Anticipatory forest-fire risk governance in Nepal

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Abstract

Nepal's pre-monsoon forest fires are becoming increasingly frequent, widespread and socially consequential, damaging lives and livelihoods. However, responses remain largely reactive. These risks are compounded by institutional fragmentation and policy gaps that prevent timely and coordinated action. Drawing on disaster risk reduction principles, this perspective proposes an anticipatory approach to fire risk governance, emphasising the importance of community forestry institutions. In doing so, it combines empirical insights from Nepal with operational lessons from New South Wales and Victoria, Australia. Both cases highlight how forecast-based fire danger ratings function as decision triggers for agencies and communities. The Victorian case also illustrates how such triggers are embedded in the broader governance system. Together, these cases demonstrate that anticipatory governance is not about the forecast system alone, but about the systematic linkage of information to decision-making and behavioural response.

Keywords: Forest fire, Anticipatory governance, Disaster risk reduction, Fire preparedness, Nepal

INTRODUCTION

Nepal has been experiencing recurrent dry-season forest fires in both the Hill and Terai regions, with impacts on air quality, livelihoods, and public safety. The persistence and spatial extent of these fires indicate a systemic risk. Forest fires typically peak during the pre-monsoon period (February-May) and are increasingly driven by rising temperatures, prolonged dry periods, land-use change, and expanding exposure at the forest-settlement interface, thereby reducing the effectiveness of response-focused approaches (NASA Earth Observatory, 2021; Nepali Times, 2023). To make matters worse, response capacity, especially at the local level, remains limited. Fire response tends to remain reactive, with limited emphasis on proactive and systemic risk management. Internationally, forest fires are increasingly recognised as a disaster risk with cascading effects across health, livelihoods, infrastructure, and ecosystems (UNDRR, 2015; UNDRR, 2023). Australia has a long history of governance reform to manage fire risks in one of the most fire-prone continents on the planet.

In this perspective paper, we examine anticipatory forest fire risk in Nepal through a systems lens, analysing how institutional fragmentation and governance gaps constrain effective forest fire risk management, and how anticipatory governance can strengthen coordination, preparedness, and early action across levels of government. To do this, we also draw on insights from the state of New South Wales in Australia. This perspective uses the "boiling pot" analogy to analyse forest fire risks in Nepal, where rising temperatures, increased fuel loads, frequent ignitions, and expanding exposure are building simultaneously.

FOREST FIRE RISK AS A "BOILING POT"

The "boiling pot" metaphor effectively illustrates how multiple factors can combine to push a system past a critical point. Just as a pot boil only when heat, fuel, and pressure are sustained, Nepal's forest fire situation is becoming more threatening. Rising temperatures and prolonged dry periods increase heat; land management shifts lead to fuel accumulation; human activities frequently cause ignitions; and expanding settlements, roads, and infrastructure along forest edges increase exposure. When these elements converge, the risk of rapid, severe fires escalates significantly, potentially overwhelming local response capabilities.

Disaster risk reduction (DRR) frameworks emphasise managing risk before it becomes a disaster by focusing on-understanding risk, strengthening risk governance, investing in risk reduction, and enhancing preparedness for effective response and recovery (UNDRR, 2015). In forest fire contexts, this implies anticipatory action through predefined, trigger-based measures linked to forecasts and observed conditions (e.g., fire danger ratings, fuel dryness, wind events) that activate prevention measures, resource pre-positioning, restrictions on high-risk activities, and readiness of incident management structures. This involves monitoring and acting on changing fire risk conditions before escalation occurs. Without such anticipatory governance, Nepal risks being trapped into a recurring cycle of emergency mobilisation, short-term containment of fires that limits immediate spread but does not reduce underlying risk and recurring losses, effectively a 'pot' that boils over each year and becomes progressively harder to manage.

Scientific evidence and lived experience point in the same direction: baseline fire risk conditions are shifting. Hotter days, longer dry spells, erratic pre-monsoon rainfall and stronger wind events are changing how quickly forests dry and how aggressively fires spread (Barik and Roy, 2023). At the same time, rural out-migration and changing farming practices can leave more fuel in the landscape, as grasslands are not grazed as before, terraces are not maintained, and forest floors accumulate dry leaf litter (Moreira *et al.,* 2020). As roads, power lines and settlements expand along forest edges, the likelihood of ignition rises precisely where exposure is greatest. Nepal does not need to become as dry as Australia to face forest fire (known as bushfire in the Australian context) dynamics; it only needs more heat, more fuel, and more people and assets in harm's way. As elaborated below, this convergence is already underway, and the "boiling pot" is no longer a future risk but a present and intensifying reality.

DRIVERS OF ESCALATING FOREST FIRE RISK IN NEPAL

The escalation of forest fire risk in Nepal is not driven by a single factor but by the interaction of multiple reinforcing

drivers. These include climatic, ecological, institutional, and socio-economic drivers, and they are increasingly aligned, intensifying both the likelihood and the impacts of fire.

Weather and climate signals

The pre-monsoon period in Nepal is characterised by low humidity, rising temperatures, and unpredictable winds that can rapidly increase fire spread potential. Satellite-based analyses have documented extreme fire seasons, including 2016 and 2021, when drought conditions contributed to unusually high hotspot counts and smoke impacts (NASA Earth Observatory, 2021). For example, in 2021, the National Aeronautics and Space Administration (NASA) reported that Nepal received roughly a quarter of normal rainfall between January and April, and that the Visible Infrared Imaging Radiometer Suite (VIIRS) sensor detected tens of thousands of hotspots early in the season, with smoke contributing to hazardous air quality and disruptions (NASA Earth Observatory, 2021). These conditions are consistent with broader regional trends. The Intergovernmental Panel on Climate Change (IPCC)'s Sixth Assessment Report concludes with high confidence that the Hindu Kush Himalaya (HKH) has warmed faster than the global average and that compound hot-and-dry events, which elevate fire weather, are projected to intensify across South Asia (IPCC, 2022). Region-specific assessments by the International Centre for Integrated Mountain Development (ICIMOD) reach similar conclusions, projecting longer dry seasons and an increased frequency of extreme heat across the cryosphere-monsoon transition zones where Nepal's most fire-prone forests are located (Wester *et al.,* 2019). While any single season has multiple contributing causes, the direction of risk towards hotter and potentially longer fire seasons is clear, aligns with regional climate risk projections for the HKH region, and warrants precautionary governance.

Fuels, forest condition and land management

Nepal's success in forest regeneration, largely through community forestry, has environmental benefits, but it can also increase available biomass that can burn if forests are under-managed for fuel loads. Empirical analyses underscore the magnitude: between 2001 and 2020, more than 172,000 hectares of Nepal's forest burned, with biomass losses exceeding 7 million tonnes (Bhujel *et al.,* 2022). Additional evidence from vulnerability mapping shows that 78-89 per cent of the burned area occurs between March-May, and that fire frequency has trended upward by roughly 0.6 per cent per year (Mishra *et al.*, 2023; Matin *et al.*, 2017). Commentary and reporting in Nepal increasingly link rising fire impacts to fuel accumulation in protected and regenerating forests, compounded by reduced everyday use and stewardship in some places due to labour scarcity and rural out-migration (Nepali Times, 2023). Recent policy analysis similarly argues that insufficient and delayed forest management, together with weakened community-level collective action, has allowed fuels to build and small ignitions to escalate (ForestAction, 2025a). In the "boiling pot" analogy, fuels represent the contents of the pot, where greater accumulation without active management leads to more severe outcomes when conditions align.

Ignitions and incentives

Many forest fires have proximate human ignition sources: escaped agricultural burning,

roadside fires, carelessness during forest product collection, or deliberate lighting linked to grazing and access. However, focusing only on these immediate human causes risks overlooking the underlying structural issue. Across Nepal, changing rural livelihoods, out-migration, declining livestock rearing, and regulatory constraints on forest use and timber harvesting have reduced everyday forest-community interaction and weakened collective forest management practices (Tiwari *et al.,* 2022; Poudyal *et al.,* 2023). While these changes have contributed to forest regeneration and the expansion of forest cover, they have also reduced biomass extraction and landscape management in many community forests, creating conditions that increase forest fire risk. Additionally, Nepal lacks consistent incentive systems and enforceable, locally legitimate rules that reduce preventable ignitions on the highest-risk days. A risk-governance approach shifts the question from who started the fire to under what conditions ignitions are most likely to become damaging fires, and what rules, communication systems, and enforcement capacities exist to suppress that transition.

Exposure and the forest-settlement interface

Roads, power infrastructure, and expanding settlements increase both the probability of ignition and the consequences of fire. For instance, the spatial risk modelling for the Terai Arc Landscape, shows that human ignition pressure and exposure converge precisely where transport corridors and settlement edges meet regenerating forest, producing localised hotspots that are poorly captured by district-level statistics (Parajuli *et al.,* 2022). Nepal now has several operational and near-real-time information systems that can support exposure-aware planning, including the Government of Nepal's Forest Fire Detection and Monitoring System and associated interfaces that report fire statistics and locations, and regional systems developed with ICIMOD's SERVIR-HKH programme that integrate MODIS/VIIRS detections and provide outlook indices (DoFSC, 2026; SERVIR-HKH/ICIMOD, 2020). However, these systems only reduce risk if they inform action. When danger is elevated, agencies and communities need pre-defined and trigger-based actions that include resource staging, patrols, restrictions, and readiness of incident management teams, rather than passive observation. However, translating information into action remains constrained by fragmented institutional mandates, weak command-and-control arrangements, and unclear coordination across forest agencies, disaster authorities, and local governments, often resulting in delayed and uneven responses.

These drivers clearly show that forest fire risk in Nepal is not only increasing but also becoming more complex and interconnected. Forest fire is best understood as a livelihood shock that also creates long-tail ecological and economic impacts. Fire interrupts the seasonal calendar that supports rural households: fodder and bedding collection, grazing routes, leaf litter for compost, access to fuelwood and timber, and income from non-timber forest products (NTFPs). Severe fires can erase years of investment in regeneration and protection by community forest user groups (CFUGs) and can damage the watershed functions on which agriculture depends. Burned slopes can erode rapidly with the first heavy rains, contributing to sedimentation, irrigation disruption and downstream flood risk, illustrating how fire can cascade into other hazards rather than competing with

them (UNDRR, 2015). A substantial body of geomorphological evidence shows that forest fire-induced changes in soil hydrophobicity, vegetation cover and surface roughness can increase post-fire erosion and debris-flow hazard by one to several orders of magnitude, with effects persisting for years (Shakesby, 2011). For Nepal's steep mid-hill terrain, where fire seasons immediately precede the monsoon, this temporal coupling makes post-fire watershed risk a foreseeable and therefore manageable component of fire governance rather than a separate problem.

FOREST FIRE RISK AS A GROWING LIVELIHOOD CRISIS IN NEPAL

Forest fires in Nepal are not only an environmental hazard but also a multidimensional livelihood crisis with far-reaching social, economic, and health impacts. The consequences extend well beyond burned areas, affecting public health, labour productivity, equity, and governance systems.

Smoke, health, and productivity losses

Smoke turns local fires into a national-scale public health and economic issue. During dry seasons, smoke has driven unhealthy air quality, flight disruptions and school closures (Kuikel *et al.,* 2024). Health impacts are difficult to quantify precisely in Nepal due to limited monitoring coverage and attribution challenges, but the mechanism is well established: increased pollution levels elevate respiratory and cardiovascular risks and reduce labour productivity. A critical review of forest fire-smoke epidemiology found consistent associations between landscape fires and respiratory exacerbations, with growing evidence of cardiovascular and perinatal effects (Reid *et al.,* 2016). A subsequent global multi-city analysis attributed an estimated 33,500 deaths per year to short-term exposure to forest fire pollution with PM 2.5 (microscopic airborne particulate matter considered highly toxic to human health) across 749 locations (Chen *et al.,* 2021). For Nepal specifically, the Lancet Countdown estimates that ambient air pollution, of which dry-season biomass burning is a substantial seasonal contributor, reduces life expectancy by roughly 3.4 years (Lancet Countdown, 2024). Treating fire as only an environmental or forestry issue thus underestimates its cross-sectoral costs.

Equity and inclusion issues

Fire risk is unevenly distributed, as women, older people, and low-income households often have fewer options to avoid smoke exposure or relocate temporarily and face greater care burdens during crises. Similarly, many households living near forests remains highly dependent on forests for livelihoods such as firewood, fodder, grazing, and non-timber forest products, making them disproportionately exposed to fire impacts while also having fewer livelihood alternatives and limited recovery capacity. Historically marginalised groups, including Dalit communities in many local contexts, can be over-represented in hazardous response labour while under-represented in decision-making and in access to compensation or recovery support. Additionally, people with disabilities face greater challenges during evacuation, response, and recovery, yet these dimensions remain weakly integrated into forest fire preparedness and response systems in Nepal. Comparative work on Nepali community forestry shows that the meaningful inclusion of women in user group executive positions is associated with measurable improvements

in rule compliance and forest conditions (Agarwal, 2009). Intersectional analyses further demonstrate that caste, class, and gender jointly shape who decides, who labours, and who benefits in everyday forest management (Nightingale, 2011). Fire risk decisions such as when to patrol, who to alert, where to invest in fuel reduction, and how to compensate losses reproduce these inequities unless explicitly designed not to. This pattern mirrors broader evidence that community-based forest governance can deliver major gains yet still faces challenges of elite capture and inequitable benefit sharing without deliberate inclusion measures (Gurung *et al.,* 2011; Cadman *et al.*, 2023). A risk governance approach should therefore adopt an explicit equity lens for preparedness and response planning, ensuring that the needs, capacities, and safety of vulnerable and forest-dependent groups are integrated into fire governance systems, consistent with international DRR guidance (UNDRR, 2015).

ANTICIPATORY RISK GOVERNANCE FOR READINESS

While many fires are human ignited, the deeper determinant of disaster outcomes is governance. This encompasses how Nepal organises institutional incentives, authority, information flows, and capacity across the prevention-preparedness-response-recovery cycle. Anticipatory governance means acting on forecasts and observed risk, rather than waiting for flames to overwhelm local capacity. It requires (i) clear institutional responsibilities across forest agencies, disaster management authorities, and local governments; (ii) predictable financing for prevention and preparedness; (iii) operational protocols for escalation and inter-agency coordination; and (iv) public communication systems that translate technical risk into simple, trusted triggers for action (UNDRR, 2015; UNDRR, 2023). Without these elements, awareness campaigns and ad hoc enforcement are unlikely to shift outcomes at scale.

Translating early warning into early action

Nepal already receives near-real-time hotspot detections from global systems (e.g., NASA FIRMS) and has national and regional monitoring platforms that provide alerts and outlook indices (NASA FIRMS, 2026; SERVIR-HKH/ICIMOD, 2020; DoFSC, 2026). However, the missing link is institutionalising what happens *after* an alert is issued: Who verifies it? Who issues public warnings? What restrictions apply? Which resources are pre-positioned? Which CFUGs or communities receive support for patrols and fuel management? Without clear answers to these questions, early warning does not translate into early action. Anticipatory action requires that these steps be defined before the season, exercised, and resourced. Otherwise, information becomes a dashboard rather than a life and livelihood protecting system. The forecast-based financing (FbF) literature offers a transferable template: pre-agreed triggers tied to weather, and exposure forecasts release pre-positioned funds and authorise pre-defined actions hours to days before a hazard escalates, shifting the cost curve from response to readiness (Coughlan de Perez *et al.,* 2015). Embedding such triggers into Nepal's disaster financing, administered via the National Disaster Risk Reduction and Management Authority (NDRRMA), and matched to municipal preparedness plans, would convert existing fire danger information into binding operational decisions.

Financing prevention and preparedness

Nepal's fire response often relies on emergency mobilisation and short-term transfers of basic equipment. This approach is structurally expensive and inefficient because it pays repeatedly for response while underinvesting in the measures that reduce incident numbers and severity. Policy analysis has called for dedicated institutional arrangements and decentralised approaches that empower CFUGs and local governments, while strengthening coordination with security forces and disaster agencies (ForestAction, 2025a). However, despite being well positioned to support prevention and response through local resources and coordination, local governments often remain weakly accountable in forest fire management due to overlapping mandates in Nepal's forest governance system. While Division Forest Offices (DFOs) at the provincial level retain formal oversight responsibilities for forests, they often operate with limited budgets and human resources, underscoring the need for clearer institutional arrangements that support local governments through DFOs' technical oversight and coordination functions.

Strengthening community forestry for fire risk reduction

Community forestry is a globally recognised strength of Nepal's forest sector, providing local institutions and social capital that can enable prevention and rapid first response. However, its effectiveness in reducing fire risk depends on adequate support, coordination, and safeguards. Federal restructuring has created overlapping mandates and coordination challenges among local governments, DFOs, and CFUGs, contributing to 'passive' forest management and heightened hazards (ForestAction, 2025b). Anticipatory fire governance should therefore treat CFUGs as core risk reduction partners, supported by technical services, training, and resources, while also strengthening inclusive decision-making and safeguards against elite capture, so that the burdens and benefits of fire management are shared fairly (Cadman *et al.,* 2023; Gurung *et al.,* 2011). A risk lens forces practical questions about where damaging fire is likely, who and what are exposed, who is most vulnerable, what capacities exist, and how prevention, preparedness, response, and recovery (PPRR) connect. Insights from bushfire management in New South Wales (NSW), Australia, offer instructive operational example of how a jurisdiction can translate these questions into everyday systems, while also showing that even well-developed systems must continually adapt to climate-driven extremes.

OPERATIONAL LESSONS FROM NEW SOUTH WALES (NSW), AUSTRALIA

Experience from NSW, Australia, provides instructive examples of how anticipatory risk governance can be translated into practice through forecasts, institutional coordination, and public communication that support timely and pre-defined action.

Fire danger ratings and triggers

NSW uses publicly communicated fire danger ratings to translate complex weather-fuel conditions into simple categories that are tied to recommended actions and, on severe days, legal restrictions (NSW RFS, 2024). These ratings serve as shared anticipatory triggers for both households and agencies.

This system supports two critical functions: (i) community decision-making (e.g., prepare, avoid travel, or leave early), and (ii) agency operational readiness through pre-positioning resources, staffing incident management teams, and activating coordination arrangements before fire escalation. Since 2022, the four level Australian Fire Danger Rating System (Moderate, High, Extreme, Catastrophic) has unified what was previously a patchwork of state level scales. Post-implementation evaluations in NSW emphasise that simplicity and consistency rather than technical sophistication are what make ratings actionable for households and agencies (AFAC, 2022; McCoy and Field, 2022).

Consistent incident management

NSW applies a common incident management language and role structure so that, when a fire escalates, coordination can scale quickly without re-inventing who does what. For Nepal, the transferable point is modest but important: anticipatory governance works best when roles, authority, information flows, and requests for support are organised in a shared way across community, municipal, provincial, and federal levels before a crisis intensifies. Without such common structures, coordination delays can undermine early action. Detailed design choices, institutional fit and sequencing for an Incident Management System in Nepal are addressed in the complementary paper (Hill and Shrestha, 2026) and are not repeated here.

Communicating risk requiring early decisions

NSW guidance explicitly states that on the highest danger days ("Catastrophic"), the safest option is to leave fire risk areas well before any fire starts because homes may not withstand fires and help may not be available (NSW RFS, 2024). This form of direct communication is critical to anticipatory risk governance because it links high risk conditions to early protective decisions. It is an uncomfortable message, but it shifts the focus from promising suppression everywhere to managing exposure and vulnerability through timely action. Nepal's rugged terrain, limited access, and constraints on specialised suppression resources make a similar realism essential, particularly for remote settlements and high value watersheds where rapid response is difficult.

STRENGTHENING ANTICIPATORY FIRE RISK GOVERNANCE: LESSONS FROM VICTORIA, AUSTRALIA

Victoria's fire governance system has co-evolved through successive cycles of fire events, public inquiries, and policy reforms, transitioning from a largely reactive firefighting model to a more anticipatory approach of fire management (Dwyer *et al.,* 2025). The evolution demonstrates that anticipatory fire governance is not simply the result of a single reform, but how it emerges gradually drawing on institutional learning, system-wide coordination, and adaptation at multiple levels.

At the core of the anticipatory system is the forecast-based decision-making, as illustrated in the NSW case. The Australian Fire Danger Rating System (AFDRS) is an official forecast system that translates weather and fuel conditions into publicly available fire risk categories expressed as 'Fire Danger Ratings', to guide both agency preparedness and communities' protective action (AFAC, 2022; Kenny *et al.,* 2024). These risk categories do not only function as the information tool but as an anticipatory governance mechanism,

connecting weather and fuel conditions to behavioural guidance, operational readiness, and regulatory controls including restrictions based on the pre-defined triggers (AFAC, 2022). Together, these ratings act as the shared reference to align decisions across households, emergency services and government agencies. Prior to adopting a nationally consistent system the AFDRS, Victoria relied on the McArthur system. The transition marked a shift from an empirically derived index to a comprehensive science-based system that integrates diverse environmental, behavioural, and spatial factors into fire risk assessment (Hollis *et al.,* 2024). This highlights that anticipatory fire governance is not merely a technical improvement in forecast system, but a shift in how fire risk is understood and acted upon.

Operation of the forecast system is deeply embedded in a broader governance structure, characterised by a multi-level coordination, adaptive institutional reform, and risk informed planning (Dwyer *et al.,* 2025), recognising that isolated sectoral responses are insufficient for an effective forest fire governance. Coordination across levels, is central to essential decision-support in Victoria, for planning and preparedness enabling prioritisation of resources, infrastructure protection and fuel management in high fire risk areas. These insights can be relevant to Nepal, in realising that the challenges are not the absence of fire risk information but the lack of a system that facilitates linking information to coordinated anticipatory action across multiple governance levels.

The Victorian case also highlights the that even within a well-established system of anticipatory fire risk governance, understanding community preparedness and behaviour are still challenging. Evidence from different fire events including 2009 Black Saturday bushfires illustrates persistent challenges in timely decision making, inadequate preparedness and reactive responses (Whittaker *et al.,* 2013) More studies also emphasise that providing early warning does not necessarily guarantee the early action, signalling the importance of comprehensive understanding of behavioural insights, communication strategies and decision-support mechanisms within the governance systems.

BUILDING AN ANTICIPATORY FIRE RISK SYSTEM UNDER FEDERALISM: OPPORTUNITIES FOR ACTION

Nepal's community forestry system is a foundational asset for fire risk reduction, but it cannot be asked to carry a growing hazard without systematic support. Many CFUGs already cut basic fire lines, organise patrols and respond to small ignitions; however, out-migration and ageing membership reduce available labour, and limited access to protective gear, tools, training, insurance, and communications constrains safe and effective response. Under federalism, overlapping mandates among local governments, DFOs and CFUGs can also delay decisions and dilute accountability (ForestAction, 2025b; Hill and Shrestha, 2026). Any effective approach must therefore recognise both the strengths and the capacity limits of community institutions and focus on how multi-level governance can enable them.

Federalism makes anticipatory fire governance both more complex and more necessary. Fires do not respect administrative boundaries, yet authority and budgets do. Hill and Shrestha (2026) analyses the constitutional and legislative sources of role confusion in detail; we therefore focus on risk governance

implications. Preparedness cannot depend on improvised negotiation once smoke is already in the sky. A practical way forward is to define (and resource) complementary roles that are activated before the crisis through pre-agreed preparedness levels linked to forecast danger. In broad terms, municipalities lead local risk mapping, preparedness planning, volunteer support, water points and public communication; provinces provide training systems, logistics, surge capacity and cross-municipality coordination; and the federal level sets minimum standards, maintains national early warning infrastructure, enables mutual aid, and integrates fire risk into disaster-risk financing and accountability mechanisms.

Decision support is the connective element of anticipatory governance. Nepal's monitoring systems already integrate satellite detections and provide incident reporting and outlook information (SERVIR-HKH/ICIMOD, 2020; DoFSC, 2026). The next step is to formalise an end-to-end chain from forecast to action. This could include: (i) a Nepal adapted fire danger rating or readiness index communicated in plain language; (ii) standard operating procedures that specify what municipalities, forest offices and CFUGs do at each level (e.g., patrols, restrictions on open burning, staffing of response teams); (iii) escalation rules for requesting provincial or federal support; and (iv) routine post-season evaluation using consistent incident data capturing livelihood and health impacts as well.

First, Nepal can treat large forest fires as a core disaster-risk governance issue rather than a seasonal forestry problem by establishing a clear national framework that defines PPRR responsibilities across forest agencies, disaster authorities and all three levels of government. Such a framework should include standing coordination arrangements that are activated by risk levels (not ad hoc crisis negotiation), minimum standards for planning and capability, and predictable financing for prevention and preparedness. This includes support for community-level fuel management and fire lines, equipment maintenance, communications, training, and post-season learning so that investment shifts from repeated emergency mobilisation towards sustained readiness.

Second, anticipatory action requires shared triggers that convert risk information into routine decisions. Building on existing monitoring and outlook tools, Nepal could co-design a simple, nationally consistent preparedness-level system (or fire danger rating/readiness index) communicated in plain language and explicitly tied to actions at each level. These actions may include patrols, restrictions on high risk burning, pre-positioning of resources, staffing arrangements, and clear escalation rules for requesting provincial or federal support. Standard operating procedures should specify who verifies alerts, who issues public warnings, and what actions are authorised and funded at each preparedness level; and routine incident reporting, seasonal summaries and after-action reviews should track livelihood and health impacts alongside burned area so that budgeting reflects the true costs of fire.

Third, capability must be built where fires start. Municipalities and CFUGs should be supported as front-line risk-reduction partners through training, basic protective equipment, communications, and safe operational guidance that prioritises responder protection and avoids hazardous "heroic" suppression. This should be complemented by a scalable coordination doctrine and role clarity to enable smooth support as incidents become more complex (detailed incident-

management system design is addressed in the companion paper). Equity should be made operational by specifying inclusive representation in preparedness planning, fair access to training and equipment, and safeguards so marginalised groups are not disproportionately assigned the most dangerous tasks.

Finally, preparedness will not reduce losses if combustible forest fuels continue to accumulate. Locally appropriate landscape and fuel management options that are designed with community acceptance and safety in mind, should be prioritised, particularly considering the financial and technical limitations faced by local communities. In many areas, indigenous knowledge systems and locally available resources can support prevention and early responses. However, increasingly severe forest fires can also place communities and frontline responders at significant risk, highlighting the need for stronger institutional support, training, protective equipment, and access to more specialised tools and operational capacities. Additionally, targeted learning partnerships can further help Nepal adapt proven elements of public warning and operational readiness to its federal and community forestry context.

CONCLUSION

Nepal's forest fire risk is no longer a seasonal issue, but a systemic governance challenge driven by the convergence of rising heat, fuel accumulation, human ignitions, and expanding exposure. The paper shows that the core gap is not the absence of information or local institutions, but the failure to convert these into timely, coordinated, and anticipatory action. Without such a shift, reactive response will continue to produce escalating livelihood, health, and environmental losses.

The main opportunity is to build an end-to-end anticipatory fire risk system that links monitoring to action through clear roles, shared triggers, predictable preparedness financing, and practical coordination across all levels of government. Priority recommendations include strengthening community forestry institutions as supported local partners, establishing standard operating procedures and escalation arrangements, investing in locally appropriate fuel management and responder safety, and adapting relevant lessons from NSW to Nepal's federal and community forestry context.

Anticipatory fire governance is not a technical upgrade but rather a fundamental shift in how the state understands and manages risks. Without this shift, forest fires will continue to be treated as isolated seasonal events, even as their impacts become increasingly national in scale. With it, Nepal has a credible pathway to reduce losses, protect vulnerable communities, and align its forest and disaster governance systems with the realities of a changing climate.

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REFERENCES

Australasian Fire and Emergency Service Authorities Council. (2022). *The Australian fire danger rating system.* https://afdrs.com.au/

Agarwal, B. (2009). Gender and forest conservation: The impact of women's participation in community forest governance. *Ecological Economics, 68*(11), 2785–2799. https://doi.org/10.1016/j.ecolecon.2009.04.025

Barik, A., & Baidya Roy, S. (2023). Climate change strongly affects future fire weather danger in Indian forests. *Communications Earth & Environment, 4*, 452. https://doi.org/10.1038/s43247-023-01112-w

Bhujel, K. B., Sapkota, R. P., & Khadka, U. R. (2022). Temporal and spatial distribution of forest fires and their environmental and socio-economic implications in Nepal. *Journal of Forest and Livelihood, 21*(1), 1–13. https://doi.org/10.3126/jfl.v21i1.56575

Cadman, T., Maraseni, T., Koju, U. A., Shrestha, A., & Karki, S. (2023). Forest governance in Nepal concerning sustainable community forest management and red panda conservation. *Land, 12*(2), 493. https://doi.org/10.3390/land12020493

Chen, G., Guo, Y., Yue, X., Tong, S., Gasparrini, A., Bell, M. L., Armstrong, B., Schwartz, J., Jaakkola, J. J. K., Zanobetti, A., Lavigne, E., Nascimento Saldiva, P. H., Kan, H., Royé, D., Milojevic, A., Overcenco, A., Urban, A., Schneider, A., Entezari, A., ... Li, S. (2021). Mortality risk attributable to wildfire-related PM2.5 pollution: A global time series study in 749 locations. *The Lancet Planetary Health, 5*(9), e579–e587. https://doi.org/10.1016/S2542-5196(21)00200-X

Coughlan de Perez, E., van den Hurk, B., van Aalst, M. K., Jongman, B., Klose, T., & Suarez, P. (2015). Forecast-based financing: An approach for catalyzing humanitarian action based on extreme weather and climate forecasts. *Natural Hazards and Earth System Sciences, 15*(4), 895–904. https://doi.org/10.5194/nhess-15-895-2015

Department of Forests and Soil Conservation. (2026). *Forest fire detection and monitoring system in Nepal* [Web portal]. Government of Nepal, Ministry of Forests and Environment.

Dwyer, G., Marjoribanks, T., Morgan, F., & Farmer, J. (2025). Bushfire public inquiries: From recommendations to hybrid emergency management arrangements. *Australian Journal of Public Administration, 84*(2), 403–441.

ForestAction Nepal. (2025a). *Strengthening forest fire management in Nepal* (Policy Brief No. 52). ForestAction Nepal.

ForestAction Nepal. (2025b). *Fostering collaboration between community forestry and local government in Nepal* (Policy Brief No. 51). ForestAction Nepal.

Gurung, A., Karki, R., & Bista, R. (2011). Community based forest management in Nepal: Opportunities and challenges. *Resources and Environment, 1*(1), 26–31.

Hill, A., & Shrestha, M. (2026). Institutional fragmentation and forest fire management in federal Nepal: Bridging the governance gap through incident management systems. *Journal of Forest and Livelihood*. [Companion paper, this issue].

Hollis, J. J., Matthews, S., Anderson, W. R., Cruz, M. G., Fox-Hughes, P., Grootemaat, S., ... & Sauvage, S. (2024). A framework for defining fire danger to support fire management operations in Australia. *International Journal of Wildland Fire, 33*(3), WF23141.

Intergovernmental Panel on Climate Change. (2022). Asia. In H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama (Eds.), *Climate change 2022: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the IPCC* (pp. 1457–1579). Cambridge University Press. https://doi.org/10.1017/9781009325844.012

Kenny, B. J., Matthews, S., Sauvage, S., Grootemaat, S., Hollis, J. J., & Fox-Hughes, P. (2024). Australian fire danger rating system: Implementing fire behaviour calculations to forecast fire danger in a research prototype. *International Journal of Wildland Fire, 33*(4).

Kuikel, S., Pokharel, B., & Bhattarai, N. (2024). The effect of wildfires on air quality in Kathmandu, Nepal. *Environmental Advances, 15*, 100493. https://doi.org/10.1016/j.envadv.2024.100493

Lancet Countdown on Health and Climate Change. (2024). *The 2024 report of the Lancet Countdown on health and climate change — Nepal country profile.* Lancet Countdown on Health and Climate Change.

Matin, M. A., Chitale, V. S., Murthy, M. S. R., Uddin, K., Bajracharya, B., & Pradhan, S. (2017). Understanding forest fire patterns and risk in Nepal using remote sensing, geographic information systems and historical fire data. *International Journal of Wildland Fire, 26*(4), 276–286. https://doi.org/10.1071/WF16056

McCoy, L., & Field, D. (2022). Lessons from the NSW RFS trial of the Australian fire danger rating system. *Australian Journal of Emergency Management, 37*(4).

Mishra, B., Panthi, S., Poudel, S., & Ghimire, B. R. (2023). Forest fire pattern and vulnerability mapping using deep learning in Nepal. *Fire Ecology, 19*, Article 3. https://doi.org/10.1186/s42408-022-00162-3

Moreira, F., Ascoli, D., Safford, H., Adams, M. A., Moreno, J. M., Pereira, J. M. C., Catry, F. X., Armesto, J., Bond, W., & González, M. E. (2020). Wildfire management in Mediterranean-type regions: Paradigm change needed. *Environmental Research Letters, 15*(1), 011001. https://doi.org/10.1088/1748-9326/ab541e

NASA Earth Observatory. (2021, April 15). A fierce fire season in Nepal. NASA. https://earthobservatory.nasa.gov/images/148185/a-fierce-fire-season-in-nepal

NASA Land, Atmosphere Near real-time Capability for EOS. (2026). *Fire information for resource management system (FIRMS)* [Database]. NASA LANCE.

Nepali Times. (2023, May 13). More pre-monsoon forest fires in Nepal. *Nepali Times.*

Nightingale, A. J. (2011). Bounding difference: Intersectionality and the material production of gender, caste, class, and environment in Nepal. *Geoforum, 42*(2), 153–162. https://doi.org/10.1016/j.geoforum.2010.03.004

NSW Rural Fire Service. (2024). *Fire danger ratings and total fire bans in NSW.* https://www.rfs.nsw.gov.au/fire-information/fdr-and-tobans

Parajuli, A., Gautam, A. P., Sharma, S. P., Lamichhane, P., Sharma, G., Bist, B. S., Aryal, U., & Basnet, R. (2022). A strategy for involving community forest managers in effective forest fire management in Nepal. *Banko Janakari, 32*(1), 41–51. https://doi.org/10.3126/banko.v32i1.45476

Poudyal, B. H., Khatri, D. B., Paudel, D., Marquardt, K., & Khatri, S. (2023). Examining forest transition and collective action in Nepal's community forestry. *Land Use Policy, 134*, 106872. https://doi.org/10.1016/j.landusepol.2023.106872

Reid, C. E., Brauer, M., Johnston, F. H., Jerrett, M., Balmes, J. R., & Elliott, C. T. (2016). Critical review of health impacts of wildfire smoke exposure. *Environmental Health Perspectives, 124*(9), 1334–1343. https://doi.org/10.1289/ehp.1409277

SERVIR-HKH/ICIMOD. (2020). *Forest fire detection and monitoring system in Nepal.* International Centre for Integrated Mountain Development.

Shakesby, R. A. (2011). Post-wildfire soil erosion in the Mediterranean: Review and future research directions. *Earth-Science Reviews, 105*(3–4), 71–100. https://doi.org/10.1016/j.earscirev.2011.01.001

Tiwari, S., Paudel, N. S., Sze, J., & Karki, R. (2022). Unravelling the local dynamics of increasing fires in community forests of mid-hills of Nepal. *Journal of Forest and Livelihood, 21*(1), 60–71. https://doi.org/10.3126/jfl.v21i1.56587

United Nations Office for Disaster Risk Reduction. (2015). *Sendai Framework for Disaster Risk Reduction 2015–2030.* UNDRR.

United Nations Office for Disaster Risk Reduction. (2023). *Report of the midterm review of the implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030.* UNDRR.

Wester, P., Mishra, A., Mukherji, A., & Shrestha, A. B. (Eds.). (2019). *The Hindu Kush Himalaya assessment: Mountains, climate change, sustainability and people.* Springer. https://doi.org/10.1007/978-3-319-92288-1

Whittaker, J., Haynes, K., Handmer, J., & McLennan, J. (2013). Community safety during the 2009 Australian 'Black Saturday' bushfires: An analysis of household preparedness and response. *International Journal of Wildland Fire, 22*(6), 841–849.