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Tikendrajit Saikia
Department of Soil Science, Assam Agricultural University, Jorhat, Assam, India

Jahnabi Hazarika
Department of Soil Science, Assam Agricultural University, Jorhat, Assam, India

Kishore Kumar Kurmi
Department of Seed Science and Technology, Assam Agricultural University, Jorhat, Assam, India

Dipankar Gogoi
Department of Seed Science and Technology, Assam Agricultural University, Jorhat, Assam, India

Corresponding Author:
Tikendrajit Saikia
Department of Soil Science, Assam Agricultural University, Jorhat, Assam, India

Seed Bomb: A new approaches of afforestation: An overview

Tikendrajit Saikia, Jahnabi Hazarika, Kishore Kumar Kurmi and Dipankar Gogoi

Abstract
Multiple worldwide dangers now confront humanity. They consist of a pandemic and the resulting economic turmoil, food insecurity, poverty, climate change, conflicts, degradation of land and water, and a decline in biodiversity. When the planet is not healthy, neither the economy nor the people can thrive. Climate change, biodiversity loss, and the appearance of new diseases are all exacerbated by environmental degradation. Trees and forests have the potential to play crucial roles in mitigating these crises and fostering the transition to more sustainable economic models. The United Nations Strategic Plan for Forests sets a goal of increasing forest area by 3 percent worldwide by 2030, however the world is not on track to fulfil this target (FAO, 2022). Afforestation projects are essential for forest management, and as a result, they can aid in the fight against global warming and assist build climate resilience in areas where a sizable population depends on trees for survival. Forests and trees offer obvious potential as large-scale, cost-effective, and fair solutions that may be adopted quickly. Greening of fragmented and degraded lands is accomplished at cheap cost by seed ball multiplication. This method can counteract the effects of biotic and abiotic stresses that reduce seed germination and viability. Even in low-supply environments, it can be put to good use to improve seedling germination, growth, and survival.

Keywords: afforestation, climate change biodiversity, seed ball

Introduction
The COVID-19 pandemic has increased the difficulty and urgency of efforts to end world hunger and extreme poverty. The most susceptible members of society have been disproportionately affected by the pandemic and the methods taken to contain it, hence it is imperative that the recovery process address these issues. Much of humanity's growth has already endangered ecosystems before the pandemic. Environmental degradation and the climate problem are caused in part by expanded agricultural production practises, such as the cutting down of forests to make room for additional farmland. The current methods of producing agricultural foods cannot be maintained indefinitely.
Trees will unavoidably be a significant part of the solution as the world works to mitigate the effects of climate change, protect endangered species, and provide for billions of people. Still, deforestation at an industrial scale persists, trading the long-term benefits of living trees for the short-term gains of timber. There are few ecosystems as rich in biodiversity as forests, making forest ecosystems an essential part of global biodiversity.
About 31% of the Earth is still covered by forests, making up about 4.06 billion hectares, however this number is rapidly decreasing. Although the rate of deforestation has reduced over the previous three decades, it is estimated that 420 million hectares of forest have been lost since 1990 due to conversion to other land uses. The rate of deforestation is predicted to slow to 10 million hectares annually between 2015 and 2020, from 16 million hectares annually in the 1990s. The world's primary forest has shrunk by more than 80 million hectares since 1990. Between 2000 and 2020, almost 47 million hectares (ha) of primary forests were destroyed. Between 1990 and 2020, a total of 178 million hectares of forest cover were lost worldwide. That's roughly the size of Libya as a whole. Around 80% of the world's amphibian species, 75% of the world's bird species, and 68% of the world's mammal species rely on forests for their survival, while about 60% of the world's vascular plant species may be found in tropical forests. More over 700,000,000 hectares (18% of the total forest area) are designated as protected areas by law. Forest biodiversity, however, continues to be threatened by deforestation and forest degradation. Deforestation, forest fragmentation, and biodiversity loss

in forests continue to be mostly driven by agricultural development. Efforts to improve the conservation status of species that are already in danger of going extinct have progressed slowly.

Fighting global warming is one of the primary functions of trees and forests. More than half of the world's carbon reserve in soils and vegetation is found in forests, which contain 662 billion tonnes of carbon. From 2011 to 2020, forests absorbed more carbon than they released due to replanting, improved forest management, and other factors, despite a continuing decline in area. Other ways in which forests contribute to global warming are through their effects on albedo, atmospheric water vapour, and aerosol emissions. Major regional consequences on rainfall, and thus on rainfed agriculture, could result from deforestation in the Amazon and the African tropics. Forests can have significant local to regional impacts on climate; for instance, trees in urban settings can reduce land surface temperatures in Central Europe by as much as 12 °C in the summer and during heat extremes.

The United Nations Strategic Plan for Forests has set a goal of increasing forest area by 3 percent worldwide by 2030, however the world is not on track to fulfil this target. The COVID-19 epidemic severely impacted forest value chains and trade in the start of 2020. Although business as usual was rapidly resumed in most areas, the possibility of further epidemics must be considered. Green recovery can greatly benefit from forestry's established position. There is a strong relationship between the two goals of feeding the world's population and preserving and utilizing ecosystems responsibly.

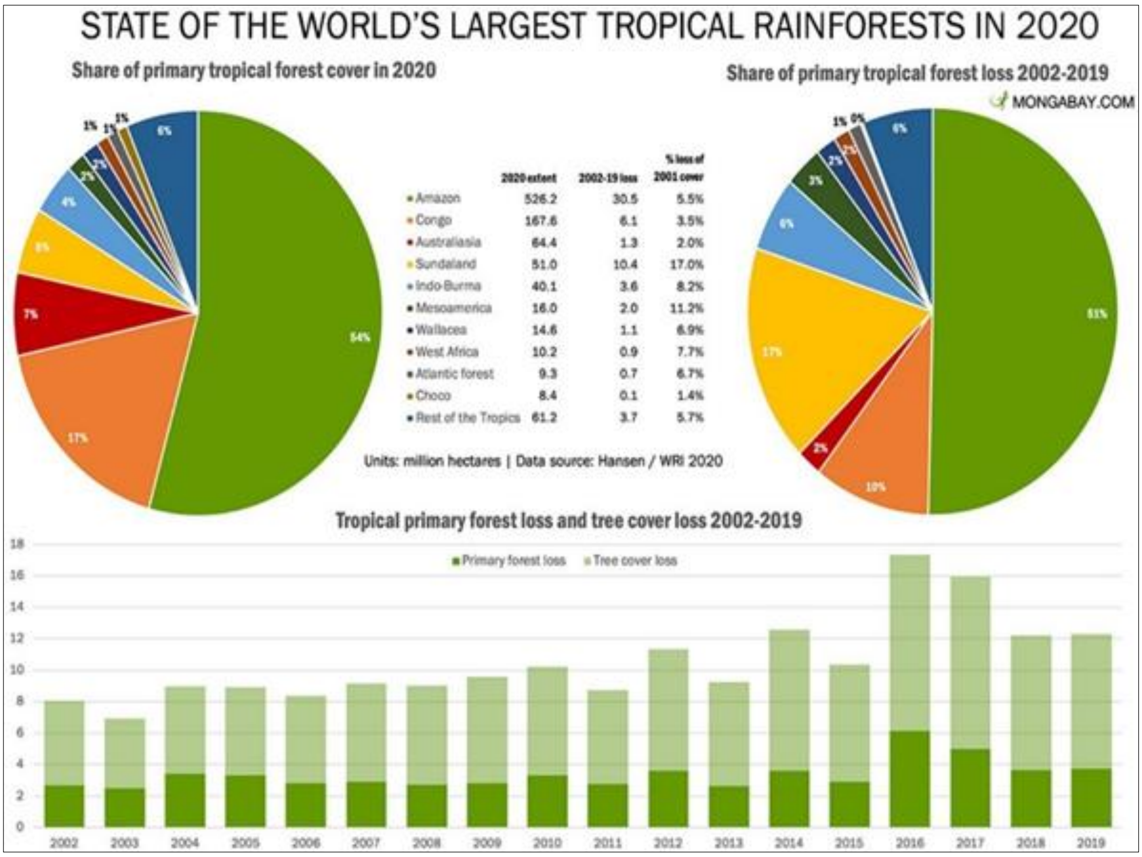

Fig 1: Chart showing the state of primary forests in the tropics (Hansen/WRI 2020)

Afforestation-the way forward

The Kyoto Protocol defines afforestation as human-induced conversion of land that has not been wooded for at least 50 years to forested land (UNFCCC, 2006) [12]. Unlike deforestation, reforestation involves replanting trees in deforested areas.1.6 billion people depend on forests for subsistence, livelihoods, jobs, and income, and 60 million to 200 million indigenous people are nearly entirely dependent on forests (Chao, 2012) [3]. A/R initiatives manage forests and battle global warming and climate change by helping huge populations survive. Climate change exacerbates inequalities and disproportionately impacts underprivileged populations and countries with low human and technological resources (Islam and Winkel, 2017; UNCTAD, 2018) [5, 10]. It can also create negative feedback loops since people must put more pressure on forests to survive. In this regard, the continued fall in forest area in low- and middle-income nations from 1990 (33.72%) to 2016 (31.93%) requires immediate attention (World Bank, 2016) [13].

Forest management can reduce zoonotic disease spread. Approximately 60% of infectious diseases in humans are zoonotic, caused by germs from animals (UNEP, 2016) [11]. Deforestation and degradation of natural habitats like forests reduce buffer zones that separate humans and animals, increasing the risk of zoonotic infections spreading between animals and humans (Bloomfield *et al.*, 2020; Brancalion *et al.*, 2020) [1, 2]. Forest fragmentation indirectly promotes bushmeat hunting, wet markets, poaching, illegal wildlife trading, and wild animal pathogen harbouring, which can transmit pathogens to humans (Plowright *et al.*, 2020) [8]. Multiple studies in Uganda and Cote d'Ivoire have shown how the destruction of tropical forests increased the danger of people coming into contact with wild primates and their viruses (Bloomfield *et al.*, 2020) [1].

Deforestation has a considerable impact on zoonotic diseases, even though COVID-19 is not a primary cause. Forest management planning and rational Judgements should be coupled with zoonotic pathogen transmission research to reduce disease spreads. Given the importance of A/R programmes in achieving UN SDGs and preventing future zoonotic diseases, alternative monitoring methods and policy paradigms must be introduced without delay to address the unprecedented challenges conservation agencies faced during the COVID-19 pandemic, especially in developing and LDCs (Mohan *et al.*, 2021) [6]. Seed ball propagation is inexpensive, protects seeds from predation, and provides a favourable seedling habitat, making it successful at upscaling regeneration at damaged sites.

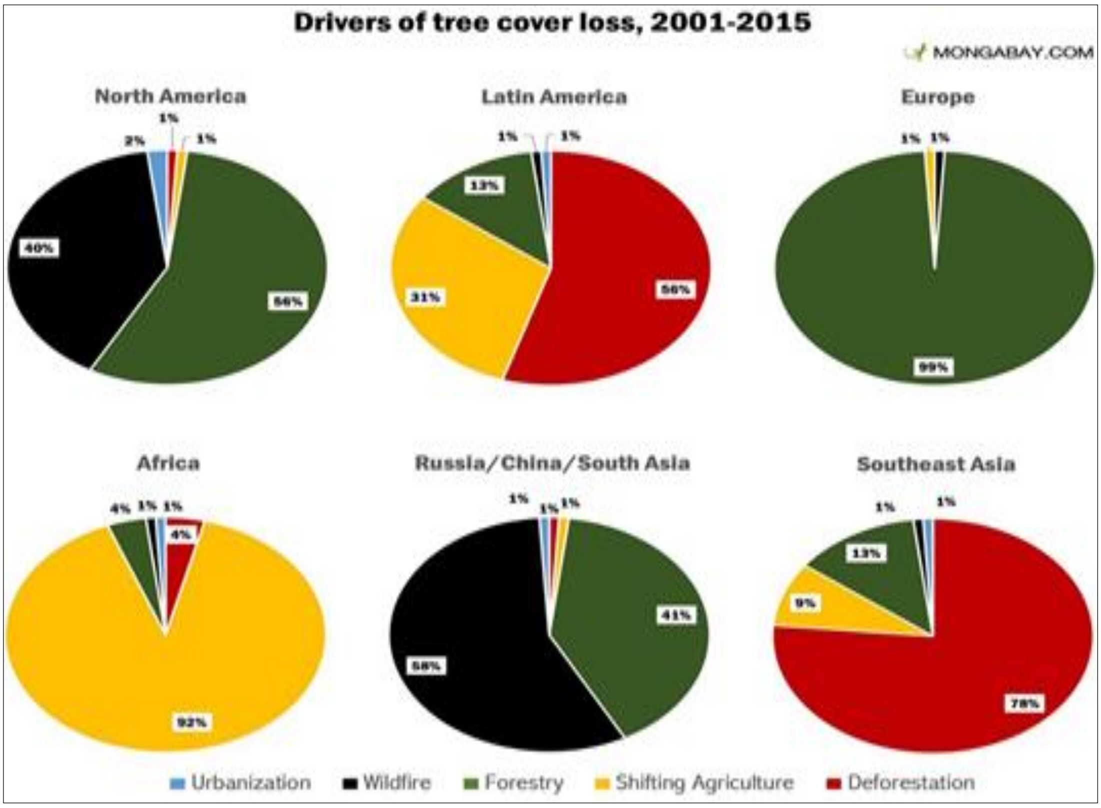

Fig 2: Pie chart showing tree cover loss by region (Curtis *et al*., 2018)

Seed bomb-the need of the hour

Propagating a native species by the use of seed balls, also known as seed bombs, is a simple and long-lasting method because it creates an ideal environment for seed germination and allows for more time for seedlings to multiply.

Masanobu Fukuoka, a Japanese pioneer in natural farming, rediscovered the method of making seed balls. The concept of aerial replanting was inspired by the traditional Japanese custom of Tsuchi Dango (earth dumpling).

Tamilarasan *et al.*, 2021 [9] reported that the seed ball technique proved to be low cost and can be used to recover vegetation in deforested areas. This technique can overcome biotic and abiotic stresses which hinder seed germination and viability. It can be effectively utilized for better seedling establishment, vigour and survival even in resource-limited conditions. Under non- irrigated condition, seed ball performed better then control. The nutrients in the seed ball medium provided additional nutrients and growth promoting factors for enhancing the establishment and survival rate of the seedings.

Suitable Time for Seed Ball Preparation and Propagation: Seed balls can be propagated before monsoon on damp soil based on climatic calendars of the respective country. By October, winter-planting seed balls should be ready. Seed ball propagation should be done after two to three days of rain in drier areas. At monsoon, coastal seed ball propagation should begin. Late propagation may fail.

Criteria for selection of site: A site survey should be conducted before selection of plant species for making seed balls. In coastal areas neem seed may not germinate and grow easily. The seeds should be collected from local vendors or from forest areas. The viability and germination percentage of seeds should be assessed before making a seed ball. In annual grass or legume species, seed should not be older than one year.

Suitable Species for Seed Ball Propagation: Seeds of native species from same climatic conditions must be selected for making seed balls. This improves the chances of germination. Native trees species should be selected for propagation along highways, avenue plantation etc. Along railway tracks tree *sps.* are not advised, as during cyclone or monsoon it may fall on it. Deep rooted, non-palatable, nature ornamental shrubs are most suitable for these areas. In tree *sps. viz*. Neem, Ficus sps. seeds may be collected, shade dried and propagated in same year.

Pre-treatment of Seeds: Some seeds remain dormant in soil after propagation due to the immature embryo, chemicals on seed coat or hard seed coat. These types of seeds require pretreatment. Annual grass and herbaceous legume seeds do not require pretreatment. In leguminous trees, mechanical scarification, hot water scarification, soaking in cold water and acid scarification improves the seed germination. After scarification seeds should be shade dried to remove the traces of moisture. It reduces the chances of pre germination of seeds in seed ball.

Preparation of seed balls: Well drained native soil should be collected and sieved from 0.075 mm (200 no.) sieve to get clay particles. Clay, organic fertilizer, and perlite/vermiculite should be mixed well as per convenience in the ratio of 1:0.5:0.25. A culture of beneficial microorganisms *viz*. N fixers, P solubilizers and mobilizers should be added for improving the germination of seeds and growth of seedling even in adverse conditions. By adding *Trichoderma sp.*, the occurrence and infestation of root zone pests and diseases can be reduced. Water must be added in the seed ball substrate to prepare dough. If dough is very sticky, cocopeat may be mixed. 1 kg substrate can make 90-100 balls of 0.5 to 1inch that may accommodate 2-4 seeds depending on the size of seed. In 5000 kg of substrate 5,00,000 seed balls can be prepared in advance before propagation. Seed balls must be air dried for 24-48 hours in a shade before sowing or storing.

Methods of seed balls application

Dibbling Method: In the first method, called "dibbling," a dibbler (either a metal rod or a bamboo stick) is used to drop seed balls in a hole or cavity at regular intervals. To find a level area, usually a plain landscape can be selected. Such places include the side of the road, a garden, a patch of grass, etc. Depending on the desired plantation and the desired number of tiers or rows of propagation, the seed balls can be propagated in a variety of shapes and patterns, such as a triangle, a square, a single hedge, a double hedge, etc.

Broadcasting/aerial throwing: In order to grow the most grass possible on knolls and other inhospitable, strewn landscapes, it is advised to use aerial throwing. Seed balls can be dispersed by hand or by being dropped from a helicopter or a drone; neither ploughing nor digging of pits is necessary. Seeds need a particular climate for optimum germination and survival, and it covers a wide region in a short amount of time. Aerial broadcasting along steep slopes is not advised since the seed balls could be lost in the rain. As a result, it might be difficult to keep track of how many seeds germinated and how many of them became healthy seedlings.

Distance to maintain in seed ball propagation: Depending on size and canopy of tree, seed balls must be propagated at specific distance.

Table 1: Distance to maintain in seed ball propagation

Sl. No	Height of plant	Preferable position for plantation	Distance to maintain
1.	Tall	On Boundary	10m x 10m
2.	Medium	Roadside	7m x 7m
3.	Short	Block Plantation	5m x 5m

Precautionary measures taken after propagation: Grazing should be controlled to get better survival ratio of germinated seedlings. In waterlogged land, small bunds can be prepared near germinated seedlings to prevent deterioration of seed. In case of long break in rain fall, light irrigation should be done.

Counting & monitoring of germinated sapling: After 45 days of propagation 1st monitoring should be done to check the germination and calculate germination ratio. For counting of germinated saplings quadrat method is used. Germination percentage can be calculated by,

$$\text{Germination \%} = \frac{\text{No. of seeds germinated}}{\text{No. of seeds propagated}} \text{ X } 100$$

Along with this, information of rainfall, nature of area, slope, mode of propagation etc. can be recorded.

Future prospects in seed bomb technique

Aerial Seeding: An effective afforestation method

Spraying seeds from a drone, plane, or helicopter is called "aerial seeding," and it's used to quickly and effectively reduce erosion risks and suppress the growth of invasive plant species. Aerial seeding is commonly used to spread various grasses and legumes to large areas of land in need of vegetative cover after fires. Aerial seeding, the practise of broadcasting seeds from aircrafts, has been used for nearly 80 years. It was first performed in 1926 in Hawaii to recover large areas of burned tropical forest. The main goal of aerial seeding projects has been the re-establishment of specific ecosystem services, rather than the reconstruction of viable, resistant, and resilient ecosystems that are representative of bio diverse reference communities.

Benefits of aerial seeding using seed bomb

Drones can readily reach places that are difficult to reach by humans. This is a common argument used to persuade nations to implement aerial seeding programmes. When the globe needs to guarantee effective coverage of a large region in a short length of time, seed bombardment by drones is increasingly being regarded a viable choice. Not only do high-tech drones make forest restoration easier on humans, but they also boost crop yields through aerial planting. What's more, seed bombing is a gentle technique for plants. Aerial reforestation is the most efficient method of treatment when wet soil and undulating land render other methods ineffective. Because it does not lead to soil compaction, aerial application reduces runoff. Most of the benefits of this planting strategy will accrue to tropical forests since they are more efficient carbon sinks and host a greater variety of plant and animal life.

Conclusion

Numerous global threats are pushing humanity nearly to the brink of devastation and catastrophe. These include pandemics, economic hardship, food insecurity, poverty, climate change, conflicts, land and water degradation, and biodiversity loss. Unhealthy planet leads to an unhealthy economy. Environmental degradation causes climate change, biodiversity loss, and new diseases. Forests and trees can help solve these challenges and create sustainable economies. The UN Strategic Plan for Forests goal of increasing forest acreage by 3% by 2030 is not on track (FAO, 2022) [4]. Afforestation projects manage forests and counteract global warming and climate change by helping huge populations survive (Mohan *et al.*, 2021) [6]. Forests and trees can provide global, cost-effective, egalitarian, and fast solutions. Forests and trees can maintain nature, improve human well-being, and create money, especially for rural people. Seedball propagation greens fractured and degraded lands cheaply. Seedballs can quickly cover enormous areas. It's inexpensive, sustainable, and effective for planting in challenging areas. Seedball intervention works well in grazing-free environments. This method overcomes biotic and abiotic factors that prevent seed germination and viability. Even in resource-limited situations, it improves seedling establishment, vigour, and survival (Tamilarasan *et al.*, 2021) [9].

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