

Alder-Based Shifting Cultivation in Nagaland – A Theoretical Perspective

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Abstract: Alder-based shifting cultivation, particularly, has been identified for its unique ecological and socio-economic role. It is a distinctive agricultural practice in Nagaland, India, with significant implications for climate change. This study explores the interactions between alder-based shifting cultivation and climate change dynamics. The paper examines how integrating alders into the shifting cultivation system influences carbon sequestration and soil enrichment in this bio-diversity-rich but environmentally vulnerable region. The paper comprehensively analyses the carbon balance within this managed ecosystem. The findings emphasise alder trees' role in enhancing nitrogen levels in the soil and promoting carbon storage in the biomass and soil organic matter. This paper advocates that agroforestry systems can be effective strategies for climate-resilient development in Nagaland if adequately managed. The study concludes that recognising and reinforcing the role of indigenous practices is crucial in shaping effective and inclusive climate change responses in the region. The other hilly parts of the country can set this as a model.

Keywords: Alder-based shifting cultivation; Climate change; Carbon sequestration; Soil enrichment; Biodiversity-rich.

Introduction

Over the past three decades, the unsustainable socio-economic developmental strategies have culminated into the escalation of Green House Gas emissions (GHGs), which ultimately translated into a disruption in global warming. The evolution of industrial and urban societies can be held significantly accountable for the ecological imbalances manifested in global warming and climate change. There are two prime classifications for the sources of climate change – GHGs and particulate. The foremost GHGs like carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and halocarbons sustain a prolonged life in the atmosphere and disperse so quickly across the atmosphere. Particulate emissions

are felt only by the place of origin; hence, they do not disperse across the atmosphere quickly. The distinction between GHGs and particulate emissions is essential from the point of view of policy implication. Particulate emissions and consequent ripples could be regulated more by a source country. The most significant contributor to GHG emissions is the CO₂ followed by CH₄, N₂ and Fluorinated gases (F-gases).

Regarding sector-wise composition, the energy sector has contributed three-quarters of GHG emissions, of which electricity and heat generation are the largest, followed by transportation and manufacturing. The farm sector stands only next to the energy sector in this regard. Changes in land-use patterns and forestry have also been considered the significant 'sources and sinks'

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of emissions and are crucial to accomplishing net-zero emissions (UNFCCC, n.d.). Top emitting countries like China contributed as much as 842.46 t CO₂e/million \$ Gross Domestic Product, followed by the United States of America (USA), which contributed 281.55 tCO₂e/million \$ GDP...etc. (Ibid). The G20 countries like the USA have contributed 4749.57 MtCO₂e, and the European Union (EU) 2636.99 MtCO₂e to total CO₂ emissions worldwide (Ibid).

Global Reactions

There are two paramount classifications of the response to climate change, i.e., Mitigation and Adaptation. Here, mitigation refers to human intervention to evaporate the sources of GHGs. This can be accomplished by increasing the share of renewable energies, establishing a cleaner mobility system, or enhancing the storage of these gases by enhancing the geographical area under the forest cover. Adaptation to climate change is a process, action, and outcome. It helps individuals, groups within society, organisations, and governments on behalf of society to acclimatise or come to terms with the prospects and challenges correlated with climate change (Smit & Wandel, 2006). Adaptation is a herculean task for low and middle-income countries due to their incapacities in resource utilisation, inadequate physical infrastructure, and inefficient governance systems. The adaptation cannot be contemplated as a substitute for mitigation. Each country's policy implications for reducing climate change call for cost-effective ways. Ironically, the countries that emit the least GHGs are the worst hurt by climate change, while the countries that have reaped dividends from high levels of GHG emissions are the least threatened by the ramifications of climate change (World Bank Group, 2008). Climate change is occurring due to the cumulative GHG emissions in the atmosphere. Developed countries are primarily accountable for global climate change since they are the highest exploiters and emitters of GHGs (Timperley, 2020). The United Nations Framework Convention on Climate Change in 1997 (UNFCCC) has debarred the mitigation obligations of developing countries like China, India, Brazil...etc. Developed countries in the EU and the USA proclaim that major developing countries should also tackle mitigation actions since their GHG emissions have escalated rapidly and overwhelm any reductions by developed countries.

Impact on Developing Countries – Externality

Climate change mitigation depends on each country's diligent assessment of the consequences on the economy. Evaluating the country's developmental strategies is critical to shed climate variability, environmental stress, and growing socio-economic distress. Climate change vulnerability can be viewed as marginalisation, susceptibility, adaptability, fragility, risk, or access to entitlements. Climate change has devastated developing and developed countries. Climate change significantly impedes the LDCs' (Less Developed Countries) preparedness to accomplish the Sustainable Development Goals (SDGs). It also disrupts the LDC's aptness to link the prescribed goals on literacy, gender equality, energy utilisation, inequality, sustainable consumption, supply tendencies, peace, and implementation. Climate impacts are also likely to multiply the cost of meeting all SDGs in LDCs, especially under high-emission scenarios (Wright et al., 2015).

Impact on Agriculture

The most endangered climate change sector is '*farming*' due to its inherent and direct subordination to climate/temperature/nature. It is well observed that compared to developed countries, developing countries are more susceptible due to the impact of climate change (Antônio et al., 2015). The vulnerability of the farm sector can be assessed from different points of view. On the one hand, climate change leads to high temperatures, obstructing plant life, animal life, pests, water supply constraints... etc. It could pose serious and catastrophic spin-offs on agriculture and transportation systems. Water supply is also highly volatile to the changes in the precipitation pattern. The disruptions in the water supply will adversely affect plant growth, the yield of crops, and the availability of the gestation period for crop production (Kaiser et al., 1993). The crop productivity rate is also directly conditioned by increased atmospheric carbon dioxide levels.

The escalation in mean sea levels can lead to flooding, downsizing arable land, and eroding the most profitable production systems (Antle, 2008). Agriculture has the great potential to adapt to climate change and has already adapted to many significant fluctuations. The boom of the 1970s for agriculture in the USA and the recession of the 1980s demonstrate that agriculture can respond to climatic aberrations. However, those

changes have imposed many costs on producers and rural communities. Climate changes look probable over the next hundred years that may vehemently dampen the livelihood prospects of the disadvantaged.

Indian Predicament

Though the salience of the agricultural sector in India has declined since 1991, it still has a quintessential role from a socio-economic point of view. The share of the primary sector in total employment is 42.6 per cent and the Labor Force Participation Rate (LFPR) is 44 per cent. While male LFPR is 69 per cent and female LFPR is 18 per cent (World Bank, 2021). From the perspective of poverty, the country is estimated to have 1/3rd of the world's poor. At the beginning of the era of the new economic reform, India's primary sector failed to maintain the pre-reform growth (De et al., 2017). The dicey and teetering farm sector has a profound implication on the Indian economy from the point of view of income distribution.

Income inequalities increase due to the high dependence on the primary sector. The farm sector in India has both short-term and long-term structural bottlenecks. Over the decades, the rift between per-worker productivity in farming and non-farm sectors has aggravated, leading to unavailability in farming for small and marginal farmers. There has been a shift away from farming to the nonfarm sector among the farmers due to unavailability in farming, escalation in input costs, unsupportive market ecosystem, and environmental degradation, eventually leading to the spike in farmers' suicides. Farming has also been exposed to vagaries like population pressure, pre-dominance of food grains, primitive methods of cultivation, labor-intensive farming, aberrations in monsoons, inelastic supply of land, policy paralysis, deficient agricultural research, education, and training... etc. With the soaring population pressure on Indian agriculture, labour has transferred from farm to non-farm sector. *Lewis*, in his article, "Development with Unlimited Supplies of Labour," in 1954, addressed the mechanism of transferring surplus labour from traditional activity to a modern capitalist sector under the conditions of the unlimited supply of labour (Cervantes-Godoy & Dewbre, 2010).

North-East India

Northeast India's economy heavily relies on agriculture, a sector deeply interlinked with the region's social,

cultural, and environmental fabric. However, the mountainous terrain poses challenges for settled farming, leading indigenous tribes to adopt traditional practices like slash-and-burn cultivation, known as Jhum or shifting cultivation. This method, rooted in centuries-old customs, is particularly suited to the hilly regions and reflects the close bond between tribal communities and their land. Alternative techniques like the Bun method for potato cultivation are also prevalent in areas like Meghalaya, albeit with potential drawbacks such as soil erosion and water mismanagement (Basavaraj et al., 2019). Despite its historical significance, slash-and-burn farming presents ecological challenges such as biodiversity loss, soil erosion, and declining forest productivity (Shaw et al., 2022). Rapid population growth has shortened the Jhum cycle, leading to concerns about decreased crop productivity and heightened environmental degradation. However, shifting cultivation remains integral to the livelihoods of many remote communities in South and Southeast Asia, where mixed cropping offers a sustainable means of subsistence amidst global trends favouring commercial agriculture (Rasul et al., 2003). Efforts to address the ecological impacts of shifting cultivation have seen progress in states like Tripura and Nagaland. In Tripura, the Forest Department has implemented the Joint Forest Management Committee (JFMC) to transition farmers from crop rotation towards rubber cultivation in degraded forest areas (Japan International Cooperation Agency, Tripura Government 2024). Nagaland's Village Development Boards have embraced modified Jhum practices, where Alder-based shifting cultivation is practiced. This method boasts of high productivity, sustained soil fertility, reduced input costs, and increased economic profit for farmers (Giri et al., 2018). While challenges persist, initiatives aimed at promoting environmentally friendly practices show the region's commitment to preserving its natural resources and enhancing the well-being of its communities.

This study explores the alder-based shifting cultivation and its implications for climate change mitigation in Nagaland, India. The study aims to elucidate the mechanisms driving the sustainable coexistence of traditional agricultural practices and environmental conservation by employing a multidisciplinary approach encompassing ecological and climatological perspectives. This study seeks to bridge the gap between indigenous knowledge systems and contemporary climate change discourse, advocating for recognising and integrating traditional practices. It unlocks innovative solutions for climate-resilient

development that prioritise ecological integrity by harnessing the wisdom accumulated over centuries of cohabitation with nature.

Biodiversity and Carbon Sequestration for Climate Change

In recent years, agroforestry has garnered increased attention due to its capability to produce varied outputs, enhance agricultural productivity, generate diverse income sources, moderate climate extremes, and facilitate technological advancements through contributions from research institutions and private entities (Chavan et al., 2015). The Intergovernmental Panel on Climate Change (IPCC) acknowledges the intangible advantages of ecosystem services for their potential in carbon sequestration, which aids in climate change mitigation strategies. These services encompass microclimate regulation, biodiversity preservation, carbon capture, water source protection, soil erosion, and pollution mitigation. Agroforestry systems are increasingly seen as viable tools for climate change mitigation and adaptation (Ibid). Established agroforestry practices can evolve into self-sustaining production systems that do not require external inputs like fertilisers and pesticides. These indigenous methods effectively stabilise areas prone to landslides through deep-root systems, prevent soil erosion, reforest abandoned jhum land, reclaim wastelands, and support biodiversity conservation (Haeggman, 2020). Alder-based shifting cultivation, commonly referred to as jhum cultivation in Nagaland, India, stands as a testament to the integration of traditional farming techniques with contemporary environmental priorities. Given the significant benefits of alder-based farming practices in sustainable agriculture, it is crucial to analyse the multifunctional attributes and ecosystem services of alder-based shifting cultivation.

In Nagaland, the distinctive feature of the jhum practice is incorporating alder trees (*Alnus nepalensis*). Alder-based shifting cultivation is an indigenous agricultural practice tailored to the ecological, social, and cultural landscape of certain tribes in Nagaland, India. This method involves the strategic use of the alder tree, which is known for its nitrogen-fixing capabilities, to enhance soil fertility through natural processes (Kehie et al., 2017; Rana et al., 2018; Rathore et al., 2010; Sharma et al., 2008; Kandpal & Bhowmik, 2017). Historically, the Angami, Konyak, Sumi, Chang, Khiamungan, and Yimchungru tribes have perfected this system, integrating it deeply with their

traditional farming practices (Ramakrishnan, 1992). In this system, alder trees are cut or pollarded at about two meters from the ground to promote the growth of new shoots, which are then managed across the jhum (slash-and-burn) cycle. The trees are valuable for their role in soil fertility and for providing timber and fuel wood. This cultivation cycle typically spans four years, with two years dedicated to cropping followed by a fallow period to allow for ecological regeneration. The crops grown in this system include rice, Job's tears, maize, and various secondary crops like *Perilla frutescens*, colocasia, potatoes, and various beans and vegetables. These crops are interplanted with the alder trees, taking full advantage of the enriched soil. The unique root structure of the alder tree also plays a crucial role in preventing soil erosion on sloped terrains, further contributing to the sustainability of this farming method (Rathore et al., 2010; Das et al., 2012). Alder-based shifting cultivation in Nagaland illustrates how traditional agricultural methods can be adapted to address modern environmental challenges. It highlights the importance of combining indigenous knowledge with contemporary conservation strategies to develop sustainable agricultural practices that meet food security needs and climate change mitigation goals. This model emphasises the potential of traditional practices to contribute significantly to global environmental objectives, provided they are supported by thoughtful policy-making and active community involvement.

Alder trees are integral to this agricultural system in two primary ways. Firstly, they enhance soil fertility by naturally improving soil conditions and supporting various crops' growth during cultivation. These trees are known for their nitrogen-fixing abilities, facilitated by a symbiotic relationship with Frankia bacteria in their root nodules. This natural conversion of atmospheric nitrogen into a more accessible form significantly enriches the soil, diminishing the need for synthetic fertilisers. Synthetic fertilisers are costly and environmentally detrimental, associated with substantial greenhouse gas emissions during production and application. Secondly, alder trees function as effective carbon sinks. They absorb and store carbon dioxide from the atmosphere in their biomass and the surrounding soil, contributing to reducing greenhouse gases, a major factor in climate change. This carbon sequestration is essential for mitigating the adverse effects of global warming and maintaining a balanced atmospheric composition. The use of alder trees in shifting cultivation supports continuous vegetation cover over the land, even during

the fallow periods. This continuous cover is vital for preventing soil erosion – a common problem in many conventional agricultural practices that can lead to significant loss of soil organic carbon. It also promotes biodiversity, creating habitats for various species of flora and fauna and ensuring ecological balance. This biodiversity benefits the environment and agriculture, enhancing resilience to pests and diseases and reducing the dependence on chemical pesticides. This alder-based system is a farming technique and a well-established agroforestry practice supporting the local communities' environmental and economic needs. It represents a sustainable model of agriculture that has been adapted over generations to meet the challenges of farming in hilly terrains (Gokhale et al., 1985; Das et al., 2009; Singh, 1992). By integrating crop production and forestry, this system offers a dynamic approach to managing agricultural landscapes in Nagaland, providing a resilient agricultural framework that aligns with the region's cultural traditions and ecological realities (Cairns, 2007; Pulamte, 2008). This practice highlights the importance of traditional knowledge and local innovations in developing sustainable agricultural systems that are both environmentally sound and socially beneficial.

Additionally, collective efforts within the villages of Nagaland ensure efficient water management and irrigation. The community collectively addresses water needs by constructing channels that divert stream water to downstream fields while minimising environmental impact. The Alder-based Jhum cultivation practice exemplifies a harmonious relationship between humans and nature. Leveraging traditional knowledge and innovative techniques demonstrates the potential for sustainable agriculture to thrive in harmony with the environment. 2005 marked a significant milestone in India's journey towards sustainability in a village of Nagaland i.e., Khonoma, nestled in the verdant hills of Nagaland, honoured as the nation's first green village (Papu & Nathani, 2020). This prestigious recognition, bestowed jointly by the Government of India and Nagaland, emphasised Khonoma's pioneering efforts to champion sustainable development goals and foster a harmonious coexistence with nature. At the heart of Khonoma's green village status lies a steadfast commitment to environmental preservation and biodiversity conservation principles. The village's dedication to maintaining a pollution-free environment is evident through its adopting eco-friendly practices such as rainwater harvesting and natural water management.

By harnessing the power of indigenous knowledge and modern technology, Khonoma has succeeded in mitigating the adverse effects of pollution and ensuring the sustainable use of precious water resources.

Challenges and Solutions in Sustainable Shifting Cultivation

The alder-based shifting cultivation preserves the essence of the ancient practice. This adaptation has emerged due to the dual pressures of limited available agricultural land and increased governmental control over forest resources. The Northeastern Regional Centre of the Indian Council of Agricultural Research (ICAR) and the International Rice Research Institute (IRRI) document these changes, highlighting how local innovations meet the challenges posed by population growth and regulatory constraints on land use (NEPED and IRRI, 1999). Traditionally, this method requires vast tracts of land to allow for extended fallow periods necessary for full ecological restoration. However, with increasing population pressure and the push for economic development, the availability of suitable land for traditional shifting cultivation is increasingly compromised. This decrease in available land can lead to shorter fallow periods and insufficient ecological recovery, leading to soil degradation, loss of biodiversity, and a reduced capacity for carbon sequestration. Addressing these challenges requires approaches that involve preserving traditional agricultural practices and integrating sustainable land management strategies. This involves community-based forest management, introducing more sustainable agricultural techniques that reduce the need for frequent shifting cultivation, and formulating policies that foster the preservation of alder trees and other native vegetation. Such strategies help maintain ecological balance and effectively empower local communities to adapt to changing environmental and economic conditions. Introducing alder trees into these traditional farming systems necessitates understanding agroforestry principles. Farmers must acquire specific knowledge about the optimal conditions for alder growth, alongside understanding how these trees can be integrated with other crops to maximise agricultural output. This knowledge transfer requires effective educational programs and extension services that can bridge traditional practices with new scientific insights (Dove, 1983).

Moreover, the initial phase of establishing alder trees in shifting cultivation systems involves considerable investment in both time and labour. Alder trees

take several years to mature and begin significantly contributing to soil fertility through nitrogen fixation (Padoch, 1991). This delayed benefit can be a deterrent, as farmers often need immediate results to sustain their livelihoods. Financial and technical support from government or non-governmental organisations could alleviate some of these burdens during this initial phase. Another critical challenge is the issue of land tenure security. Shifting cultivation typically occurs on lands with unclear ownership or usage rights, which can complicate the introduction of perennial tree species like alders. Secure land tenure is crucial as it ensures that farmers can reap the long-term benefits of their investment in tree planting without fear of displacement or loss of access to their land. Cultural acceptance also plays a significant role in adopting alder-based shifting cultivation. Traditional practices are deeply ingrained in local communities, and any new agricultural techniques need to be introduced in a manner that respects and integrates into existing cultural frameworks. Community involvement in the planning and implementation stages can foster greater acceptance and willingness to adopt new practices. While alder-based shifting cultivation offers a promising approach to sustainable agriculture, its success depends on effectively addressing these challenges. Adequate training, secure land tenure, financial support, and cultural integration are essential components that need to be considered to facilitate the adoption of this innovative farming practice. Addressing climate change and food security challenges requires approaches that acknowledge the interconnected nature of these issues.

Conclusion

Alder-based shifting cultivation in Nagaland, India, represents a sophisticated amalgamation of traditional knowledge and ecological sustainability, offering a viable model for contemporary agricultural practices that seek harmony with nature while addressing the challenges of modern environmental concerns. This system leverages the nitrogen-fixing capabilities of alder trees to enrich the soil naturally, minimising the reliance on chemical fertilisers and reducing the environmental footprint associated with conventional farming methods. Moreover, integrating alder trees in shifting cultivation practices enhances soil fertility. It stabilises sloped terrains to prevent erosion and plays a crucial role in carbon sequestration, contributing to climate change mitigation.

The adoption of alder-based shifting cultivation emphasises the potential of indigenous agricultural techniques to contribute significantly to global sustainability goals. It reflects a deep understanding of the interdependencies within ecosystems and utilises these relationships to create a productive, sustainable agricultural system. However, the successful implementation and scaling of such practices demand concerted efforts to address several key challenges, including land tenure security, cultural acceptance, and the need for immediate economic returns. Effective educational programs, secure land tenure, and community involvement are critical to fostering acceptance and enhancing the resilience of these systems. Initiatives like those in Khonoma village highlight the broader potential of integrating traditional practices into modern environmental conservation strategies, promoting biodiversity, and advancing sustainable development goals. These efforts exemplify how localised solutions can profoundly impact global environmental challenges, offering insights and models for other regions facing similar ecological and agricultural issues. By valuing and integrating Indigenous knowledge with contemporary conservation strategies, we can unlock innovative solutions for sustainable development that prioritise ecological integrity and social equity.

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