species throughout the country's diverse bio-geographic zones.

Accordingly, 32% of Indian plants are endemic, meaning they can only be found in India, making it a highly endemic country in terms of flora. India's riches in fauna is likewise diversified, with an estimated 91,307 different species, or 7.465 % of the world's fauna. Forest cover refers to the entire area declared by the government to be forested. According to the Indian State Forest Report, Forest Cover, 2019, there are 71.22 million hectares of forests throughout the country (712,249 sq km). India has a total of 80.73 million hectres of forest and trees (807,276 Sq km) [53].

Forest fires, natural disasters, shifting cultivation, tree-felling, development programmes, and other anthropogenic disturbances may be to blame for a decrease in forest cover, while better protection measures, conservation strategies, tree planting, and afforestation activities contributes for an increase.

2. FOREST DEFORESTATION & DEGRADATION-

The loss of a specific forest feature, service, or functions in response to varied disturbances is referred to as forest degradation. Disturbance is defined as the discrete event in time that disrupted the ecosystem's structure or function. This alters the ecosystem's structural properties and species composition [20].

The costs of forests degradation is in reducing productivity and natural resources such as water, land, grassland etc. deforestation effect the whole globe but it is of main concern of developing countries of Tropics [71] due to which the area of tropical forests are shrinking [9]. The graphic satellite images depicted the spreading threat of deforestation in many areas of tropics [68, 69, 31, 96]. Deforestation in tropical forests is predicted to be around 500 million hectares (ha), far exceeding the deforestation in the Congo basin, Amazon, and Indonesia [4].

Tropical forests, through transpiration, atmospheric circulation and cloud formation, are acting as a crucial regulator of world climate [60, 96, 25]. Tropical forests acting as shelter for over 5-20 million species [6, 89] and about 1.2-1.5 billion people rely directly on them for timber, food, medicines and other services. According to the data available 11 million hectares area of forests is cleared every year from surface of earth [75]. The sufficient evidences are available on account of heavy forest degradation causing environmental crises worldwide [17]. Forests are razed for industrial raw materials (e.g., Malaysia, Indonesia, Thai- land), for agricultural land use (e.g., India, Nepal), and for pasture land (e.g., Brazil's rainforests). Forest degradation has halted the wide range of ecosystem goods and services, which leads to potential damaging impacts [13].

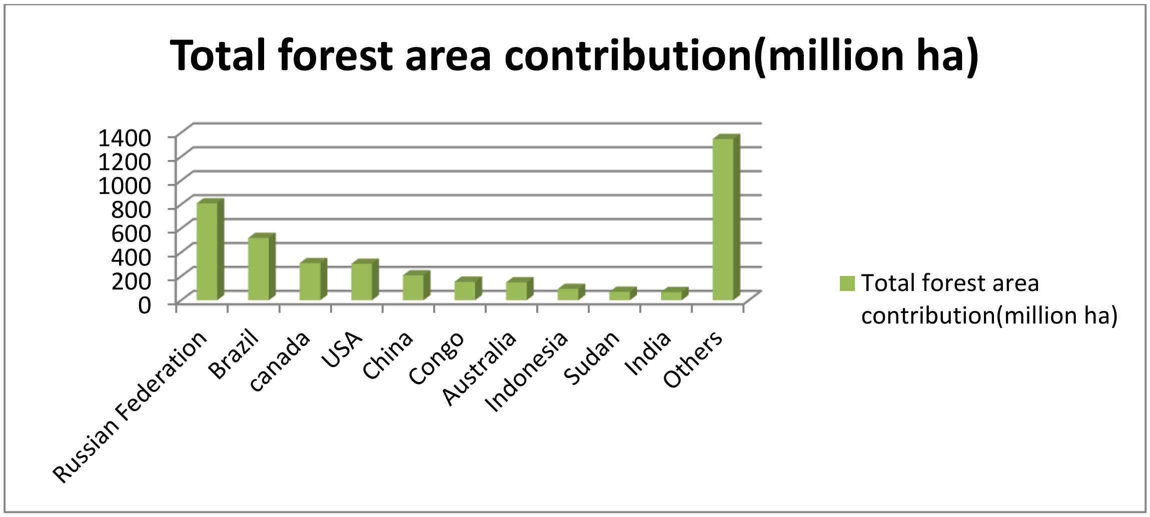

Fig:1. Total forest area contribution by top ten countries globally.

3.DIFFICULTIES IN DEFINING FOREST DEGRADATION

Forest degradation is recognized separately by various stakeholders who have different purposes (e.g., wood production, biodiversity conservation, soil conservation, carbon sequestration and cultural or recreation values). For different motives and targets there are about more than 50 definations of forest with emphasis ranging from loss of carbon stock, soil degradation [51] and climate change mitigation [98]. However, there seems to be no universally accepted approach for classifying & assessing forest degradation (UNFCCC, 2010), making it much more difficult to detect and measure. Furthermore, there are over Sixty definitions of forest deforestation, with focus on anything from ecosystem carbon loss to climate change mitigation to soil degradation. The innate amount of ambiguity around the definitions and mechanism of deterioration will result in a significant degree of heterogeneity in forest potential.

The forest degradation and deforestation are unconsciously made as same terms but, these two are different. Deforestation is the purposeful razing of forest areas such as urbanization, construction, animal grazing, agriculture and mining activities [58]. It is related with alteration of landscapes around the globe. Whereas, the Forest degradation is related with diminishing in quality of forest area and its wealth [58]. FAO defines forest degradation as 'the reduction of the capacity of a forest to provide goods and services' [34]. Alternatively, forest degradation can be defined in terms of crown density of less than 40% [84]. Deforestation is not only one of the modern environmental crises, but has a long history and affect human society historically .Most of the present day croplands are once supported forests and has been converted into croplands by heavy deforestation [79].

Any change in forest structure or species composition is not always indicative of deterioration; it could, on the contrary, indicate that the forest is improving. FAO defines forest degradation, as 'the reduction of the capacity of a forest to provide goods and services'. These forest services comparises biomass, soil protection, water regulation, carbon sequestration and biodiversity conservation. Some definations of forest degradation focus on functional approach, structural components of forests or one based on resources. Overall, it becomes exceptionally difficult to set up an intangible and practical definition of a degraded forest. As per Sasaki and Putz [88], the definition of forest degradation must be evaluated on the basis of full scale of social and biophysical conditions under which forests evolve and a variety of methods by which the forests can be degraded. ”Degraded forest” is treated as a generic term applying for all kinds of forests that have been altered for unsustainable uses beyond a threshold power. Degraded forests becomes highly fragile and have a limited biological diversity thus provides a reduced supply of products and services. [41].

4. MAJOR KEYS TO RECOGNIZE DEGRADED FORESTS

Loss of forest attributes such as structure, function and composition reflect the extent of forest degradation. For analysing and describing the state of altered Forest condition it is crucial to categorize the forest condition. Three criteria are used to evaluate the forest degradation: structure, composition and regeneration of forests. Leading to a shortage of clear rules, existing forest deterioration assessment parameters are hard to implement over diverse forest ecosystems and classifications, and hence must be resolved on a larger scale. This approach must be watched over time and does not account for relatively brief variations that occur as a result of conservation activities. A decrease in Net Primary Productivity (NPP), variations in the structure and composition of the forests, and a cycle of restoration are all part of this process. These modifications even have an impact on fundamental bio-physical dynamics, which impair forest performance and decrease ecological functions.

A summary of characterstics and criteria has been created based on guidelines proposed by Vásquez et al and compositional and structural characterstics of damaging forests that are subjected to selective extract [111] and has been altered by anthropogenic disturbances. The main systemic characteristics of anthropogenic dominated forests, also known as high grading forests, are a low total basal area (20 m2 ha1) [7], a low density of commercially important species with diameter at breast height (DBH>65 cm) [111], small tree diameter classes (DBH>20 cm), and a low density of implicit seed species.

For forest managers, tree diameter classes are essential because tree diameter impacts the value and price of trees for marketing, as well as the types of machineries utilized. Tree diameter classes also reveal the age structure, stand structure, and stand stability of a forest. Degraded forests are also characterized by alterations in diameter distribution. Changes in diameter distribution classes are particularly relevant in a mature forest with reverse –J type of diameter structure that is exposed to high grading degradation, with intermediate diameter classes having a low frequency of individuals [111](Table-1). These kinds of results are almost certainly the results of extensive logging and harvest of larger-diameter trees for commercial purposes.

Forest degradation is also inspected on the basis of” Degradation threshold” [81] which is elucidated as least forest canopy cover defined according to the kind of forest and specific ecozone circumstances. Sasaki et al. [87] advocated a canopy cover of more than 20% as a criterion for assessing forest degradation.

For evaluating wood harvesting decisions and analysing the relationship between forest wildlife and habitat, basal area is an important metric. The vegetation of the ground cover is determined by the tree species' basal area. Because less sunlight is available for ground cover plant species, there is a decrease in wood growth and less ground cover in forests with a basal area more than 100 sq ft per acre, which has an impact on wildlife. Shade tolerant plant species predominate in forests dominated by trees with a basal area more than 80 sq ft per acre, yet they may not be suitable for wildlife growth. Forest stands with a basal area of 60 sq ft per acre are considered stands with less basal area and are suitable for the growth of herbs and vines, supporting a diverse range of fauna. As a result, a basal area of 60-70 square feet per hectare is considered suitable for forest ecosystems. When compared to non-degraded forests, degraded forests have a smaller basal area [10]. Degraded forests have a smaller volume and poor growth of residual trees resulted in fewer volume of most valued tree species and volume of poor valuable tree species is bigger if anthropogenic damaging activities occur at regular intervals.

The high grading of forests decreases the tree species diversity which harm the one or another main aspect of forest species [111]. High grading of forests resulted into loss of High Relative Importance Value species (HIV) and only the remaining species in a given forest type will be Low Relative Importance value species (RIV) [111]. This type of species disappearance behaviour is more as the degree of degradation increases.

By selective depletion of plants, even in places with 100% forest cover, key plant species die extinct. Forest logging selectively harvests the most valuable trees, but each forest species may be targeted for commercial and subsistence extraction[77], leaving behind an ecologically, commercially, and physiologically depleted forest [23]. The entire structure and composition of the forest is transformed in extensively damaged forests when the main harmful factor is selective extraction of valued species. Due to selective extraction, the dominance and density of secondary species that are not as commercially important may reach high levels [111].

Many ecological products and services are directly affected or reduced when biodiversity is reduced. When highly functional species [26], essential species, and food animals are lost, the effects are magnified. "Empty forest Degradation" [46] or "cryptic degradation" is a type of degradation in which animals are overhunted for food and there is no visible change in forest structure or ecosystem services. Because of changes in herbivory patterns [101] and the absence of effective seed disperserls, the loss of animal species resulted in extremely degraded forests.

Regeneration, is an another key to recognize a degraded forest which depends upon the amount and type of alteration. The power of regeneration of forest stand is directly propotional to the amount of alteration. The high grading forests have low or complete absent regeneration or the regeneration of secondary less commercial plant species. More precisely, data gathered from forest degradation measurements may be utilised to improve management and conservation of forests.

Table:1. Guidelines to characterize a degraded forest: criterion and characteristic features used for categorization of degraded forest [111]-

Criteria used	Characteristic features
Composition	Reduced species composition and loss of biodiversity), less density and nce of commercial or primary species, High volume dominance of competitive,

Non- commercial and secondary species.

Structure — Dropping of canopy cover Alterations in diametric class structure (High Frequency of low diametric classes, absence of some diametric classes and Low frequency of High diametric classes), Reduced basal area and growing Stock.

Regeneration — Low or complete lack of Regeneration in High grading forests with Regenration of Non-commercial species

5. DRIVERS OF FOREST DEGRADATION (Fig: 2)

Drivers of Forest degradation and deforestation have been addressed in UNFCCC discussions and REDD+ debates for many years. It is becoming increasingly important to examine the various drivers of forest deforestation and degradation aiming to eleviate forest carbon stocks in REDD+ countries by bring down the emissions from degradation. Forest deterioration and deforestation are caused by a variety of factors that vary depending on the location. Natural drivers, both biotic and abiotic, such as wildfires, droughts, pests, and disease, must be considered in addition to anthropogenic drivers that resulted in land use change. It's not always easy to tell the difference between obvious and underlying causes, as well as between changes brought on by humans and those brought on by nature. In reality, deforestation or the deterioration of forests can result from several, intricate causal chains.

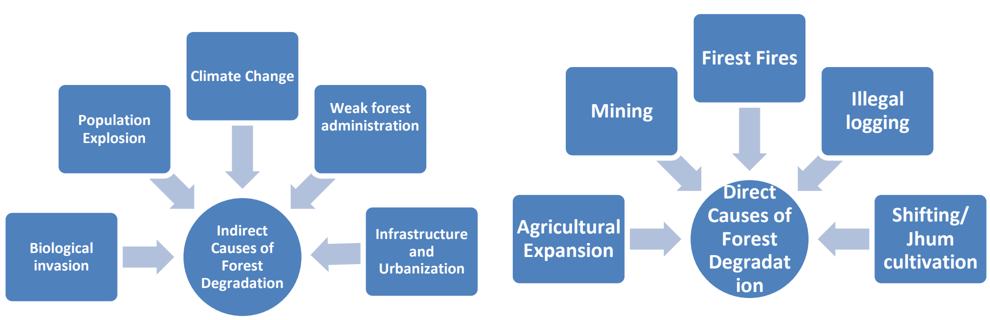

Fig:2. Types of different Direct and Indirect Causes of Forest Degradation

Direct or far known as proximate drivers of forest degradation are the human activities that directly influence the forest composition and resulted into reduction in carbon stocks. These causes can be further categorized into agricultural expansion, as the tropical forests are being converted into agriculturable lands since years thus, special attention must be given to the drivers of this conversion. Complex interconnections of fundamental, economic, cultural, social, political, and technological processes that are remote from their area of impact are referred to as underlying or indirect causes. They may have effect either locally or at national or global level.

5.1 Excessive Mining

Mining is the extraction of useful material from earth surface. The excessive mining results into loss of forest cover and biodiversity causing large soil cavities. Mineral resources will be further exploited as global demand for minerals rises, thereby contributing to forest deforestation [83]. Along with industrial mining diminutive unlawfull mining actions leads to be detrimental for forest health.

5.2 Agricultural Land expansion

While urban expansion, infrastructure and mining are foremost but less dramatic causes. Agricultural conversion of forest land is considered as a main direct driver of deforestation that constitutes about 80 % of the total deforestation globally [57]. About 60 % of the land clearing of tropical forests is for agricultural uses [70], while roads, logging, fuel-wood and, urbanization accounting for the rest [3]. By the consequences of which the peoples are forced to migrate the fresh forest frontiers which leads to more deforestation [1, 108, 2]. As per the 2011 census of country 1,70,000 villages are categories as Forest Fringe Villages (FFV) as the people of these areas are dependent on forests for one and another use [53].

According to the Indian forest report 2019 the people of these forests fringe remove small timbers at a fraction of 7% from total average annual yield of forest in India [53]. Thus agricultural expansion is the leading cause for deforestation [17]. Conversion of forests to other type of use areas leads to more logging and consequently increases erosion and rates of landslides. Removal of forests from a particular area not only causes disturbance to that area specifically, but the remaining area with forests also leads to forests patches or fragmentation and causing their breakage of connection with continues forests as a result of which ecosystem services are also disturbed there [29,59]. Shifting agriculture is also reported as a main cause of deforestation. Shifting cultivation involves growing crops until the site is exhausted of nutrients or the soil becomes nutrient poor or the site is overpowered by the invasive species after which the people choose the other site.

5.3 Selective Extraction of Wood

Logging in the forests selectively exploit most valuable trees but each species in the forests may be target to extraction for commercial and subsistence use [77] leaving behind a ecologically , economically and biologically depleted forest [23]. Even in the areas of 100% forest cover the important plant species become extinct by selective depletion of plants.

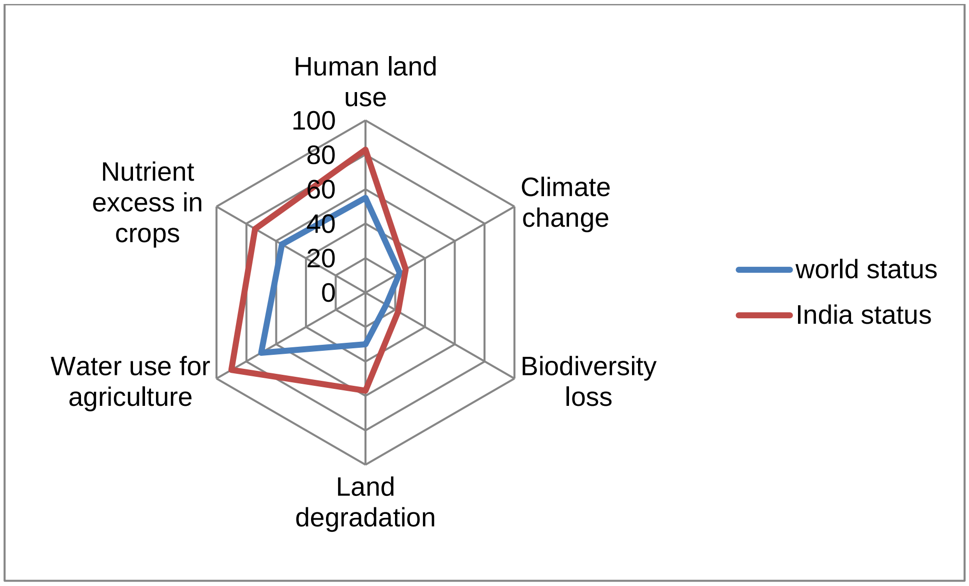

Fig:3. Different types of degradation drivers and their magnitude of impact at world and India level.

5.4 Forest Fragmentation

It is one of the major issues for forest conservation because fragmentation of forests causes serious alterations in the forest ecosystems. By many ecologists fragmentation is regarded as the main reason for biodiversity depletion worldwide [43]. Terrestrial ecosystems being most species rich are more threatened to fragmentation globally [16, 99]. The fragmented or small patchy or isolated forests are also resulted by the conversion of Intact forest area into agriculturable land [38, 44]. Habitat fragmentation is becoming the major biodiversity loss globally that brings about changes in biological and physical changes in the forest community [22, 39].

After cut off from the continous forest the isolated patches becomes species poor [103] and is the leading cause of biodiversity depletion [94]. When fragmentation is combined with native people's basic need for fuel-wood and feed, the consequences are amplified. Another impact of fragmentation is depletion and isolation of habitat area and genetic isolation [29]. Habitat fragmentation effect the interior of forest by partly or completely degrade them causing serious consequences on environment as well as species. Unfragmented areas are less affected as compared to small fragments of forests [64, 24]. Fragmentation causes edge affects [109] in the forest consequently causing vegetation desiccation, high tree desiccation [55], more forest gaps [63] leading to high hunting areas and space for invasive species.

5.5 Overgrazing

According to FSI (1999) Overgrazing in forests beyond the carrying capacity has serious impacts on natural forests for future growth [37] because due to overgrazing the natural regeneration is either poor or insufficient. Livestock_grazing (migratory cattle as well as local cattle) and forest cover are related to each other because when overgrazing increases the forest cover decreases. Free grazing practices are done for buffalo, cows and goats near rural areas by local people. Grazing of saplings is the main threat for forest regeneration which consequently causes threat to the natural vegetation and biotic pressure.

5.6 Fires

Alteration in physical environment by humans for their own welfare is not new. These alteration operations are intimately linked with use of fire [82].

Indian Forest Fires at a glance

It is presumed that humans have been practicing the use of fire on Indian subcontinents from the past 50,000 years [67, 86]. The negative consequence of fire in India was first recognized by British administration. According to Brandis (1897) at the end of 19^{th} century about one half of the mature trees in lower hills and plains are excavate out by fire [13]. Bahuguna and Upadhyay 2002, clearly categorize fire as the main cause of Indian forest degradation [8]. Government of India reported that about 5.4 % of Indian forests (35×10^{-5} km^2) are damaged by only fire. Indian forest survey report showed that total forest area vulnerable to fire in India is about 50% [36].

According to M. A. Cochrane 2003[19], at present time anthropogenic fires are more potent in moist tropical forests as compared to natural fires following all fire promoting conditions. Some of the fire incidence may be natural but according to some, [82, 12, 8, 91] all the fire activities are human induced either they may be intentional or unintentional. FAO 2007[30], also estimated that anthropogenic fires are the main among world fires by contributing about 80%. In general the forest fires can be assigned in one out of three classes: Uncontrolled fire, Controlled burning or Fire management and targeted fires to make available one or more ecosystem service [90]. In spite of remarkable negative impacts of fires on ecosystems, our understanding about the interrelation between our natural environment and anthropogenic fires are limited [11].

Heavy fire leads to loss of ecosystem services because the resilience of forests is declined by fires [102]. Forest fires consequently results into poor graded secondary forests [29], deprivation of habitats and species, changes in plant communities and trophic structures within communities [27]. It may be estimated that fire incidence may be increased in future due to increasing drought linked with global warming [92]. The particulates released by the forest fires affect nearby people as well as they can travel across the oceans thus, they may cause various carcinogenic effects on humans [13]. In India early march is considered as the main season, where forest fires are at its peak. According to the global forest watch report the highest forest fires was recorded in year 2012, with a burned land area of 6.0 Mha.

5.7 Biological invasion

Studies of Elton 1958 [28]; Burke and Grime 1996 [15], reported that the communities are more prone to biological invasion when they are already disturbed as compared to intact ecosystems. Invasive species invade the fresh habitats through open canopy environments and also through edge environments and modify the microclimate of the site consequently, causing substantial pressure and competition on existing native species [32, 85]. Thus, the success of exotic species as an invader is totally depends on the involved community [35, 48, 74] and the level of disturbance. Sometimes, invasion may initially lead to increase in diversity but as they become the colonizer of the environment the diversity starts to decreases by their competitive behaviour [50]. Invasive alien species in a given forest type causes ecosystem alterations [76,105] resulting decline in biological diversity thus, consequently reduction in ecosystem services [93].

5.8 Population Explosion and Urbanization

In developing countries like India population increament leads to agricultural expansion and overexploitation of the forest resources causing deforestation. With the rapid population explosion the people have migrated from rural to urban areas and that leads to conversion of natural lands into agricultural lands. This process of land conversion is aiming at improving the quality of life and economic development but the negative influences on ecosystems have been neglected. The process of urbanization arise the demands of people for forest products [84]. Human dominance had a severe effect on forest ecosystems. Earth's forests has eroded dramatically and shrunk by approximately 2 billion ha, since the agricultural based civilizations [72]. Humans industrially harvest trees for building materials as well as commercial gain purpose.

5.9 Climate Change

Climate change is unavoidable in today era and consequently amplify the stresses on forests through extreme environmental events, warmer temperatures and longer drought periods [52]. Climate change causes reduction in forest area thus, have serious impacts on forest ecology, ecosystem integrity and biodiversity. Climate is the main determinant in vegetation patterns and has remarkable impact on structure, distribution and ecology [56]. At local and global level the Climate change is associated with alterations in mass balances and surface energy [62]. Thus, it would be logical to dictate that patterns of distribution of forests are related with changes in climate. Globally, climate change has the impact to alter the genetic diversity of plants but, the effect is not well documented because there are a lot of complications to approach the effect of global climate change on reduction of plant genetic diversity. In spite of these complications, it is feasible to drive some forecast about the effect of climate change: especially in light of some scheme proposed by Hulme and Viner (1995) [106]. Their predictions involve an increase in mean global temperature of 0.1 °C -0.4 °C per decade, by the year 2100 the increase in temperature would be 2.7 °C, a drying shift in South and West Africa, Amazon basin and west and central Australia; an elevation in precipitation from eastern Africa to India [106].

According to Hansen et.al.2013 [44], global forest change assessment between 2000-2012 menifest that amid the four climate domains (tropical, subtropical, temperate and boreal), the Tropical forests display the highest proportion of loss to gain of total forests. Tropical forests are hitherto exhibit symptoms of stress from climate change. When the forests are deforestated in lowland plains, one of the remarkable changes occurs in climate is the shifting of cloud formation from lowland plains to high elevation areas [61]. According to the recent reports Tropical climates may be liable to changes in global climate. Tropic temperatures have been 5° cooler in last ice-age as compared to today [42, 100]. O'Brien et al. 1992 [73], imagined the effect of climate change on Future Tropical forests as they likely to experience more periodic and potent hurricanes and most of them will encounter seasonal extremes between dry and wet seasons. Rainfall in Tropical forests partly depends on the evapotranspiration of plants from standing forests [67, 86]. So, that regional climate changes might accelerate forest decline. Because fragmentation and deforestation prevent plants and animals from moving across future landscapes to find their ideal climate, they pose a very serious threat to their ability to survive.

5.10 CO2 Emission

Co2 is the main photosynthetic gas for plants and is also a greenhouse gas. The increasing concentration of co2 has biological importance for some fast growing plant species because they are pre adapted to use high resources [21]. Increase in Co2 concentration makes the plants enable to use high water efficiency [80] and increased cambial growth in trees [101, 40]. Anthropogenic emissions are the main cause of Co2 increase that directly affect plant metabolic processes [21, 54]. The Carbon plays an important role in regional and global carbon cycles as they can store a huge amount of carbon in their vegetation, soil and detritus. By storing around 60% of the carbon, forests serve as a major contributor to the global carbon cycle [110]. The photosynthesis, respiration, and carbon cycle are all disrupted when these forests are disturbed by any means [14]. Therefore, forests play a significant role in climate change as a source and sink of CO2. Thus, forests acts as both source and sink of CO2 and play important role in climate change [45]. According to IPCC estimation deforestation would liberate 140Gt of Carbon from forests from 1985 to 2100. According to Houghton et al. (1990) [49] 122-330 Gt of carbon would be liberate from 1980-2100 [106]. The release of carbon because of forest loosening in 1890-1980 was 135×10^{15} and 228×10^{15} grams.

Deforestation from unregulated logging, jhum cultivation, fire and other anthropogenic disturbances leads to reduction in carbon storage [5, 4, 33]. According to Singh & Singh 1991 [95] perennial aerial structures contains 82 % of carbon density and course roots of trees and foliage structures contains 14 % and 45% respectively in Tropical deciduous forests. According to a recent estimate by Saatchi et al., 2011 specify that out of 247 Gt vegetation carbon in tropical forests, 193 Gt are stored above ground. Currently, it appears that tropical forests are growing in biomass and removing carbon from the environment at a pace of 1.1+ 0.3 Pg C each year, which reduces the rate of global warming by around 15% [65, 66]. The terrestrial carbon has to be managed by preserving the existing carbon and creating the new sources for carbon sink for alleviating the climate change and sustainable development [18]. Depletion of deforestation, upgradation of agricultural practices and reconditioning of degraded areas would remarkably lower the atmospheric CO2 conc. and the goals for sustainable development can be achieved [47, 50].

6. MANAGEMENT & CONSERVATION OF FORESTS

The significance of a forest is easy to comprehend, but it can be difficult to measure. Forests are perhaps the most significant and important natural renewable resources on the planet, as well as storehouse of terrestrial biodiversity. These forests provide various ecosystem values such as Productive values, Protective values, Regulative values and aesthetic values.

It is highly improbable that forests can be administered as a state property system until people's reliance on the forest is decreased by providing them with better possibilities. The only way to manage forests sustainably at this time is to involve people in the process. Political and scientific interest in deciduous forests is significant, despite the fact that these forests' decline and conversion have gotten very little attention. Despite a decrease in the pace of destruction during the 1990s, forests nevertheless face a serious risk of further deterioration due to the consequences of climate change.

The Indian government understands that the long term health and wellbeing of India's natural forests is contingent on preserving and restoring the variety of natural biological ecosystems, as well as reducing exploitation rates. India significantly increased its forest area during the last couple of decades thanks to social forestry projects, however, the integrity of that cover remains a key problem.

Worldwide, the political, administrative, and structural framework promotes biodiversity management, growth, and restoration. India is also a member country of agreements and treaties, and is dedicated to biodiversity protection and sustainable forest management. There are many different types of forest management approaches, each with its own set of aims in terms of output and conservation. In its most basic form, natural forest management (NFM) entails cutting trees in such a way that the forest may spontaneously recover until another round of harvesting. In other words, NFM is based on the forest's natural regeneration abilities. In past years, the NFM has been the focal point of international development organisations' forest-related operations.

Environmental degradation is seen to be positively impacted through education. Increased levels of literacy are linked to the use of new agriculture methods as well as out-migration, resulting in less strain on forests. Education also aids in the speedier adaptation of innovative agricultural productivity-enhancing technology. Forest deterioration has been linked to a lack of local literacy and institutional finance. Rural literacy not only raises farmers' environmental awareness, but it also offers up non-farm income opportunities, reducing their reliance on communal resources like forests. In a household research, it was shown that households with greater levels of literacy clear the forest less, because they appear to reap larger agricultural yields, produce better money, have lower birth rates, and so on.

Eco-development programme is an inter and multi-stakeholder method for connecting the conservation benefits of protected areas with community people's livelihoods and development practices in the environments around them. The main objective of this programme was to get a better grasp of the challenges surrounding community involvement in animal conservation. To increase the ability of state forest administrations and other parties to engage local people in protected areas management, as well as to collaborate with variety of stakeholders to achieve consensus on combining restoration and redevelopment at the regional scale.

Since 1976, India's Government Bureau of Plant Genetic Resources (an autonomous national center) has worked to import, accumulate, and protect plant genetic resources, mostly from agriculturally and horticulturally important species. This would be interesting to examine the significance of Joint Forest Management (JFM) in contributing to the improvement of India's forests at this time. The responsibilities of the protective communities for forest areas are outlined in the JFM agreement. Societies are granted the right to gather grasses, lops and tips of branches, non-timber forest produce, and a percentage of the earnings from the selling of mature trees. Well, over 33,000 communities were created under JFM, spanning 17 states and contributing for around 81,000 sq.km of forest land, or 20% of the entire forest cover. The amount of forest land covered by JFM varies from 0.2 % in Kerala to 95.7 % in state Haryana. Haryana's high coverage rate is owing to the presence of forestland on the fringes of the state [84].

The recent Indian forest policy 2018, sets two national level bodies for the management and conservation of country's forests: Community Forest Management (CFM) and National Board of Forestry (NBF). Although community forestry is fairly recent in most nations, it began in the mid-1980s to 1990s. Community forestry has the shared aims of enhancing forest ecosystem functions and supporting ecologically sustainable forest management methods, as well as boosting forest communities' availability to and influence over neighbouring trees.

Based on the main land use, state-managed forests are further categorised into three categories: restricted, protected, and unclassified forestry. 85% of all the forests in India are reserved, which have the strictest limitations on resource use. 10% of India's forested land is covered under protected forests, which offer certain resource usage authorizations and licences. The remaining 5% of India's forested area is made up of unclassified woods, some of which are waiting to be designated as restricted or protected.

7. CONCLUSION & A WAY FORWARD

There are compelling evidences that present and historical methods of managing forests are not the best for attaining sustainability. Many people struggle to attain social and ecological sustainability, and as a result, they inevitably struggle to achieve economic sustainability. Frequently, clearance and land conversion to non-forest uses are the outcome. This void is filled by outlawing operations like heavy tree cutting, cutting saplings, and gathering tree bark and branches, therefore fast action is required to protect against these risks. It's important to monitor the conversion of grazing area to agricultural land. The pasture and grassland should be planted with the best palatable plants and grasses possible; this will aid in the area's regeneration and supply sufficient and nourishing feed. With the assistance of the local population, the grazing area should be well managed and the fodder should be conserved. To hasten the processes of tree, shrub, herb, and grass regeneration, scientific approaches should be used. Establishing nurseries, fodder banks, and stall feeding should be done to increase the output of fodder and pelletize nutritional grasses. Natural forests, especially well-kept tropical forests, are increasingly seen as a benefit to the environment on a worldwide scale. Therefore, it is necessary to address the cost and compensation concerns. In order to prevent residents of tropical forest regions from being compelled to utilise or destroy the remaining wooded lands in an inefficient manner, the global community should be willing to pay or compensate them.

One sort of sustainability in a managed forest is the system of several landowners, each with a modest multifunctional, multispecies plot. However, a trend toward more cash crops is endangering it. This exemplifies the dilemma of managing the landscape. At the forest garden or jungle rubber level, for example, people have little impact on the local environment, therefore it is possible to create a management system that is ethical, financially viable, socially responsible, and politically acceptable. These systems can endure if they are protected from outside influences or kept free from them, but they are extremely vulnerable to disturbance from outside inputs or demands. Population expansions, which is frequently the consequences of outside factors, and the ensuing demand for cash crops take control of these people's ability to make decisions away from them. The bigger businesses dependent on clearing native forests, however, show signs of improvement in the direction of more sustainability. A shift toward whole-landscape management is required, with a focus on places with high levels of usage mixed with areas principally maintained for conservation, recreation, and water catchment. Some guidelines are being created, but more interactions between ecologists, foresters, social scientists, and economists are urgently needed.

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