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Community-Based Strategies for Chalguza Pine (*Pinus gerardiana*) Conservation: A Case Study from Sub-Division Darazinda, District Dera Ismail Khan, Pakistan

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Abstract

Chalghuza pine (*Pinus gerardiana*) forests in Pakistan's Sulaiman Range are a vital ecological and socio-economic resource, providing food, income, and ecosystem services to thousands of households. These forests play a crucial role in biodiversity conservation, watershed management, and carbon sequestration. In Sub-Division Darazinda, District Dera Ismail Khan, Chalghuza pine forests are facing serious threats from over-harvesting, uncontrolled grazing, frequent wildfires, climate change, and weak institutional oversight. This article explores community-based conservation strategies that align sustainable forest management with improved local livelihoods. By drawing lessons from similar initiatives in Balochistan, Khyber Pakhtunkhwa, and cross-border regions of Afghanistan and India, the paper highlights approaches such as village-level forest committees, sustainable nut harvesting protocols, assisted natural regeneration, fire prevention systems, value-added nut processing, and livelihood diversification through eco-tourism and non-timber forest products. The findings suggest that locally-driven co-management, combined with fair benefit-sharing, awareness raising, and livelihood incentives, offers the most viable pathway for safeguarding Chalghuza pine forests while sustaining rural incomes. The Darazinda case study demonstrates that the inclusion of local communities, particularly women and youth, in conservation decision-making is central to achieving both ecological sustainability and socio-economic resilience.

Keywords

Chalghuza Pine, Community-Based Conservation, Darazinda, Forest Management, Livelihoods, Pakistan

1. Introduction

Chalghuza pine (*Pinus gerardiana*) is an ecologically significant and economically valuable tree species that grows in the dry temperate forests of Pakistan, Afghanistan, and India. Pakistan accounts for almost 20% of the world's Chalghuza forests, largely concentrated in the Sulaiman and Hindu Kush mountain ranges [1]. These forests are crucial not only for biodiversity but also for the socio-economic well-being of mountain communities.

The edible nut (Chalghuza) is one of the most expensive dry fruits in South Asia and the Middle East, commanding prices that often exceed other forest products [2]. In Darazinda, Chalghuza nuts contribute up to 60% of annual household income, making them the single most important livelihood source [3]. Additionally, Chalghuza forests prevent soil erosion, regulate water flows, and act as carbon sinks, thus contributing to climate change mitigation [4].

However, these forests are under threat. Over-harvesting, branch cutting, wildfires, overgrazing, and weak governance have severely reduced regeneration [5]. The lack of local management institutions and reliance on exploitative market intermediaries further erode community incentives to conserve forests [6]. Climate change, in the form of rising temperatures, increased droughts, and pest outbreaks, exacerbates these challenges [7].

Darazinda, a Sub-Division of Dera Ismail Khan (formerly part of FATA), presents an ideal case study for examining community-based conservation approaches. Its Chalghuza forests are vital for both biodiversity and livelihoods, yet they face critical pressures from unsustainable practices. Exploring community-driven strategies here provides valuable lessons for sustainable forest governance across Pakistan.

2. Study Area: Darazinda, D.I. Khan

Darazinda is a Sub Division (EX FR) of District Dera Ismail Khan lies at the southern foothills of the Sulaiman Range, bordering South Waziristan, Dera Ismail Khan and on the West connected to Balochistan Province. There are one tribe on both sides of Suleiman Forest a single tribe known as Sherani tribe and the economics benefits gain through local

harvester. The area has a semi-arid to dry temperate climate with cold winters and hot summers [8]. Forest cover is dominated by Chalghuza pine, intermixed with wild olive, deodar patches, and scrub vegetation.

The population is mostly Pashtun, organized into tribes governed by the Pashtunwali code and jirga system [9]. Forest use is communal, with no formalized private tenure, although customary rules exist for grazing and harvesting. The forest is divide between local sub branches of sherani Tribe of Ub division Darazinda and district Sherani from Balochistan side. The economic life is primarily based on livestock, subsistence farming, and seasonal Chalghuza nut collection [10]. Poverty, limited education, and lack of alternative livelihoods increase dependence on forest resources.

Chalghuza harvesting occurs between September and November. Cones are collected manually, often by climbing trees, and sold to middlemen who transport them to urban markets [11]. Limited access to processing technologies means that most collectors receive only a fraction of the nut's market value.

3. Threats to Chalghuza Forests in Darazinda and Findings

Table 1. Key threats to Chalghuza Pine forests in Darazinda

Threat	Impact
Overharvesting of cones	Reduces regeneration potential
Overgrazing	Damages seedlings and soil structure
Illegal logging	Loss of mature trees, reduced biodiversity
Climate change	Increased droughts, pest attacks

The Table 1 explanation given as;

3.1 Over-Harvesting

Unregulated cone collection has reduced regeneration potential. Branch cutting permanently damages trees, while premature harvesting results in low-quality nuts. 3.1 Over-Harvesting

Unregulated harvesting of Chilghoza pine cones significantly reduces the regeneration capacity of the trees. The collection process often involves cutting branches, which causes permanent damage to the trees' structure. Premature harvesting also results in lower quality nuts, reducing their economic value. This unsustainable practice impairs the long-term productivity of the forests and hampers natural regeneration efforts. [12].

3.2 Forest Fires

Forest fires, both natural and human-induced, pose a serious threat to Chalghuza forests. For example, the 2022 Sherani fire in Balochistan destroyed almost 40% of the local Chalghuza pine cover. According to a report, the fire make loses of local livelihood was about 4 billion rupees. In Darazinda, the situation is exacerbated by a lack of firefighting resources and capacity, making the forests highly vulnerable to similar devastating fires. The fire was controlled after 90 days of rescue operation and after all the fire was controlled. Both natural and human-induced fires devastate forests. The 2022 Sherani fire in Balochistan and from Sub Division Darazinda destroyed nearly 40% of local Chalghuza cover [13]. In Darazinda, lack of firefighting capacity makes the area highly vulnerable.

3.3 Overgrazing

Increasing livestock grazing within Chalghuza forest areas leads to suppression of young seedlings by trampling and soil compaction [14]. This directly hinders natural regeneration and forest recovery. With rising herd sizes, the pressure on these forestlands has intensified, further contributing to degradation.

3.4 Weak Governance

The Forest Department responsible for managing these remote forest areas suffers from insufficient staff and limited resources, severely restricting their ability to monitor and regulate forest use. The absence of local by-laws or enforcement mechanisms allows unregulated exploitation to continue unchecked, further endangering the sustainability of Chilghoza forests. [15].

3.5 Market Exploitation

The pine nut trade is dominated by middlemen who capture up to 70% of the profits from the sale of harvested nuts. This leaves the actual collectors, who do the hard work of harvesting, with minimal bargaining power and profits. The lack of cooperatives or collective organization among local collectors traps them in poverty despite the high economic value of Chilghoza nuts [16].

3.6 Climate Change and Pests

Climatic factors such as droughts and erratic rainfall patterns weaken tree health and regeneration potential. Moreover, pest infestations like pine blister rust and bark beetles add to the stress on Chilghoza trees, threatening both regeneration and survival. These combined factors pose an increasing risk to forest sustainability in the face of changing environmental conditions [17]. After all, the threats to Chalghuza forests in Darazinda are multifaceted, involving unsustainable harvesting, fire vulnerability, livestock pressure, inadequate governance, exploitative market

dynamics, and environmental stresses from climate change and pests. Addressing these requires coordinated community, government, and environmental interventions to ensure forest regeneration and long-term sustainability.

4. Community-Based Strategies for Conservation

Table 2. Community-based strategies and expected outcomes

Strategy	Expected Outcome
Community forest management	Sustainable harvesting and equitable benefit sharing
Alternative livelihoods	Reduced dependence on forest resources
Eco-tourism development	Increased income and awareness
Capacity building	Enhanced skills and long-term conservation commitment

Table 2 explanation given below;

4.1 Village Forest Committees (VFCs)

Village Forest Committees serve as grassroots organizations that empower local communities to take charge of managing their forest resources. These committees help regulate activities such as nut harvesting, livestock grazing, and fire management by establishing rules tailored to the local context. In the Sherani region, the active engagement of VFCs led to significantly improved protection of seed-bearing trees and consequently enhanced forest regeneration. Additionally, the community-managed approach resulted in a measurable 20% increase in local incomes, illustrating the dual benefits of conservation and economic uplift through community stewardship [18].

4.2 Sustainable Nut Harvesting

Sustainable harvesting protocols are essential to maintain the health and productivity of Chilghoza forests. These include harvesting only fully mature cones to ensure seeds have adequately developed and leaving a sufficient number of seed trees intact to naturally regenerate the population. Furthermore, rotating harvest zones each season allows previously harvested areas time to recover before being tapped again. This systematic approach balances economic needs and ecological sustainability, securing long-term yields and avoiding overexploitation that could diminish forest vitality [19].

4.3 Assisted Natural Regeneration (ANR)

Assisted Natural Regeneration involves deliberate human intervention to accelerate forest recovery. Key practices include establishing nurseries to grow saplings, creating protective enclosures, and erecting fencing to shield young plants from grazing and other disturbances. In Balochistan, projects supported by organizations like WWF have demonstrated the effectiveness of ANR, with sapling survival rates reaching as high as 65%. These efforts not only enhance the density and diversity of regenerating forests but also strengthen ecosystem resilience against future threats [18].

4.4 .Fire Prevention and Response

To mitigate the threat of forest fires, community-based fire prevention and response mechanisms play a crucial role. Community fire brigades, formed from trained local volunteers, are equipped to quickly detect and suppress fires. The creation of firebreaks—deliberate gaps in vegetation—is a preventive measure to stop fires from spreading across large areas. Accompanying these physical measures are awareness campaigns aimed at educating locals about fire risks and safe practices. Building firefighting skills within the community enhances local resilience, making early detection and effective response possible before fires become uncontrollable [19].

4.5 Livelihood Diversification and Value Addition

Economic sustainability of forest communities can be boosted through livelihood diversification and added value in forest product chains. Processing units dedicated to shelling nuts, branding, and packaging can increase income by up to 30%, adding economic value beyond raw product sales. In addition, promoting complementary activities such as eco-tourism and beekeeping introduces new revenue streams, reducing over-dependence on nut harvesting alone. These approaches contribute to economic empowerment while reducing pressure on forest resources by broadening income options [20].

4.6 Monitoring, By-Laws, and Benefit-Sharing

Effective forest conservation is supported by robust community governance frameworks. Establishing by-laws and sanctions for illegal tree cutting creates a deterrent against unsustainable exploitation. Participatory monitoring involves locals directly in tracking forest conditions and the adherence to agreed management rules. Transparent benefit-sharing mechanisms ensure that revenues from forest products are fairly distributed among community members, reinforcing collective ownership and motivation for conservation. Such inclusive approaches foster a sense of responsibility and accountability, crucial for sustaining long-term forest protection [21].

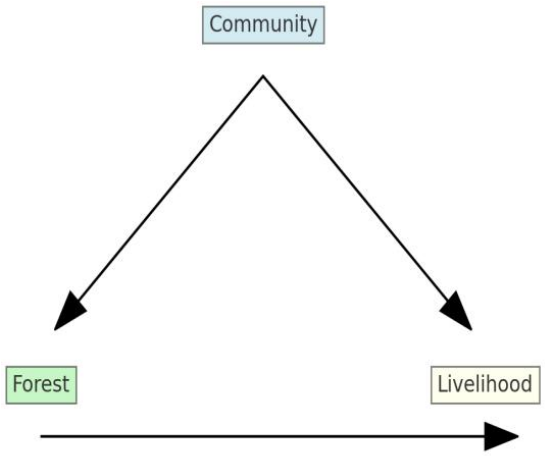

Figure 1. Community–Forest–Livelihood Nexus (schematic)

Figure 1 illustrates the Community–Forest–Livelihood Nexus. It shows the interconnected relationship among three key elements:

Community relies on the forest for resources such as timber, fuelwood, fodder, and non-timber products like Chalghuza pine nuts. These forest resources contribute directly to people's livelihoods, providing income, food security, and employment opportunities. At the same time, the way communities interact with forests affects their sustainability—responsible use strengthens livelihoods, while overexploitation leads to resource depletion and reduced income opportunities. In short, the diagram highlights a triangular relationship where the community, forest, and livelihoods are mutually dependent. Healthy forests support livelihoods, strong livelihoods reduce pressure on forests, and sustainable forest use benefits both communities and their future economic well-being.

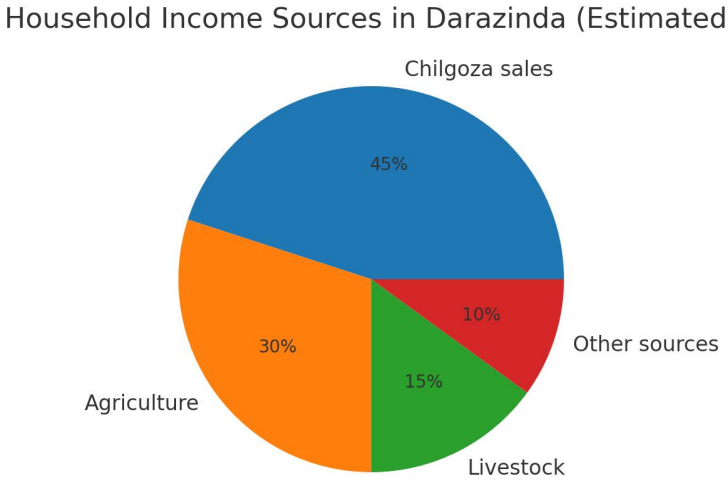

Figure 2. Household income distribution (Chalghuza vs. other sources)

Figure 2 presents the estimated household income sources in Darazinda, highlighting the relative contribution of Chalghuza (pine nut) sales compared with other income streams.

Chalghuza sales account for the largest share, contributing about 45% of household income. This shows that Chalghuza is the most significant economic activity for local communities.

Agriculture provides the second major share at 30%, reflecting the importance of crop farming as another livelihood source.

Livestock contributes around 15%, showing that animal husbandry also plays a role, though less significant compared to agriculture and Chalghuza.

Other sources make up only 10%, suggesting limited alternative income opportunities beyond these three sectors.

Overall, the chart demonstrates that Chalghuza pine nut sales are the backbone of household income in Darazinda, surpassing both agriculture and livestock. This underscores the forest's crucial role in sustaining local livelihoods and the community's heavy dependence on Chalghuza resources.

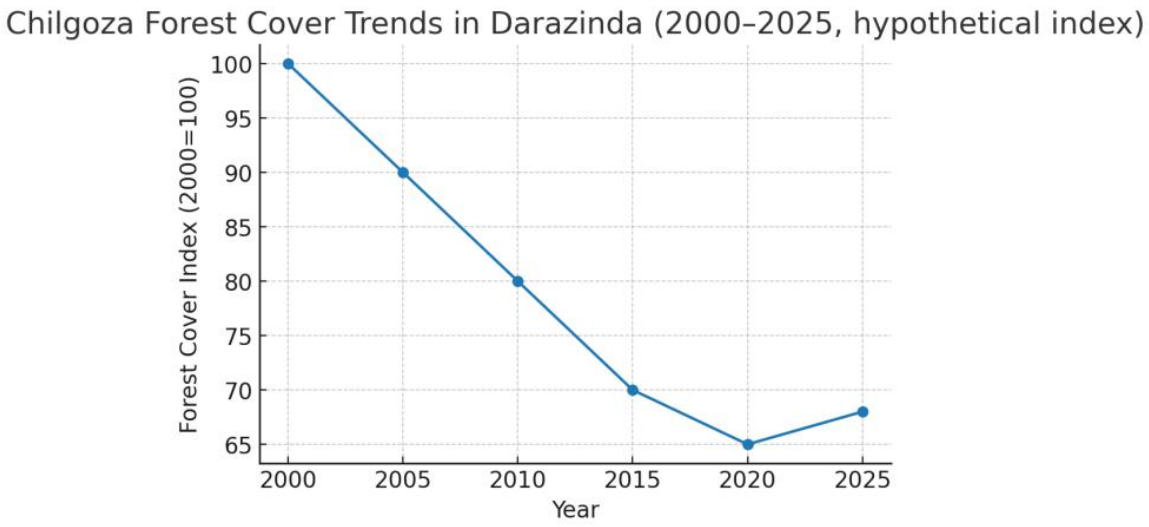

Figure 3. Hypothetical forest cover decline and regeneration (2000–2025)

The figure 3, displays a line chart showing the changes in forest cover of Chalghuza trees in Darazinda from the year 2000 up to 2025, using a hypothetical index where the year 2000 is set as the baseline (100). Over this period, the forest cover shows a significant decline. Starting at 100 in 2000, the index steadily drops, reaching around 70 by 2015 and then hitting its lowest point near 65 by 2020. After that, the trend slightly reverses with a small increase projected toward 2025. This suggests that while the forest cover has decreased sharply over two decades, there might be some recovery or stabilization efforts beginning to take effect in recent years.

5. Lessons from Other Regions

5.1 Sherani, Baluchistan

In Sherani, Balochistan, community-based regulation emerged as a successful model for forest conservation and socioeconomic improvement. Local communities were empowered to enforce harvesting and grazing rules, which led to better protection of seed-producing trees. This approach contributed directly to enhanced natural regeneration of the Chilghoza forest. Additionally, these regulatory efforts translated into tangible economic benefits, with local incomes increasing due to improved yields and more sustainable resource use. Sherani's experience underscores the critical importance of community ownership and participation in forest management to achieve both ecological restoration and poverty alleviation [22].

5.2 Chitral, KP

In Chitral, the Food and Agriculture Organization (FAO) supported the establishment of nurseries specifically aimed at raising healthy saplings for forest regeneration. These nurseries contributed to significantly higher survival rates of young trees, demonstrating the effectiveness of assisted regeneration techniques. Moreover, Chitral's communities embraced collective marketing strategies that reduced their dependence on exploitative middlemen. By organizing cooperative selling and direct market access, local harvesters secured better prices and more equitable income distribution. The Chitral case highlights the dual impact of technical support for regeneration and improved market structures in enabling sustainable forest management [23].

5.3 Kinnaur, India

Kinnaur's approach involved the formation of cooperatives that empowered forest-dependent communities to take control over the sale of pine nuts and other forest products. By bypassing intermediaries, these cooperatives enabled collectors to capture a much larger share of the profits, leading to increased community earnings and stronger incentives for forest conservation. The cooperative model promoted transparency, collective decision-making, and sustainable harvesting practices, illustrating how organizational strengthening can shift economic benefits toward local stakeholders while reinforcing natural resource stewardship [24].

5.4 Nuristan, Afghanistan

In Nuristan, a collaborative model combining traditional tribal governance with modern forestry practices proved effective in safeguarding local forests. Non-governmental organizations (NGOs) worked closely with tribal elders and community leaders to integrate customary laws and community norms with scientific forestry principles. This partnership fostered mutual trust and ensured that conservation strategies were culturally appropriate and widely accepted. The blending of indigenous knowledge with contemporary management techniques facilitated resilient forest governance systems that enhanced both ecological and social outcomes, making Nuristan a valuable example of adaptive, culturally sensitive forest management [25].

6. Policy Implications and Conclusion

(1). Provincial (KP): At the provincial level, formalizing co-management arrangements between government forest departments and local communities is essential. This approach recognizes communities as legitimate partners in managing Chalghuza forests, blending traditional knowledge with official regulatory frameworks. Integrating Chalghuza conservation explicitly into provincial forest action plans ensures that these forests receive dedicated attention, resources, and monitoring within broader forest management priorities. Such formal co-management mechanisms can enhance accountability, improve resource management, and empower communities to sustainably steward these valuable forest ecosystems [26].

(2). Federal: At the federal level, incorporating Chalghuza forest conservation into national climate adaptation and forest policy frameworks is critical. Given the sensitivity of these pine nut forests to climate change impacts such as drought and pest outbreaks, aligning conservation efforts with national climate strategies can mobilize cross-sectoral support and funding. Embedding Chalghuza within the federal forestry policies reinforces its ecological and economic value, promoting coordinated actions across provinces while ensuring long-term policy backing for sustainable forest management and restoration initiatives [27].

(3). International: At the international level, mobilizing financial and technical support through major multilateral organizations is vital for scaling up restoration efforts. Agencies such as the Food and Agriculture Organization (FAO), United Nations Development Programmed (UNDP), and the Green Climate Fund offer both funding and expertise for large-scale landscape restoration and sustainable forest management. By tapping into these international mechanisms, Chalghuza forest conservation can benefit from global best practices, capacity building, and significant investment flows that enable effective rehabilitation and long-term resilience of forest ecosystems in the face of climate challenges [29].

(4). Education: Education and capacity building play a foundational role in fostering inclusive and sustainable conservation. Training programs aimed at youth and women can equip these groups with skills in forestry management, sustainable nut harvesting, and value-added processing techniques. Empowering youth ensures the transfer of ecological knowledge to future generations, while involving women broadens community participation and income opportunities. Such inclusive education initiatives build local expertise, enhance livelihoods, and strengthen community ownership of conservation efforts, making forest protection a shared and sustainable endeavor.

7. Conclusion

Community-based strategies stand out as the most effective and practical approach for conserving Chalghuza forests in Darazinda. These strategies center on empowering local communities by recognizing their rights over forest resources, providing them with the necessary technical knowledge, and facilitating better access to markets. When communities have formal and clear ownership or management rights, they develop a vested interest in protecting and sustainably managing the forests, as their livelihoods are directly tied to the health of these ecosystems. Technical support is critical in this empowerment process, equipping communities with sustainable harvesting techniques, regeneration practices, and fire and grazing management skills. Training and capacity building ensure that the management of the Chalghuza forests is informed by best practices that optimize both ecological health and economic returns.

Improving market access is equally important, as it addresses exploitation by intermediaries, increases local incomes, and enhances overall economic stability. By enabling communities to participate fairly in value chains—through cooperatives, collective marketing, and value-added processing—they gain stronger bargaining power and secure higher profits from forest products.

Darazinda's community-based conservation model can provide a replicable blueprint for other dry temperate forest regions across Pakistan. It demonstrates how harmonizing livelihood security with forest conservation is not only possible but mutually reinforcing. When local people benefit economically from sustainable forest stewardship, they become proactive guardians of forest ecosystems. This balance supports biodiversity conservation, secures vital ecosystem services, and sustains rural economies, contributing to broader environmental and social development goals in Pakistan. In essence, Darazinda can serve as a leading example of how participatory governance, technical empowerment, and equitable economic opportunities together create a resilient framework for forest preservation and community well-being across challenging dry temperate landscapes.

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