Challenges and opportunities in forest fire management in Nepal: An economic perspective

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Abstract

Climate change and human negligence are often cited as main drivers of forest fires in Nepal. However, this perspective argues that these factors are the result of underlying economic and institutional failures in forest management. Reduced interactions between forests and people, protection-oriented forest management practices, and weakened forest-agriculture interactions have led to underutilisation of forest biomass and the accumulation of combustible fuel. Consequently, recurrent and intense forest fires have emerged as negative externalities, where social costs exceed private benefits. Although they have caused significant economic, environmental, and health costs, the prevention and suppression of forest fires are not viewed as co-benefits of forest management. Hence, aligning forest fire management with biomass utilisation, incentive mechanisms, and climate policy commitments can help convert fire prevention into a long-term investment for sustainable forest management in Nepal.

Keywords: Biomass, Climate change, Externalities, Forest management, Incentive

FOREST FIRES BEYOND CLIMATE CHANGE: AN ECONOMIC INTERPRETATION

Forest fires constitute both an ecological and a socio-economic challenge in Nepal, as they impose substantial costs on forest resources, rural livelihoods, public health, climate change and national development. Every year, thousands of hectares of forest are affected during the dry season, particularly in the middle mountains and Chure regions of Nepal (Joshi *et al.*, 2025). Climate change is frequently cited as the major driver of these fire incidents (Rajbhandari *et al.*, 2025). In addition to climate change, forest fires are also linked to the underutilisation of forest biomass and the erosion of forest–agriculture linkages in Nepal. From an economic lens, forest fires should therefore be understood not only as natural hazards but also as outcomes of weak forest management incentives and the inefficient utilisation of forest resources (Qadir *et al.*, 2021; Rajbhandari *et al.*, 2025).

Historically, forest-people interactions in Nepal were intensive, primarily driven by subsistence activities such as the extraction of fuelwood, fodder, leaf litter, grasses, and small timber (Acharya, 2006). Forest products constituted essential inputs into the farm household production function. The regular collection of these materials contributed to the reduction of combustible biomass, while livestock-based agriculture, compost production, and seasonal grazing served as effective fuel management systems. In addition, the daily movement of farmers to collect fuelwood and fodder led to the formation of walking trails, which functioned as firebreaks.

However, the gradual transition from a non-monetised subsistence economy to a monetised and market-oriented economy has altered these traditional forest–agriculture linkages. Increased access to alternative energy sources, off-farm employment, migration, and rising opportunity costs of labour have collectively reduced the incentives for rural households to collect forest materials, leading to the accumulation of combustible biomass (KC *et al.*, 2021). Therefore, forest fires should be understood not only as environmental phenomenon but also as outcomes of declining forest resource utilisation driven by structural transformations in rural economies.

DECLINING FOREST–PEOPLE INTERACTION

Forests in Nepal are increasingly managed under a protection-oriented paradigm, resulting in the excessive accumulation of biomass (Shahi *et al.*, 2022; Van Winckel *et al.*, 2025). Moreover, rural-to-urban migration, the gradual shift away from livestock-based agriculture, and the complexity of forest-product harvesting processes have reduced interactions between forests and local communities. This has disrupted the socio-ecological dynamics of fire management that historically contributed to fire prevention. As a result, the frequency, intensity and coverage of forest fires have been increasing each year (Mishra *et al.*, 2023). The effects of forest fires are multidimensional, encompassing socio-psychological, economic, and environmental dimensions (Kalogiannidis *et al.*, 2023). These evidences show that forest-fire are destructive and economically inefficient tool to remove accumulated biomass.

This situation reflects a case of market failure and negative externalities from a welfare economics perspective. Forest biomass, which previously served as a raw material for both households and industries, is now left unused and instead contributes to the fuel component of the fire triangle. As a result, society bears the costs of forest fires, in terms of air pollution, carbon emissions, biodiversity loss, and disaster response expenditures (Poduška and Stajić, 2024). The absence of appropriate incentives, including an enabling environment for active forest management, shifts costs from forest managers and users to the broader public, thereby reducing overall economic efficiency.

ECONOMIC COSTS OF FOREST FIRES AND POLICY GAPS

In Nepal, the economic costs of forest fires are significant but remain inadequately accounted for (Paudel, 2022). Forest fires generate both direct and indirect costs. Direct damages include the loss of standing timber and non-timber forest products, carbon emissions, and delayed forest regeneration, which in turn reduces forest production and productivity. Indirect costs of forest fires encompass soil erosion, disruptions to water regulation, biodiversity reduction, declines in agricultural and hydropower production, and increased public health expenditures associated with smoke-related illnesses. Existing empirical studies suggest that prevention costs are substantially lower than post-fire recovery costs (Amacher *et al.*, 2006; Simon *et al.*, 2022). This provides a strong economic rationale for investing in preventive measures, such as active forest management aimed at sustainably utilising forest products.

Community Forest User Groups (CFUGs), which manage a large portion of Nepal's forests located near settlements, occupy a central position in forest fire economics. Their contributions to conservation and livelihood benefits have been widely

acknowledged (Aryal *et al.*, 2020). However, incentive structures, which were appropriate in a subsistence economy context now discourage active forest management in an increasingly monetised economy. Complex harvesting procedures and unfavourable market conditions increase transaction costs associated with thinning, harvesting, and transportation (Aryal *et al.*, 2020; Poudyal *et al.*, 2022). As a result, CFUGs often adopt protection-oriented forest management approaches despite rising forest fire risks. This is an example of incentive misalignment, in which forest users must internalise forest management costs, but externalise damages caused by forest fire.

Forest fires generate broad environmental impacts, including carbon emissions, biodiversity loss, and air pollution, many of which extend beyond local communities and are largely borne by society at national or global scales rather than by local actors (Gajendiran *et al.*, 2024; Hadiwijoyo *et al.*, 2026). In contrast, local impacts such as public health effects from smoke, land degradation, and limited availability of forest products are mostly borne by individuals. As a result, they are not reported as costs of the CFUG as a whole. CFUGs neither directly bear the economic costs of external damages nor receive private benefits from removing biomass. Therefore, they often have limited or no financial incentives to invest in fuel management practices such as cleaning, thinning, and harvesting (g, 2022).

Nepal's Forest Act 2019 provides a legal basis for sustainable forest management, emphasising protection, utilisation, silvicultural operations, and community participation (GoN, 2019). However, its practical implementation, particularly with regard to biomass utilisation, remains weak due to lengthy administrative procedures (Poudyal *et al.*, 2020). Existing policies, including the act, regulations and directives, need to recognise silvicultural operations such as thinning, pruning, and harvesting as economically productive and legally protected activities, rather than treating them as strictly controlled interventions. Integrating these activities into routine forest management, rather than subjecting them to special approval processes, would better align policy frameworks with forest fire management strategies. This is particularly important as forest-fire mitigation should be understood as a co-benefit of active forest management.

INCENTIVES FOR FOREST FIRE MANAGEMENT

Nepal's Nationally Determined Contributions (NDCs) highlight emission reduction, climate resilience, and sustainable land management (GoN, 2025). Forest fires play a dual role in undermining these commitments by releasing stored carbon and reducing the carbon sequestration potential of forests. Given that the costs of forest fire prevention are lower than the damages caused by forest fire, prevention represents a cost-effective climate mitigation strategy (Pacheco and Claro, 2021). This situation calls for the systematic integration of fire prevention into NDC implementation in order to generate co-benefits for livelihoods, biodiversity, and public health. In addition, Forest fire mitigation is essential for achieving the goal of Nepal's Long-term Strategy for Net-Zero Emissions (2021), which aims to achieve net-zero greenhouse gas emissions by 2045. This integration can be supported through targeted budg*et al.*ocations, performance-based grants, and enhanced access to climate finance.

Forest fire mitigation in Nepal, particularly through forest management aimed at reducing fuel loads, does not necessarily require

substantial financial investment. Rather, it depends on the establishment of market-oriented policies for timber and non-timber forest product harvesting, such as demand-based forest management, harvesting plans aligned with technical rotation ages, long-term auction mechanisms, and royalty reforms. Similarly, existing economic studies highlight the importance of restoring forest–agriculture linkages, as the decline of livestock-based farming systems has reduced demand for forest fodder and bedding materials, thereby contributing to fuel accumulation (KC *et al.*, 2021).

An ecosystem-based approach that boosts demand for local products can help restore forest–farm relationships. For this, Community Forest Operational Plans (CFOPs) should emphasise silvopastoral systems, controlled grazing, and demand-driven management. Such measures not only contribute to reducing fire risk but also boost overall forest productivity.

The cost-return gap often discourages local communities and the private sector to undertake restoration initiatives. Economic valuation tools, such as cost–benefit analysis and avoided damage assessment, can support more effective policy design to incentivise these actors to undertake restoration efforts. Incentive-based mechanisms such as payments for ecosystem services, carbon market instruments, and market creation for restoration benefits can help internalise the social and environmental benefits of restored forest ecosystems, while compensating stakeholders for opportunity costs and management efforts (Al Abri, 2022; Thompson, 2021)..

Post-fire restoration initiatives are costly, require long-term investment, and involve uncertain outcomes (Amacher *et al.*, 2006; Poduška and Stajić, 2024; Ryu *et al.*, 2017). As a result, local communities and public finance in developing countries often lack the capacity to bear restoration costs independently. In this context, a co-investment model involving governments, communities, donors and the private sector is essential to reduce upfront financial burdens and to align ecological recovery with livelihood, biodiversity and climate objectives (Besacier *et al.*, 2021). Private finance may be attracted if restoration investments are aligned with corporate net-emission-reduction commitments, sustainable supply chain goals, and branding opportunities (Löfqvist *et al.*, 2023).

Leveraging private finance may create opportunities to redirect public funds toward higher return interventions. For example, investment in early warning systems, fire lines, and community fire brigades yield higher returns compared to suppression costs (Simon *et al.*, 2022). Therefore, a co-investment model helps lower financial barriers, distributes risks, and aligns restoration efforts with biodiversity and climate objectives.

Nepal's federal governance system presents both challenges and opportunities for economically rational forest fire management. Local governments are in a strategic position to design context-specific incentive schemes, while provincial and federal governments can provide funding and coordination. Linking fiscal transfers to fire-risk reduction indicators (e.g. area under forest management, fire-line maintenance, or reduced incidence of forest fire) can further encourage preventive actions by CFUGs and local governments. Such performance-based fiscal transfers have the potential to incentivise proactive local government interventions in biomass reduction.

CONCLUSION

While climate change and individual actions are often cited as causes of forest fires in Nepal, the underlying driver is economic neglect. Forests have become a source of combustible fuel because of weak economic incentives, deteriorating forest–agriculture interactions, and regulatory barriers to forest management. Linking forest biomass to markets, simplifying forest use policies, and aligning fire management with forest management and NDC commitments can transform Nepal's forests from liabilities into productive assets that simultaneously support climate mitigation, biodiversity conservation, and rural livelihoods.

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