Paper No.152

ROLE OF AFFORESTATION INITIATIVES IN RESTORATION AND SUSTAINABILITY OF LAND ECOSYSTEMS AND CLIMATE MITIGATION IN PAKISTAN

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By

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Abstract

To meet the Paris Agreement's target of limiting global warming to 1.5°C above pre-industrial levels, rapid adoption of negative emissions technologies, such as enhancing forest carbon sinks, is essential. Afforestation on non-agricultural lands is proposed as a key strategy for greenhouse gas (GHG) mitigation. This review evaluates the role of afforestation and sustainable agriculture in soil conservation and management, focusing on major afforestation project (BTAP) in Pakistan in the context of socio-economic and environmental impacts, and encountered challenges. Key socio-economic impact is that these initiatives improve the livelihood and food security of local communities in developing countries like Pakistan. As these projects helps in job creation, increased income, and heightened community participation in forest management. Environmentally, afforestation has both positive and negative impacts but in case of BTAP it significantly increased forest cover, reduced soil erosion, and improved biodiversity. However, the challenges faced by the project include political instability, inconsistent community engagement, and inadequate long-term monitoring. The paper emphasizes the need for policy reforms, sustainable agricultural integration, and community empowerment to enhance the long-term success of afforestation efforts in Pakistan. It emphasizes the need for ongoing research, adaptive management, and stakeholder collaboration to achieve global climate goals.

Introduction

Landscape restoration programs are increasingly important due to global and regional commitments to climate regulation and ecosystem service sustainability. Forest landscape restoration aims to mitigate climate change, restore biodiversity, rehabilitate degraded lands, and combat desertification (Bustamante et al., 2019). Pakistan is one of the most important South Asian countries and has been affected tremendously through several impacts namely; temperature rise, drought, pest diseases, health issues, seasonal and lifestyle change and it has the potential to continue doing so

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in future (Hussain et al., 2018). Achieving the ambition of the Paris Agreement to limit global warming to 1.5°C above pre-industrial levels requires rapid implementation of negative emissions technologies, particularly increasing forest carbon sinks (Doelman et al., 2020). Afforestation on land spared from agriculture is proposed as an integral element of greenhouse gas (GHG) mitigation. Still, its efficacy is highly context-specific and depends on climate, tree species, management, and product substitution (Cvjetković et al., 2020). Forest restoration is a pivotal element, driven by objects analogous to alleviating climate change, restoring biodiversity, rehabilitating demoralized land, and controlling desertification (Stanturf et al., 2015). Meeting the global climate goals to keep warming below 1.5°C requires quickly using technologies that remove carbon, especially by boosting timber forests (Bustamante et al., 2019). Afforestation and sustainable agricultural practices help soil erosion, enhance soil fertility, and promote long-term land productivity, icing environmental sustainability and food security (Doelman et al., 2020). However, its impact on Soil Organic Carbon (SOC) is complex and context-dependent. For example, in northern China, afforestation increases SOC density in carbon-poor soils but decreases it in carbon-rich soils (Wang et al., 2016). This review examines the role of afforestation and sustainable agriculture in soil conservation and management, focusing on case studies from Pakistan, highlighting the Billion Trees Afforestation Project (BTAP) and its socio-economic and environmental impacts. The main objective of this paper is to evaluate the role of afforestation in the restoration of land ecosystems and climate change mitigation in developing countries like Pakistan.

Afforestation and Reforestation Initiatives in Pakistan

During the period between 1990 to 2010 Pakistan lost about 41,100 ha of its forest cover due to a high deforestation rate of about an average of 1.6 % per year. Several factors are responsible for driving high rates of deforestation in the country including socio-economic changes followed by political changes in 1970, population growth, improved asses to remote areas and land use changes (Sajid, 2016). Many forestry programs were launched but not proved effective due to various shortcomings. Recognizing the urgency of the situation the government of Pakistan and local communities launched several afforestation projects in the past. The billion tree afforestation project is one of the most important restoration projects in this regard initiated by the Government of Khyber Pakhtunkhwa in 2013 (Haq el al., 2024). The main aim of the project is not only limited to new plantations but it also focuses on imposing bans on grazing, commercial

logging and reduction of fuel wood harvest for the restoration of the deforested areas (Kamal et al., 2018). Efforts for afforestation and sustainability of land ecosystem not only increase the carbon sequestration but also support livelihood of local communities and biodiversity.

Socio-Economic Impacts

In several parts of the globe, economic system, livelihoods and the assess to natural resources are affected by climate change. Forest plays an important part of lives of the people living in forests or around them. For addressing climate change one of the most straightforward policy measures is afforestation (Gbadebo,2022). Afforestation initiatives not only enhance carbon capture potential, restore ecosystems and help in combating climate change but also help in aligning sustainable development goals and improve resilience of local communities in developing countries like Pakistan (Trumper, 2009). In developing countries forest products are considered as essential component of food and livelihood security for the local communities. This initiative positively affects living organisms and confers socio-economic benefits to local communities (Harbi et al., 2018). A study shows that in Soth Africa people living in rural setting use 85% of forest products in daily lives for food and construction works (Charlie and Sheona, 2004) Investments in tree-based technologies and agroforestry can lead to increased incomes and improved resilience against climate change (Dewees et al., 2011).

The BTAP has generated significant socio-economic benefits, including job creation and income growth. The project created approximately 20,000 new jobs and increased community participation in forest management by 175% (Ullah et al., 2021). it was found that this project positively impacted the economic conditions of the local communities. The livelihood of the local community increased during the program and the highest economic benefit was gained by people in the second phase. About 47% of the women in the study area participated in the BTAP (Khan et al., 2019).

Environmental Impacts

Afforestation has both positive and negative environmental impacts as it influences soil health, carbon sequestration and local climate. For sustainable management of land ecosystem and ecological restoration understanding of these impacts is crucial. It enhances soil quality as it will contribute in increasing moisture content, total carbon concentration and nutrients especially in forests where there is plantation of mixed species (Yan et al., 2024). Careful selection of type of forest can increase carbon sequestration potential up to 25% but inappropriate practices may

compromise the land efficiency (Hasegawa et al., 2024) hence, appropriate planning is required in afforestation efforts. Forest plays important role in maintaining water cycle as it reduces potential runoff and improves groundwater recharge but in arid and semi-arid regions afforestation may led to drop in groundwater table due to excessive evapotranspiration (Lu et al., 2018).

The BTAP has significantly increased forest cover and biodiversity. This project significantly increases the forest cover of the area under the project from 2% to about 35 % from 2010 to 2021. As a result, the enhanced forest cover supports more biodiversity by providing habitat to various species (Haq el al., 2024). In Pakistan, afforested regions exhibit higher biodiversity indices compared to non-afforested areas, similar to findings in other regions. In addition to all these afforestation affects soil pH, influencing biogeochemical processes and ecosystem functions. Plantation of effective species can improve soil pH, which will result in improving soil fertility and productivity.

Challenges and Limitations

- One of the challenges faced by BTAP is inconsistency and the lack of long-term policies.
- For sustainable forest management community participation is crucial but inconsistent involvement of the local community causes hindrances in the normal functioning of the project.

Future strategies should focus on:

- Empowerment of local communities through education and capacity-building is required for better results in afforestation campaigns in the future.
- Promotion of agroforestry and organic farming as complementary strategies is necessary
- To decrease environmental deterioration, laws for forest management and policies should be reviewed enforced with strict penalties.

Conclusion

Afforestation and sustainable agriculture are crucial for soil conservation, climate mitigation, biodiversity, and food security. The BTAP in Pakistan demonstrates the potential and challenges of large-scale afforestation efforts. Addressing socio-economic barriers, optimizing species selection, and integrating sustainable agricultural practices are vital for maximizing

benefits. Key socio-economic outcomes of the project include job creation, increased income, and heightened community participation in forest management. Environmentally, the BTAP has significantly increased forest cover, reduced soil erosion, and improved biodiversity. However, the challenges faced by the project include political instability, inconsistent community engagement, and inadequate long-term monitoring. The greed for land resources leads to more cruelty with forestry and the environment which can't be stopped unless and until there is development of awareness at the basic level of society. Promotion of Green buildings, vertical gardening and rotational grazing are diverse ways to achieve a sustainable environment. Continued research, adaptive management, and collaboration between stakeholders are essential to ensure the success of these initiatives in achieving global climate goals.

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