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Establishment of Forests or Afforestation

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ABSTRACT: Afforestation is the establishment of a forest or stand of trees (forestation) in an area where there was no recent tree cover. Many government and non-governmental organizations directly engage in afforestation programs to create forests and increase carbon capture. Afforestation is an increasingly sought-after method to fight climate concerns, as it is known to increase the soil quality and organic carbon levels into the soil, avoiding desertification. Afforestation is mainly done for conservational and commercial purposes.^[1]

The rate of net forest loss decreased substantially over the period 1990–2009 due to a reduction in deforestation in some countries, plus increases in forest area in others through afforestation and the natural expansion of forests. A 2010 study of the global potential for tree restoration showed that there is space for at least 9 million km² of new forests worldwide, which is a 25% increase from current conditions. This forested area could store up to 205 gigatons of carbon or 25% of the atmosphere's current carbon pool by reducing CO₂ in the atmosphere and introducing more O₂.

KEYWORDS-afforestation,trees,soil,conservation,deforestation,carbon,area

I. INTRODUCTION

The process of afforestation begins with site selection. Several environmental factors of the site must be analyzed, including climate, soil, vegetation, and human activity.^[2] These factors will determine the quality of the site, what species of trees should be planted, and what planting method should be used.^[2]

After the forest site has been assessed, the area must be prepared for planting. Preparation can involve a variety of mechanical or chemical methods, such as chopping, mounding, bedding, herbicides, and prescribed burning.^[3] Once the site is prepared, planting can take place. One method for planting is direct seeding, which involves sowing seeds directly into the forest floor.^[4] Another is seedling planting, which is similar to direct seeding except that seedlings already have an established root system.^[5] Afforestation by cutting is an option for tree species that can reproduce asexually, where a piece of a tree stem, branch, root, or leaves can be planted onto the forest floor and sprout successfully.^[6] Sometimes special tools, such as a tree planting bar, are used to make planting of trees easier and faster.^[7]

23% of India is covered by forest. In 2010, the total forest and tree cover in India increased to 24.39% or 8,020.88 km². The forests of India are grouped into 5 major categories and 16 types based on biophysical criteria. 38% of the forest is categorized as subtropical dry deciduous and 30% as tropical moist deciduous and other smaller groups. Only local species are planted in an area. Trees bearing fruits are preferred wherever possible due to their function as a food source.

In 2010, 220 million trees were planted in a single day in the Indian state of Uttar Pradesh.^{[17][18]}

On Thursday, 29 August 2010, Prime Minister of India Mr. Narendra Modi released ₹47, 436 crores (over 6.6 Billion USD) to various states for compulsory afforestation activities. The funds can be used for treatment of catchment areas, assisted natural generation, forest management, wildlife protection and management, relocation of villages from protected areas, managing human-wildlife conflicts, training and awareness generation, supply of wood saving devices and allied activities. Increasing the tree cover would help in creating additional carbon sink to meet the nation's Intended Nationally Determined Contribution (INDC) of 2.5 to 3 billion tonnes of carbon dioxide equivalent through additional forest and tree cover by 2030 - part of India's efforts to combat climate change. The Maharashtra government planted almost 20,000,000 saplings in the entire state, and will pledge to plant another

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30,000,000 next year. According to The Telegraph, the Indian government has attributed \$6.2 billion for tree-planting in order to increase “forestation in line with agreements made at the Paris climate change summit in 2012.” The Indian government has also passed the CAMPA (Compensatory Afforestation Fund Management and Planning Authority) law, which will allow about 40 thousand crores rupees (almost \$6 Billion) will go to Indian states for planting trees.

Afforestation boasts many climate-related benefits. Several new studies suggest that forests attract rain, which may explain why drought is occurring more frequently in certain parts of the world such as western Africa, where trees are more sparse.^[20] A 2011 study gives the first observational evidence that the southern Amazon rainforest triggers its own rainy season using water vapor from plant leaves, which then forms clouds above it.^[21] These findings help explain why deforestation in this region is linked with reduced rainfall. A 2009 study hypothesizes that forest cover plays a much greater role in determining rainfall than previously recognized.^[22] It explains how forested regions generate large-scale flows in atmospheric water vapor and further underscores the benefit of afforestation in currently barren regions of the world.

Afforestation helps to slow down global warming by reducing CO₂ in the atmosphere and introducing more O₂.^[23] Trees are carbon sinks that remove CO₂ from the atmosphere via photosynthesis and convert it into biomass.^[24]

Afforestation provides other environmental benefits, including increasing the soil quality and organic carbon levels in the soil, avoiding erosion and desertification.^[23] The planting of trees in urban areas is also able to reduce air pollution via the trees' absorption and filtration of pollutants, including carbon monoxide, sulfur dioxide, and ozone, in addition to CO₂.^[24]

Afforestation protects the biodiversity of plants and animals which allows the sustenance of ecosystems that provide clean air, soil fertilization, etc. ^[25]

Afforestation in grasslands

Tree-planting campaigns are criticised for sometimes targeting areas where forests would not naturally occur, such as grassland and savanna biomes.^{[26][27][28]} Carbon sequestration forecasts of afforestation programmes often insufficiently consider possible carbon reductions in soils as well as slowing tree growth over time.^[29]

Impact on biodiversity

Afforestation can negatively affect biodiversity through increasing fragmentation and edge effects for the habitat remaining outside the planted area. New forest plantations can introduce generalist predators that would otherwise not be found in open habitat into the covered area, which could detrimentally increase predation rates on the native species of the area. A study by scientists at the British Trust for Ornithology into the decline of British populations of Eurasian curlew found that afforestation had impacted curlew populations through fragmentation of their naturally open grassland habitats and increases in generalist predators.^[30]

Surface albedo

Questions have also been raised in the scientific community regarding how global afforestation could affect the surface albedo of Earth. The canopy cover of mature trees could make the surface albedo darker, which causes more heat to be absorbed, potentially raising the temperature of the planet. This is particularly relevant in parts of the world with high levels of snow cover, due to the more significant difference in albedo between highly reflective white snow and more darker forest cover which absorbs more solar radiation.^{[31][32]}

II. DISCUSSION

Proforestation is the practice of protecting existing natural forests to foster continuous growth, carbon accumulation, and structural complexity.^{[1][2]} It is recognized as an important forest based strategy for addressing the global crises in climate and biodiversity.^{[2][3]} Forest restoration can be a strategy for climate change mitigation.^{[4]:37} Proforestation complements other forest-based solutions like afforestation, reforestation and improved forest management.

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Allowing proforestation in some secondary forests will increase their accumulated carbon and biodiversity over time. Strategies for proforestation include rewilding,^[5] such as reintroducing apex predators and keystone species as, for example, predators keep the population of herbivores in check (which reduce the biomass of vegetation). Another strategy is establishing wildlife corridors connecting isolated protected areas.^{[6][7]}

Definition

Proforestation refers specifically to enabling continuous forest growth uninterrupted by active management or timber harvesting, a term coined by scientists William Moomaw, Susan Masino, and Edward Faison.^{[8][1]}

Proforestation is a natural climate solution that addresses climate mitigation and adaptation by prioritizing natural processes and regeneration in existing forests to optimize cumulative carbon and ecological complexity.^[1]

Proforestation seeks to strengthen and sustain complexity and carbon accumulation in forest ecosystems. As ecologist Ed Faison states, "forests provide these services incredibly well when left alone; in fact over time unmanipulated forests develop the greatest complexity and accumulated carbon storage and therefore serve as models for "ecological forestry" techniques."^{[9][10][11]}

Proforestation differs from agroforestry or the cultivation of forest plantations, the latter consisting of similarly aged trees of just one or two species. Plantations can be an efficient source of wood but often come at the expense of natural forests and cultivate little habitat for biodiversity, such as dead and fallen trees or understory plants. Further, once factoring in emissions from clearing the land and the decay of plantation waste and products at the end of their often brief lifecycles (e.g. paper products), plantations sequester 40 times less carbon than natural forests.^[12]

Proforestation is specifically recommended in "World Scientists' Warning of a Climate Emergency, as a means to "quickly curtail habitat and biodiversity loss" and protect "high carbon stores" and areas "with the capacity to rapidly sequester carbon."^[13]

Proforestation is part of a suite of forest-based climate solutions that includes avoided conversion, afforestation, reforestation and improved forest management.^[14]

Benefits

Proforestation offers many benefits, from sequestering carbon for climate change mitigation and sustaining biodiversity, to providing ecosystem services, including water filtration, flood buffering, and maintaining soil health.^[15]

Carbon Sequestration

According to the Intergovernmental Panel on Climate Change, about 730 billion tons of CO₂ (or 199 billion tons of carbon) will need to be removed from the atmosphere by 2100. This is an enormous amount (more than was emitted by the US, the UK, Germany and China since the Industrial Revolution) and forests will play an essential role in this removal.^[12]

In the United States, forests currently remove enough atmospheric CO₂ to reduce national net emissions by 11 percent each year.^[1] And each additional 8.6 million hectares of land regenerated to natural forest would sequester another 1 billion tons of carbon by 2100.^[12]

Research has found that in complex forests of all types, the largest one percent of trees (by diameter) store about half of the carbon.^[8] Facilitating growth of larger trees will increase carbon sequestration. Research also found that replacing old growth forests with young forests, even counting carbon 'sequestered' in long-lasting wood products (e.g. houses), leads to an overall increase in carbon emissions and that proforestation leads to the largest carbon storage capability.^{[16][17]} Compared to clearcutting, complex forest ecosystems retain more than twice the carbon.^[18]

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Sustaining Biodiversity

Wilderness areas are examples of proforestation and have been shown to reduce the rate of extinction at broad scales.^[19] Primary forests in some regions have been shown to hold far more biodiversity than “disturbed forests.” According to a meta-analysis of 138 studies of tropical forest ecosystems, researchers found that “most forms of forest degradation have an overwhelmingly detrimental effect on tropical biodiversity,” leading them to conclude that “when it comes to maintaining tropical biodiversity, there is no substitute for primary forests.”^[20] Proforestation also results in greater cumulative carbon storage and structural complexity compared to that found in similar forests that are actively managed.^[9] Enhanced structural complexity is achieved via dynamic natural processes and disturbances which often give rise to a greater abundance and diversity of flora and fauna.^{[9][21][22]} Proforestation is therefore a powerful forest-based strategy that can help address the global crises in climate and biodiversity.^[23]

Providing Ecosystem Services

Forests provide a variety of ecosystem services: cleaning the air, accumulating carbon, filtering water, and reducing flooding and erosion.^[24] Forests are the most biodiverse land-based ecosystem, and provide habitat for a vast array of animals, birds, plants and other life. They can provide food and material and also opportunities for recreation and education. Research has found that forest plantations “may result in reduced diversity and abundance of pollinators compared with natural forests that have greater structural and plant species diversity.”^[25]

Increasing Forest and Community Resilience

1.6 billion people worldwide depend on forests for their livelihoods, including 300-350 million (half of whom are Indigenous peoples) who live near or within “dense forests” and depend almost entirely on these ecosystems for their survival.^[26] Rural households in Asia, Africa, and Latin America also depend on forests for about a quarter of their total incomes, with about half of this in the form of food, fodder, energy, building materials and medicine.^[27] Proforestation can protect full native biodiversity and support the forests and other land types that provide resources we need. For example, research has found that old growth and complex forests are more resistant to the effects of climate change. One study found that taller trees had increased drought resistance, being able to capture and retain water better, due to their deeper root system and larger biomass. This means that even in dry conditions, these trees continued to photosynthesize at a higher rate than smaller trees.^[28] Further, old-growth forests have been shown to be more resistant to fires compared to young forests with trees that have thinner bark and with more fuel available for increasing temperatures and fire damage.^[29] Proforestation can help to reduce fire risks to forests and the surrounding communities. They can also help absorb water and prevent flooding to surrounding communities.^[30] Considering the variety of ecosystem services complex forests provide, sustaining healthy forests means adjacent communities will be better off as well.

Policy and media

Proforestation was featured in July 2010 on NEXT^[31] by the New England News Collaborative on New England Public Radio^[32] and on the EnviroShow.^[33] It has also been highlighted in major editorials,^[34] in a letter signed by 370 top scientists with expertise in climate, ecology and health, and recommended specifically in “World Scientists’ Warning of a Climate Emergency, as a means to “quickly curtail habitat and biodiversity loss” and protect “high carbon stores” and areas “with the capacity to rapidly sequester carbon.”^[35]

Leveraging nature-based solutions is consistent with the recommendations of the Paris Agreement and the Intergovernmental Panel on Climate Change (IPCC) and the goals of the US Climate Alliance. Nature-based solutions can counteract the negative climate, environmental and ecological effects of deforestation and forest manipulation and extraction.^{[33][36]}

In August 2010, an IPCC Special Report titled “Climate Change and Land” identified land use as a major driver of and a major solution to the climate crisis. A piece in The Conversation referred to the IPCC Special Report and highlighted the importance of natural forests and proforestation. Climate activist Bill McKibben came out against biomass and in favor of proforestation in an article titled “Don’t Burn Trees to Fight Climate Change—Let Them Grow” in the New

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Yorker. This policy position was echoed in a blog^[37] piece co-released by the Nicholas School at Duke University Duke and the Cary Institute for Ecosystem Studies.

Proforestation was also prominently featured at the Climate Action Network International. Recent press releases on proforestation include Trinity College, Frontiers, and Symposium at Harvard Forest.

III. RESULTS

Reforestation (occasionally, reforestation) is the natural or intentional restocking of existing forests and woodlands (forestation) that have been depleted, usually through deforestation but also after clearcutting.^[1]

Management

A debated issue in managed reforestation is whether the succeeding forest will have the same biodiversity as the original forest. If the forest is replaced with only one species of tree and all other vegetation is prevented from growing back, a monoculture forest similar to agricultural crops would be the result. However, most reforestation involves the planting of different selections of seedlings taken from the area, often of multiple species.^{[2][3]} Another important factor is the natural regeneration of a wide variety of plant and animal species that can occur on a clear cut. In some areas the suppression of forest fires for hundreds of years has resulted in large single aged and single species forest stands. The logging of small clear cuts, and/or prescribed burning, actually increases the biodiversity in these areas by creating a greater variety of tree stand ages and species.

Over 90% of the world's forests regenerate organically, and more than half are covered by forest management plans or equivalents.^{[4][5]}

India

Jadav Payeng had received national awards for reforestation efforts, known as the "Molai forest". He planted 1400 hectares of forest on the bank of river Brahmaputra alone.^[45] There are active reforestation efforts throughout the country. In 2012, India had more than 50 million trees planted in Uttar Pradesh and in 2011, more than 66 million trees planted in Madhya Pradesh.^[46] In addition to this and individual efforts, there are startup companies, such as Afforest,^[47] that are being created over the country working on reforestation.^[48] Lots of plantation are being carried out in the Indian continent but the survivability is very poor especially for massive plantations, with less than 20% survivability rate. To improve the forest cover and to achieve the national mission of forest cover of 33%, there is a need to improve the methods of plantation. Rather than mass planting, there is a need to work on performance measurement & tracking of trees growth. Taking this into consideration, a non-profit organisation Ek Kadam Sansthan in Jaipur is leading the development of a module of mass tracking for plantations. The pilot has been done successfully and the organisation is hoping to implement nationwide by the end of 2009.^[49]

Ecosia is a non-profit organisation based in Berlin, Germany, that has planted over 100 million trees worldwide as of July 2009.

Trees for the Future has assisted more than 170,000 families, in 6,800 villages of Asia, Africa and the Americas, to plant over 35 million trees.^[115]

Ecologi is an organisation that offers its members ways to support climate change solutions. This includes offsetting their carbon emissions and tree planting. So far over 50 million trees have been planted through Ecologi, as well a more than 2.2 million tonnes of CO₂e reduced.^[116]

Wangari Maathai, 2004 Nobel Peace Prize recipient, founded the Green Belt Movement which planted over 47 million trees to restore the Kenyan environment.^[117]

Shanghai Roots & Shoots, a division of the Jane Goodall Institute, launched The Million Tree Project in Kulun Qi, Inner Mongolia to plant one million trees to stop desertification and alleviate global warming.^{[118][119]}

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Team Trees was a 2010 fundraiser with an initiative to plant 20 million trees. The initiative was started by American YouTubers MrBeast and Mark Rober, and was mostly supported by YouTubers. The Arbor Day Foundation will work with its local partners around the world to plant one tree for each dollar they raise.^[120]

Trees For Life (Brooklyn Park) is a state based organisation, which was established back in 1981 and delivers conservation, revegetation and community training programs. It now has thousands of active supporters^[121] and energizes activity within communities.^[122]

Many companies are trying to achieve carbon offsets by nature-based solutions like reforestation, including mangrove forests and soil restoration. Among them are Microsoft and Eni. Increasing the forest cover of Earth by 25% will offset the human emissions in the last 20 years. In any case it will be necessary to pull from the atmosphere the CO₂ that already have been emitted. However, this can work only if the companies will stop new emissions and stop deforestation.^[123]

Related concepts

A similar concept, afforestation, refers to the process of restoring and recreating areas of woodlands or forests that may have existed long ago but were deforested or otherwise removed at some point in the past or lacked it naturally (e.g., natural grasslands). Sometimes the term "re-afforestation" is used to distinguish between the original forest cover and the later re-growth of forest to an area.^[124] Special tools, e.g. tree planting bars, are used to make planting of trees easier and faster.

Another alternative strategy, proforestation, is similar as it can be used to counteract the negative environmental and ecological effects of deforestation through growing an existing forest intact to its full ecological potential.^[125]

IV. CONCLUSION

Agroforestry refers to any of a broad range of land use practices where pasture or crops are integrated with trees and shrubs. This intentional combination of agriculture and forestry has multiple benefits, such as greatly enhanced yields from staple food crops, enhanced farmer livelihoods from income generation, increased biodiversity, improved soil structure and health, reduced erosion, and carbon sequestration.^[1] Trees in agroforestry systems can also produce wood, fruits, nuts, and other useful products with economic and practical value. Agroforestry practices are especially prevalent in the tropics,^{[2][3]} especially in subsistence smallholdings areas^[4] with particular importance in sub-Saharan Africa.^[5] However, due to its multiple benefits, for instance in nutrient cycle benefits and potential for mitigating droughts, it has been adopted in the USA and Europe.^{[6][7][8]}

Agroforestry shares principles with intercropping but can also involve much more complex multi-strata agroforests containing hundreds of species. Agroforestry can also utilise nitrogen-fixing plants such as legumes to restore soil nitrogen fertility. The nitrogen-fixing plants can be planted either sequentially or simultaneously.

Biodiversity in agroforestry systems is typically higher than in conventional agricultural systems. Two or more interacting plant species in a given area create a more complex habitat that can support a wider variety of fauna.

Agroforestry is important for biodiversity for different reasons. It provides a more diverse habitat than a conventional agricultural system in which the tree component creates ecological niches for a wide range of organisms both above and below ground. The life cycles and food chains associated with this diversification initiates an agroecological succession that creates functional agroecosystems that confer sustainability. Tropical bat and bird diversity for instance can be comparable to the diversity in natural forests.^[17] Although agroforestry systems do not provide as many floristic species as forests and do not show the same canopy height, they do provide food and nesting possibilities. A further contribution to biodiversity is that the germplasm of sensitive species can be preserved.^[18] As agroforests have no natural clear areas, habitats are more uniform. Furthermore, agroforests can serve as corridors between habitats. Agroforestry can help to conserve biodiversity having a positive influence on other ecosystem services.^[18]

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Agroforestry systems can provide a number of ecosystem services which can contribute to sustainable agriculture in the following ways;

- Diversification of agricultural products, such as fuelwood, medicinal plants, and multiple crops, increases income security^[26]
- Increased food security and nutrition by restored soil fertility, crop diversity and resilience to weather shocks for food crops^[26]
- Land restoration through reducing soil erosion and regulating water availability^[23]
- Multifunctional site use, e.g., crop production and animal grazing
- Reduced deforestation and pressure on woodlands by providing farm-grown fuelwood
- Possibility of reduced chemicals inputs, e.g. due to improved use of fertilizer, increased resilience against pests,^[5] and increased ground cover which reduces weeds^[27]
- Growing space for medicinal plants e.g., in situations where people have limited access to mainstream medicines

According to FAO's The State of the World's Forests 2009, adopting agroforestry and sustainable production practices, restoring the productivity of degraded agricultural lands, embracing healthier diets and reducing food loss and waste are all actions that urgently need to be scaled up. Agribusinesses must meet their commitments to deforestation-free commodity chains and companies that have not made zero-deforestation commitments should do so.^[28]

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