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Towards integrated fire management in the Peruvian Andes: Moving beyond disaster risk management to address wildfires

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ABSTRACT

Wildfires pose an escalating environmental, economic, and social threat in the Peruvian Andes. This study examines wildfire disaster risk management (DRM) across seven Andean regions, assessing legal frameworks, institutional actions, and the integration of Integrated Fire Management (IFM). Combining documentary analysis and semi-structured interviews with public officials, it reveals fragmented, hierarchical governance and weak intergovernmental coordination.

Although suppression remains dominant, some regions have adopted integrated fire management elements, including community brigades and awareness campaigns, despite severe financial and technical constraints. Emergency response still relies heavily on vulnerable communities with little government support. The agricultural burning ban remains unenforced, while traditional fire knowledge is largely excluded from formal management frameworks.

The study identifies six priorities for improving wildfire risk management: budget allocation, fire-use knowledge, capacity building, institutional coordination, regulatory reform, and integrated public policy. Advancing integrated fire management requires incorporating ecological, cultural, and social dimensions, recognizing rural communities' essential role, and addressing structural inequalities that heighten wildfire risks. Framing fire as a socio-ecological phenomenon, the research informs adaptive, culturally responsive policies in the Andes and beyond.

1. Introduction

In recent decades, wildfires—defined here as escaped, unintentional vegetation fires of natural or human origin (Huidobro et al., 2024; Luna-Celino et al., 2025)—have increased in frequency and intensity worldwide (Pandey et al., 2023; IPCC, 2022; Jolly et al., 2015). These events increasingly challenge disaster risk management (DRM) systems, promoted by the United Nations since the 1990s and reinforced by the 2015 Sendai Framework to reduce risk and enhance resilience (UNDRR, 2025). DRM encompasses risk assessment, prevention, reduction, preparedness, response, and recovery, strengthening adaptive capacities through collaboration and shared responsibility among authorities, sectors, citizens, and NGOs (Kirschner et al., 2024; Huidobro et al., 2024). Governmental or community actors may lead these processes through institutional or local arrangements (Rodríguez et al., 2023). Despite its integrative potential, top-down wildfire DRM often excludes communities (Kirschner et al., 2023), overlooks local knowledge of fire's benefits and impacts (Luna-Celino et al., 2025), and neglects its ecological role (Shlisky et al., 2007).

In 2024, widespread wildfires devastated Amazonian and Andean ecosystems, marking a critical year for South America (Galarraga Gortázar et al., 2024; Rosch and Equipo de Periodismo Visual de BBC Mundo, 2025). Although partially overlapping geographically, these regions differ in environmental conditions, fire regimes, and governance contexts. Yet regional assessments and policy discussions often overlook these distinctions, treating them as a single fire landscape.

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In South American Andean ecosystems, most wildfires originate from uncontrolled small-scale agricultural burning (Alvarez et al., 2025; Aronés Cisneros et al., 2024; Correa-Quezada et al., 2025; Luna-Celino et al., 2025; Manta Nolasco, 2017; Taboada-Hermoza and Martínez, 2025). Other drivers include declining traditional fire knowledge (Mistry et al., 2016; Rodríguez et al., 2023), land tenure disputes, migration, vandalism, and retaliation (Spadoni et al., 2023; Ríos Hervas, 2023). Changing environmental and policy conditions also influence wildfire dynamics but are often overlooked by mitigation strategies that disproportionately blame smallholders (Carmenta et al., 2021).

In Andean ecosystems, DRM remains dominated by suppression tactics aimed at extinguishing or "killing" fires (Huidobro et al., 2024; Neger et al., 2024). Reinforced by national fire-use bans (Armenteras et al., 2020), this approach has encouraged illicit burning rather than prevention. Andean fire users—mainly small-scale crop and livestock farmers organized in campesino communities, producers' associations, or similar groups—must therefore balance food security against restrictive legislation and punitive fire policies (Carmenta et al., 2021).

The limitations of suppression-based strategies and top-down models have prompted debate over alternatives to growing wildfire threats. Integrated Fire Management (IFM) offers a holistic approach recognizing fire's ecological and social roles, incorporating traditional knowledge, improving stakeholder communication, and fostering community participation in risk reduction (Luna-Celino et al., 2025; Neger et al., 2024; Rodríguez et al., 2023). IFM acknowledges fire's landscape-level risks and benefits (Gillson et al., 2019; Lotan, 1979; Moore, 2019; Myers, 2006; Rego et al., 2010) through three dimensions: fire management, fire ecology, and fire culture (Myers, 2006; OTCA, 2021). Fire management encompasses prevention, detection, control, and use; fire ecology examines natural and anthropogenic processes and ecological effects; and fire culture addresses socioeconomic and traditional aspects of rural fire use (OTCA, 2021). Together, these dimensions complement DRM in reducing wildfire frequency and impacts.

Although fire suppression still dominates in South America, several countries have begun institutionalizing aspects of IFM despite ongoing challenges. Ecuador approved a National Strategy for Integrated Fire Management in 2006 (Agreement MAE-MAE-2026-0038-AM); Bolivia has regulated agricultural burning as a productive tool since 2019 (Law No. 1171); and Colombia regulates controlled agricultural burning (Decree 1076 of 2015) and has proposed integrating IFM into land-use planning (Meza Elizalde and Armenteras, 2023), with temporary prohibitions when necessary. Nevertheless, evidence linking DRM and IFM remains limited, and entrenched reactive policies persist. Comparative analyses could identify shared barriers and context-specific lessons to facilitate the transition toward IFM.

International commitment to IFM has grown. Andean members of the Amazon Cooperation Treaty Organization (OTCA) endorsed a regional memorandum supporting IFM (OTCA, 2021). At COP30, all except Bolivia reaffirmed this commitment by signing the Call to Action on Integrated Fire Management and Forest Fire Resilience, alongside 68 signatory countries (FAO, n.d.) committed to strengthening fire resilience through integrated approaches (Leaders of the Thirtieth Conference of the Parties—COP30, 2025).

Growing concern over wildfire impacts has increased attention to prevention, control, and sustainable ecosystem management (Parlamento Andino, 2024). Despite relatively strong legal frameworks, IFM remains constrained by institutional fragmentation and implementation challenges in Andean countries (Correa-Quezada et al., 2025), where its implementation is still recent. Regional experiences illustrate these limitations. Colombia's wildfire policies emphasize social co-responsibility but overlook community perceptions and fire-use practices (Meza et al., 2019). Ecuador legally recognizes controlled agricultural burning but poorly integrates it into national risk management systems (Betancourt Cuadrado, 2021). In Bolivia, Law N°1171 promotes IFM, but funding constraints hinder implementation (Correa-Quezada et al., 2025), while underlying wildfire causes remain unaddressed (Capriles, 2026). Regulatory reform alone is therefore insufficient; progress requires understanding local contexts and policy implementers' perceptions (Correa-Quezada et al., 2025; Luna-Celino et al., 2025). Because public policy can exacerbate or mitigate wildfires (Pandey et al., 2023), its design must reflect local realities (Beggs and Dalley, 2023). Incorporating stakeholder perspectives strengthens transparency and conflict management (Luna-Celino et al., 2025).

In Peru, DRM is a state-led system of strategies, resources, and measures aligned with national policies and risk governance frameworks (Kirschner et al., 2023; Asamblea General de las Naciones Unidas, 2016). Legal and institutional arrangements interact with local norms and beliefs, shaping risk perceptions and management across scales. Peruvian law defines DRM as a social process encompassing risk prevention, reduction, and control, alongside preparedness, response, and recovery (Law No. 29664, Article 3). Given wildfires' links to Andean ecosystems, this study includes ecological restoration within DRM (FAO, 2021; OTCA, 2021), complementing the seven nationally established processes (Table 1).

This study examines wildfire DRM implementation across seven Peruvian Andean regions through legal frameworks, planning documents, and stakeholder experiences, primarily those of public officials. Dominated by Andean ecosystems, these regions have Peru's highest wildfire risk (CENEPRED, 2025) and incidence during 2012–2024 (MINAM, n.d.). Specifically, it (1) assesses institutional alignment with DRM regulations, identifying convergence and fragmentation; (2) examines actions, resources, and strategies across national, regional, local, and community levels; and (3) identifies existing IFM elements and barriers to its full adoption in the Andes.

This study highlights wildfire perceptions and management in the Peruvian Andes, where fire use is tied to rural livelihoods and vulnerability (See Table 2). Although less extensive than elsewhere in South America, wildfires threaten communities that depend on fire yet suffer most when it escapes control (Alvarez et al., 2025; Luna-Celino and Kainer, 2024; Carmenta et al., 2021). While excluding other Peruvian biomes, particularly the Amazon, this focus enables a context-specific understanding of Andean fire governance. Linking local realities with experiences from other Andean countries and emerging governance paradigms, the study aims to inform more effective, context-sensitive wildfire risk reduction policies.

Table 1
Definitions of disaster risk management (DRM) processes.

Processes	Definitions
Risk Assessment	Generate knowledge of hazards, analyze vulnerabilities, and establish risk levels to support informed decision-making.
Prevention	Prevent the emergence of new risks within the framework of sustainable development management.
Risk Reduction	Reduce existing vulnerabilities and risks through sustainable development measures.
Preparedness	Strengthen preparedness through planning, capacity-building, institutional organization, early warning systems, and resource management to ensure coordinated and effective disaster response.
Response	Respond immediately to emergencies or disasters, or act in anticipation of imminent hazards.
Rehabilitation	Restore essential public services and begin repairing physical, environmental, social, and economic damage as a bridge toward reconstruction.
Reconstruction/ Restoration	Establish sustainable development conditions in affected areas, reduce pre-existing risks, and promote physical, social, and economic recovery.

Developed in accordance with Peruvian Law No. 29664.

Table 2
Socio-economic characteristics of the population in the study regions.

Region	Population (Thousands)	National population distribution (2024)	Rural population	Population self-identifying as indigenous or of Andean origin	Main occupation related to agriculture	Campesino Communities	
						Quantity	National percentage
Lima (capital)	11 305,0	33.2%	1.75%	17%	1.43%	291	4%
Ayacucho	669,7	2%	42.86%	81.41%	28.14%	704	11%
Apurímac	426,6	1.3%	55.15%	84.45%	30.24%	522	8%
Cajamarca	1 447,7	4.3%	65.47%	6.26%	36.57%	112	2%
Cusco	1 398,0	4.1%	40.29%	75.17%	24.42%	969	15%
Huancavelica	335,1	1%	70.38%	80.85%	44.70%	672	10%
Junín	1 380,6	4.1%	29.80%	35.07%	19.74%	456	7%
Puno	1 208,8	3.6%	47.21%	90.71%	34.26%	1352	20%

Source: INEI, 2017, 2018, 2024; MINAM, n.d.

2. Study context

2.1. Study area: 7 Andean regions in Peru

Of Peru's 36 continental ecosystem types, 12 occur in the Andes, covering 25.4% of its territory. Humid puna grasslands predominate (9.3%), followed by Andean shrublands (7.9%) and dry puna grasslands (3.8%) (MINAM, 2019). During 2002–2025, approximately 60% of wildfire-related emergencies occurred in Andean ecosystems, particularly humid puna grasslands, Andean shrublands, jalca, and dry puna grasslands (Román et al., 2024; Zubieta et al., 2023; MINAM, n.d.) (Fig. 1a & b). Seven regions accounted for 65% of burned area and 46% of emergencies: Cajamarca (north); Ayacucho, Huancavelica, and Junín (central highlands); and Apurímac, Cusco, and Puno (south) (SERFOR, n.d.).

2.2. Socioeconomic characteristics of the population in the Peruvian Andes

The Peruvian Andes are home to approximately 26% of the national population, a share that has declined by 39% since 1940 due to rural-to-urban migration, mainly toward coastal cities. This has contributed to rural depopulation, while the Coast held approximately 60% of Peru's population by 2024 (INEI, 2024; INEI-CEPAL, 2022). The seven study regions exhibit marked socioeconomic disparities, with Cajamarca, Puno, and Huancavelica among Peru's lowest-ranked regions in the Human Development Index (HDI) (PNUD, 2025). Disparities also extend to Indigenous self-identification (35–90%, excluding Cajamarca) and agricultural employment (20–45% of regional workforces) (INEI, 2017). The Andes contain 46.3% of Peru's agricultural land and 64% of its agricultural producers (INEI, 2013). Quechua is widely spoken across the study area, reflecting its cultural and linguistic diversity (INEI, 2017).

Andean farming is predominantly small-scale and family-based, traditionally subsistence-oriented with limited external investment (Fulcrand Terrisse, 2008). Recent studies document agropastoral changes, including crop diversification (Karpouzoglou et al., 2020), changing livestock practices (Rosas Morales, 2015; Suarez Bellido, 2015), and shifts in communal organization. Campesino communities—smallholders managing their own production (Urrutia

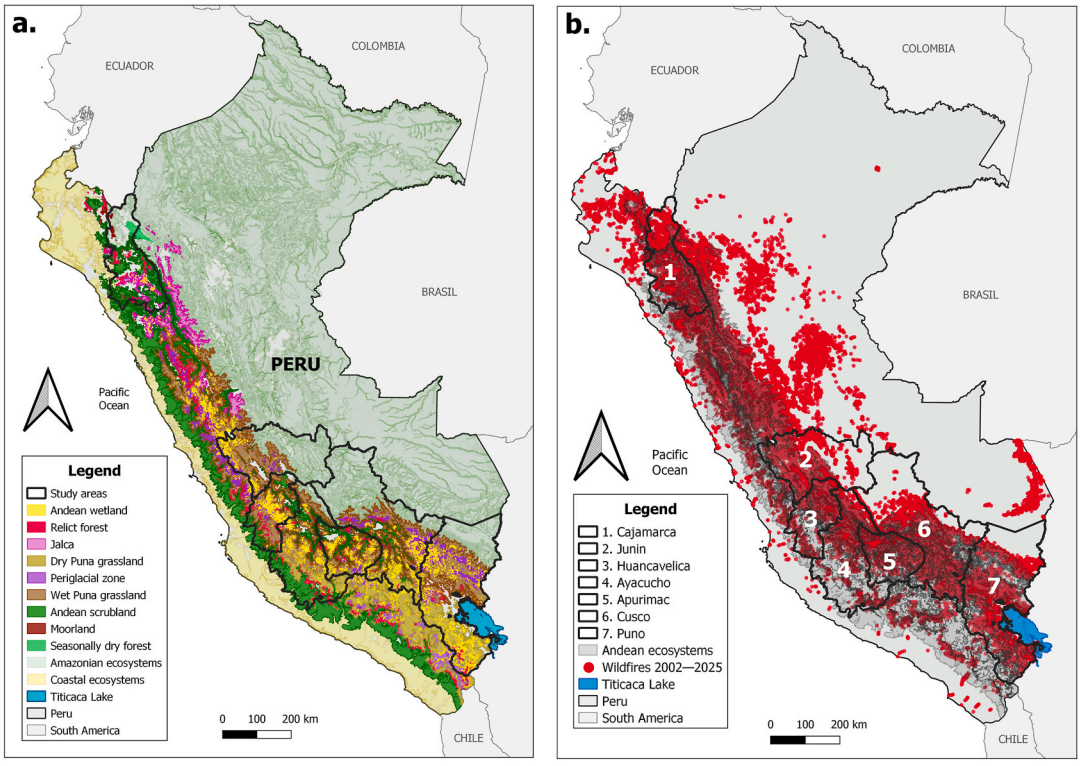

Fig. 1. a & 1b. Ecosystems and wildfires events in the Andean Region of Peru. Data source: MINAM (n.d.; 2019).

et al., 2019)—are central to Andean territorial governance and collective regulation (Hall, 2017; Mayer, 2004). They manage over 60% of Peru's agricultural land, and 73% of registered communities are in the seven study regions (INEI, 2017), underscoring their role in resource governance, food security, and local fire and risk management.

2.3. Fire use and wildfires in the Peruvian Andes

Agricultural burning is part of the agricultural calendar and is central to livestock management in the Peruvian Andes. Farmers use fire to fertilize soils, remove residues and unwanted vegetation, and reclaim cropland (Alvarez et al., 2025; Luna-Celino and Kainer, 2024). In frost- or hail-prone regions, burning protects crops (Taboada-Hermoza and Martínez, 2025). On the Altiplano, it also regenerates totora reed beds, providing fodder and materials for Lake Titicaca's floating islands.

Although widespread, agricultural burning is prohibited and penalized in Peru, including for subsistence farming (DS No. 018-2015-MINAGRI; Legislative Decree No. 1237; DS No. 016-2012-AG). Official reports rarely identify wildfire causes, but studies attribute over 90% to human activities (Manta Nolasco, 2017), often uncontrolled agricultural burning amid declining traditional fire knowledge and social structures governing its use (Alvarez Rios, 2022; Aronés Cisneros et al., 2024; Luna-Celino and Kainer, 2024; Taboada-Hermoza and Martínez, 2025). Despite being considered inexpensive, burning requires considerable time, labor, and financial resources (Madera, 2023) and depends on local knowledge-based techniques restricted by legal prohibitions (Alvarez et al., 2025; Luna Celino and Kainer, 2024). Increasing risks reflect changing participation and agricultural dynamics (Rodríguez et al., 2023), driven by multiscale factors but disproportionately affecting subsistence communities (Carmenta et al., 2021).

2.4. Disaster risk management applied to wildfires in Peru

Established under Law No. 29664, the National Disaster Risk Management System (SINAGERD) has served as Peru's integrated DRM framework since 2011, replacing the 1972 Civil Defense System. Coordinated by the Presidency of the Council of Ministers (PCM), SINAGERD operates across government levels through a decentralized, participatory structure (Fig. 2). A key innovation was establishing specialized technical advisory bodies—the National Institute of Civil Defense (INDECI) and the National Center for Disaster Risk Estimation, Prevention, and Reduction (CENEPRED)—the latter marking a shift from reactive response toward proactive risk management. Following the severe 2024 wildfire season, the PCM leaded the elaboration of a Multisectoral Plan for Wildfire Response in coordination with six mministries (Supreme Decree No. 010-2025-PCM).

Regional and local governments—provincial and district municipalities—primarily implement Peru's DRM system (Article 14, Law No. 29664). They develop and implement ordinances and plans covering all seven DRM processes (Table 1). National and Civil Defense Offices across government levels oversee, implement, and advise on DRM actions.

In 2023, amendments to the Organic Law of Regional Governments established Regional DRM Offices (Law No. 31913), strengthening regional structures. The updated SINAGERD Law (2024) clarifies conformation of Emergency Operations Centers (COEs) at national, sectoral, regional, and local levels. COEs monitor hazards, emergencies, and disasters, providing information for timely decisions (Article 51, Supreme Decree No. 060-2024-PCM). Alongside SINAGERD, national policies (State Policy No. 32, Supreme Decree No. 038-2021-PCM) and plans (Supreme Decree No. 115-2022-PCM, Supreme Decree No. 060-2024-PCM) guide subnational DRM implementation.

Peru's wildfire management is led by the National Forest and Wildlife Service (SERFOR), a technical and regulatory agency under the Ministry of Agrarian Development and Irrigation (MIDAGRI). Established in 2014, SERFOR maintains the National Wildfire Inventory and provides training to strengthen regulatory enforcement.

Under the SINAGERD Law, the Peruvian Volunteer Fire Department (CGBVP) is recognized as part of civil society and serves as the country's primary first-response agency. During wildfire emergencies, CGBVP

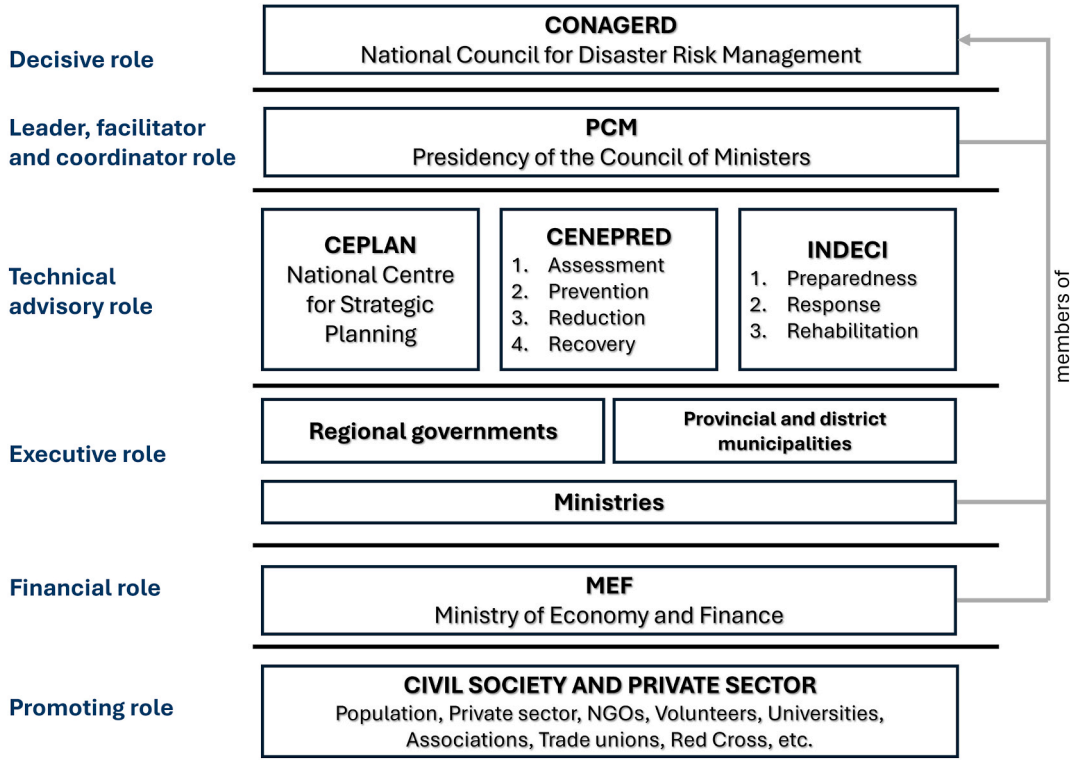

Fig. 2. Entities of SINAGERD. Adapted from INDECI, 2015.

formally leads response efforts in coordination with local and regional governments. In protected areas, responsibility falls to the National Service of Natural Protected Areas (SERNANP), under the Ministry of the Environment (MINAM), or the Ministry of Culture (MINCUL) when archaeological sites are affected. When local and sectoral capacities are exceeded, the Armed Forces (FF.AA.) and National Police (PNP) may provide support through interinstitutional brigades. The Multisectoral Plan (PCM, 2025) recognizes support brigades and community volunteers in wildfire management, but financial and regulatory constraints hinder their integration and long-term sustainability within DRM. Despite formal participation provisions, SINAGERD remains largely top-down, with national decision-making and subnational implementation (Fig. 2). Under this governance structure, public institutions dominate wildfire planning and response, while rural communities have mainly supportive and promotional roles. Despite their central role in everyday fire use and management, they remain largely excluded from formal decision-making and wildfire governance.

International cooperation supports regional wildfire risk management. Programmes such as Amazonía+ and the FiRe Project (Strengthening Resilience to Wildfire Risk), funded by the European Union and Swiss Agency for Development and Cooperation, respectively, strengthen Andean–Amazonian government capacities while recognizing Indigenous Peoples and local communities in integrated wildfire management. Yet these participatory principles remain unevenly embedded in national governance.

3. Materials and methods

This study combined a systematic review of wildfire regulations and planning documents with 22 semi-structured interviews conducted from December 2024 to May 2025. Documents and participants were selected to characterize national and regional wildfire risk management frameworks in the Peruvian Andes. Interviewees were primarily officials responsible for wildfire risk management in regional and local governments across the study regions. Non-governmental interviewees represented conservation organizations, all based operationally in Cusco. For clarity, Supplementary Material A provides a glossary of the institutions and key concepts referred to throughout the study.

This study has several limitations. First, the document review included only formal regulatory and planning documents publicly available or obtained through government agencies. Their limited availability and fragmented accessibility reflect Peru's wildfire governance landscape, where information is dispersed across sectors and administrative levels. Second, interviews focused on national and regional officials, providing detailed institutional perspectives but underrepresenting local actors, particularly rural communities and agricultural fire users. Consequently, findings primarily reflect formal institutional frameworks and wildfire risk governance rather than the diversity of local experiences and fire-use practices.

3.1. Document search and review

A document review identified regulatory instruments (laws, decrees, bylaws, resolutions) and plans addressing agricultural burning and wildfire DRM across the study regions, despite dispersed and often inaccessible information. The review first examined regulations, then compared planned national and regional wildfire DRM actions with implementation reported by officials. Planning documents met four criteria: (1) national or regional scope encompassing the seven study regions; (2) wildfire-specific coverage, or general DRM plans where specific documents were unavailable; (3) validity through at least 2025; and (4) inclusion of at least one of the seven DRM processes. These sources inform understanding of institutional operations and policy implementation. Supplementary Material B lists the reviewed documents. Fig. 3 summarizes the review process, information sources, selection criteria, and extraction and analysis of wildfire DRM activities described below.

Institutional and regulatory information was obtained from the SINAGERD Law and its regulatory framework. Legislation on agricultural burning and wildfire DRM was retrieved from the Digital Archive of Peruvian Legislation–Congress and the official newspaper El Peruano using "wildfires (incendios forestales)", "disaster risk management (gestión del riesgo de desastres)", "agricultural burning (quemas agrícolas)", and "burning (quemas)". Searches identified 112 legal documents, of which 60 current documents passed preliminary screening. Relevance screening excluded another 50, leaving 10 regulations: six concerning wildfires, two agricultural burning, and two DRM (Supplementary Material B). Exclusions covered repealed regulations, draft legislation, temporary measures (e.g., emergency decrees), and documents lacking information on institutional roles or penalties related to wildfires and agricultural burning.

Documents on regional DRM actions were collected in two stages:

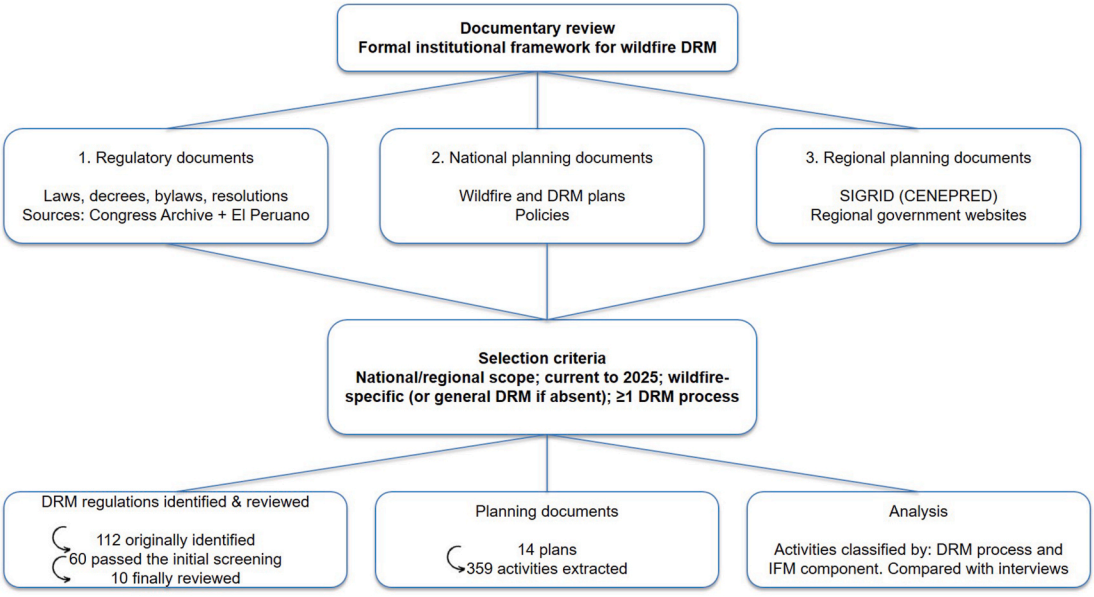

Fig. 3. Hierarchical overview of the documentary review process.

through the Disaster Risk Management Information System (SIGRID), containing CENEPRED-validated studies and instruments, followed by targeted searches of regional government websites. These sources provide insights into institutional arrangements, policy implementation, and regional DRM operations.

Subnational governments must prepare plans covering the seven core DRM processes (Supreme Decree No. 060-2024-PCM). By 2025, only Ayacucho, Junín, and Cusco had wildfire-specific prevention and risk reduction plans; other regions used general DRM plans. Emergency operations plans existed in Huancavelica, Cajamarca, and Cusco, but none had updated contingency plans, although Ayacucho was developing one. Preparedness plans existed in Apurímac, Cajamarca, and Huancavelica, the only region with a rehabilitation plan. Nationally, the Multisectoral Plan for Wildfires addresses preparedness and risk reduction, while the National Emergency Operations Plan 2023–2026, approved under Ministerial Resolution No. 237-2022-PCM, was not publicly available. A review matrix captured region, title, objective, activity, targets, budget (where available), measure type, DRM process, and IFM component. The 14 documents contained 359 activities (Supplementary Material C), which served as analytical units, classified by the seven DRM processes and three IFM components. Descriptive analysis primarily examined frequencies.

The review yielded four findings. First, despite guidelines, document formats vary considerably, resulting in inconsistent information. Second, access remains decentralized, with incomplete coverage in SIGRID. Third, all study regions have planning instruments, but few explicitly address wildfire risk, and local documents are scarce. Fourth, reliance on context-specific grey literature or officials' expert judgment limits regional comparability. This heterogeneity hampers systematization of wildfire DRM actions. Under the updated framework (Supreme Decree No. 060-2024-PCM), regional DRM planning comprises three plans: prevention and reduction, reactive management, and operational continuity.

Because regional governments lack plans covering all seven DRM processes, relying solely on planning documents biases assessments of action distribution. Addressing this limitation and implementation challenges requires primary data, particularly official interviews and ethnographic fieldwork, to capture wildfire risk governance processes and their cyclical nature.

3.2. Semi-structured interviews on disaster risk management and integrated fire management

Primary data on DRM frameworks, implementation, and IFM in the Andes were gathered through semi-structured, open-ended interviews with regional and provincial officials, SERFOR technical staff, and non-governmental organizations (NGOs). A 27-question guide covered seven thematic sections based on the DRM processes in Table 1, consistent with Peruvian Law No. 29664. Questions addressed resources, wildfire dynamics, DRM implementation, and IFM perceptions (Supplementary Material D). Public institution participants were selected according to DRM responsibilities. Interview requests targeted regional offices responsible for disaster risk, emergency operations, or environmental management. Interviewees were office heads or designated specialists. SERFOR appointed its representative, while NGO participants were selected for wildfire and DRM expertise.

Twenty-two specialists were interviewed after providing informed oral consent. Online interviews were initially considered, but low response rates, limited availability, lack of institutional obligation, and preferences for direct interaction made face-to-face interviews more effective. Twenty-one interviews occurred at participants' workplaces, enabling observation of infrastructure, equipment, and staffing. Nineteen interviewees were public officials, reflecting the focus on policy implementation, operational constraints, and State–community mediation. Tenure ranged from 1 to 16 years. NGO representatives showed greater staff continuity, while officials averaged three years in their positions and eleven years of professional experience. Gender imbalance was evident: 77% of officials were men, whereas all NGO participants were women. Transcripts were analyzed using 23 thematic codes in Atlas.ti (trial version), focusing on institutional arrangements and DRM actions. Data from 11 comuneros (10 men), including former community presidents and local leaders interviewed during ethnographic fieldwork in Cusco (2023–2024), complemented the analysis of community mechanisms for integrated fire management. To protect interviewees' identities, each was assigned a code consisting of P and a sequential number. To preserve the richness of testimonies, 139 quotations were selected and coded with Q and a sequential number (Supplementary Material C). All quotations cited below are identified by these codes.

This qualitative dataset was supplemented by fieldwork in Cusco, Apurímac, and Junín (2022–2025), contextualizing local institutions, community dynamics, and wildfire governance. Ethnographic observations and semi-structured interviews on agricultural burning and wildfires in Cusco communities (2022–2024) (Alvarez et al., 2025; Taboada-Hermoza and Martínez, 2025) informed the analysis of local fire practices and community interactions with public institutions and NGOs. These longitudinal observations also motivated the study, highlighting the need to assess systematically whether planning and regulatory frameworks guiding institutional action and public resource allocation reflect field realities.

4. Results

4.1. Institutional governance of wildfire DRM in the Peruvian Andes

4.1.1. Institutional coordination across governance levels

This study examined institutional coordination for DRM across governance levels in the Peruvian Andes. The analysis covered four dimensions: coordination between national and regional authorities, regional and local governments, government institutions and communal organizations, and public institutions, civil society organizations, and international partners. These dynamics are essential to assessing how DRM policies translate into action across institutional and territorial levels.

DRM in Peru involves a complex, multilevel system of institutions with distinct mandates. Fig. 4 summarizes key wildfire DRM actors and their relationships. Government institutions operate at four administrative levels: central, regional, provincial, and district. They interact with sectoral agencies overseeing forestry, agriculture, environment, culture, protected areas, security, and emergencies, including SERFOR, MIDAGRI, MINAM, MINCUL, SERNANP, INDECI, the Armed Forces, and National Police. Local and Regional Emergency Operations Centers (COEL and COER) coordinate territorial emergency responses. The framework also encompasses community organizations, civil society actors, including NGOs and fire departments, and agricultural fire users.

4.1.1.1. Coordination between national and regional authorities. The Presidency of the Council of Ministers leads national efforts, while SERFOR oversees wildfire hazards. Although DRM is recognized as multisectoral (Q1), leadership remains unclear. SERFOR's technical and regulatory mandate limits its authority, while resource constraints hinder subnational coordination (Q2).

Central government intervention during emergencies occurs only at Level 4, after an official emergency declaration. Escalation requires local, provincial, and regional governments to exhaust their capacities before requesting national support. Officials reported that this hierarchy delays intervention, widening response gaps and exacerbating crises. During the 2024 wildfire season, which caused 40 deaths and affected over 44 000 ha (Defensoría del Pueblo, 2024), several regional governments requested emergency declarations after exceeding their capacities. The Prime Minister rejected these requests, citing "no sufficiently

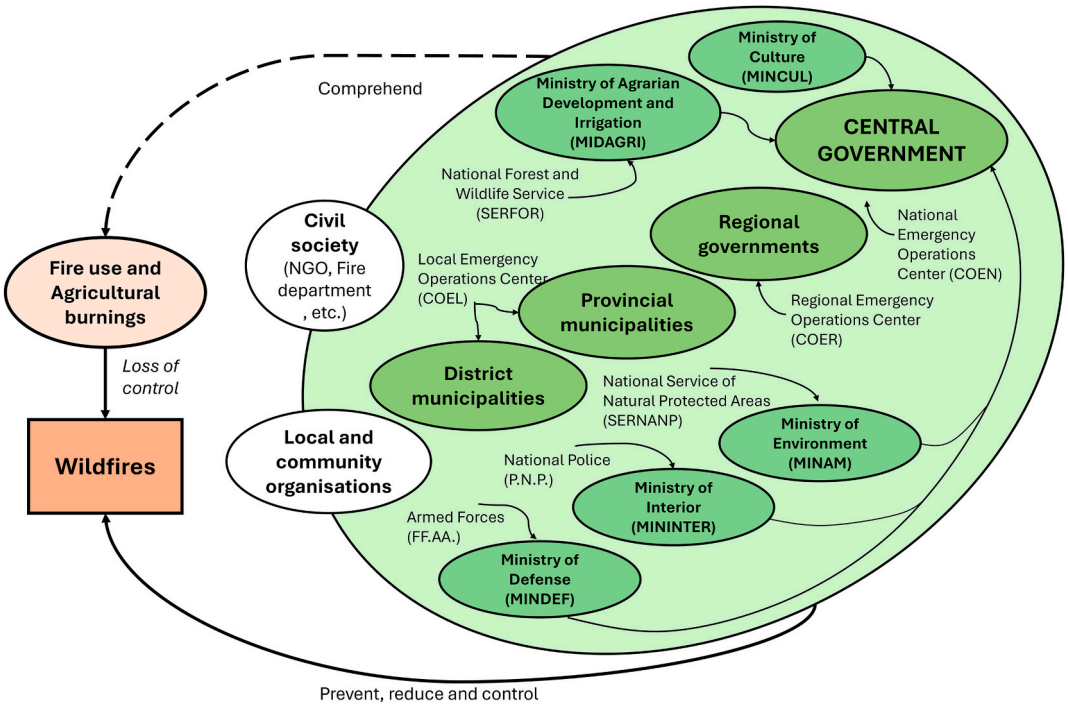

Fig. 4. Coordination for wildfire risk governance (WRG) in the Peruvian Andes.

critical reasons" for an emergency declaration or international assistance, despite acknowledging Peru's support to Ecuador and Bolivia (Actualidad Ambiental, 2024). This decision drew criticism and reinforced regional authorities' perceptions of state neglect. Only after mounting social media evidence and official recognition of the fires' severity did the central government declare emergencies in six regions, including Cajamarca (DS N°097-2024-PCM; DS N°099-2024-PCM).

Regionally, Working Groups and Civil Defense Platforms formally support coordination, while Regional Civil Defense Offices, Regional Emergency Operations Centers (COERs), Environmental Management Offices, and governors primarily implement DRM actions. Emergency Operations Centers (COEs) play varying roles. In Cusco and Puno, they proactively establish coordination mechanisms, including Cusco's Technical Committee, and strengthen response capacity, exemplified by Puno's regional wildfire brigade. In Cusco, Puno, Ayacucho, and Apurímac, COEs work closely with Civil Defense Offices, whereas in Huancavelica they primarily validate information and coordinate with the Fire Department. Nevertheless, COEs struggle to fulfill their mandates, especially provincially and locally (Q3, Q4). Interregional knowledge exchanges, particularly Cusco-led initiatives, have advanced financial, institutional, and community-based DRM strategies elsewhere.

4.1.1.2. Coordination between regional and local governments. Regional–local coordination is central to DRM in the Peruvian Andes. Although Working Groups and Civil Defense Platforms provide formal mechanisms, implementation relies primarily on Local Civil Defense Offices, Local Emergency Operations Centers (COELs), Environmental Management Offices, and elected officials, particularly provincial and district mayors.

Officials consistently reported precarious local DRM operations due to outdated equipment and shortages of specialized personnel (Q5, Q6, Q7). District municipalities often lack the financial and human resources to fulfill frontline DRM mandates. Coordinating initial responses with communities further exposes this gap between responsibilities and capacity (Q8). Environmental Management Offices, involved in wildfire DRM two decades ago, now focus on conservation areas. Despite retaining responsibility for post-wildfire ecological restoration, their activities remain largely disconnected from broader DRM processes.

4.1.1.3. Coordination between government institutions and communal organizations. Coordination between government institutions and local or communal organizations remains limited. The Multisectoral Plan assigns these groups a supporting role in wildfire prevention and risk reduction, with little involvement in emergency response. Community brigades, committees, and watch groups mainly verify fires and report them to agencies such as COEs or the Fire Department. Their establishment requires formal local recognition through participatory processes, with regional variations. In Cusco, where brigades emerged in 2012, community assemblies appoint members (Q9). In Puno, committees receive communal approval and recognition through district mayoral resolutions, with intergovernmental coordination (Q10, Q11). In Cajamarca, conservation-area brigades are supported by rondas campesinas, traditional organizations maintaining community order and enforcing local norms (Q12). In Abancay (Apurímac), local watch groups (vigías) are recorded in Civil Defense Platform minutes and advise communal authorities (Q13). These organizations link communities and subnational governments in DRM, although officials questioned their long-term sustainability. In Cusco (Q14), some governments included brigades in NGO-supported incentive schemes (Q9).

Although these programs provide funding, officials and NGO representatives warned that inconsistent incentives could undermine voluntary participation (Q10). Some institutions instead strengthened communal organizations considered more resilient to fluctuations in external support (Q15). Nevertheless, wildfire prevention and response remain low community priorities (Q16, Q17), and local organizations generally operate within their territories (Q18).

4.1.1.4. Coordination between public institutions, civil society organizations, and international partners. Civil society organizations and international cooperation agencies strengthen institutional capacity, local organization, and operational resources, compensating for subnational government constraints. In Cusco, at least three NGOs support wildfire

DRM through biodiversity conservation and ecosystem restoration, two establishing community brigades (Q19), an approach later adopted in Apurímac through local watch groups.

International cooperation has gained importance. By May 2025, the United States Agency for International Development (USAID) had pledged US$70 million through 2030 for three environmental initiatives, including US$6 million for wildfire prevention and mitigation. US political changes, however, have raised uncertainty over disbursement (Convoca, 2025). The EUROCLIMA programme, launched in Peru in 2025, began wildfire risk reduction projects in conservation areas across Cajamarca, Cusco, and Ucayali.

4.1.2. Regulatory framework and enforcement

The regulatory framework shapes wildfire governance in the Peruvian Andes by defining agricultural burning regulations, assigning responsibilities, and guiding institutional and community responses to wildfire risk.

Peru's legal framework prohibits and penalizes agricultural burning and wildfires in forest heritage areas. Despite strict regulations, interviewed officials, including those from SERFOR, the sanctioning authority, acknowledged major enforcement challenges. Two issues emerge. First, assigning responsibility is difficult because wildfires often originate from agricultural burns embedded in kinship and local networks (Q20, Q21, Q22). Attribution can strain family and community relations, particularly where communal organizations lack authority. Second, ambiguous legal definitions complicate sanctions. In Andean ecosystems, the most affected vegetation is high-altitude grassland (pajonal), which falls outside the legal definition of forest heritage (Q23). Land ownership also influences fire occurrence, mostly on communal or private lands. Officials differed on sanctions. Some favor revising penalties toward community-based measures, including public service, temporary detention, or suspension of communal membership (Q24). Others advocate stricter punitive enforcement, particularly for negligence in agricultural burning.

In 2022, Peru's Congress proposed Bill 3636/2022-CR on wildfire prevention, management, and post-fire recovery. Following the 2024 emergencies, five initiatives were consolidated into the draft "Law for the Prevention and Combat of Wildfires" (PL 8994/2024-PE). Officials stressed the need for coherent DRM policy reflecting Peru's cultural and socio-economic diversity (Q25, Q26). Some campesino communities, independently or with NGO support, have adopted agricultural burning regulations and wildfire sanctions, including expulsion, loss of membership, or damage-based fines (Q27, Q28). These measures have improved coordination and vigilance during controlled burns, reducing wildfire incidents. In Cusco, sanctions also restrict temporary employment and require labor to support affected households (Q29).

Enforcement remains inconsistent across communities. Without formal wildfire regulations, conflicts are often resolved through informal dialogue, with parties agreeing on restitution or forgiveness through compensation or labor (Q30), particularly for minor damage (Q31). Unresolved cases are referred to SERFOR or the National Police (Q32, Q33).

4.2. From planning to implementation: wildfire DRM actions

Although national policies guide integrated wildfire risk management, subnational governments must adapt them locally. According to CENEPRED (2025), 17 Peruvian regions face high or very high wildfire risk, yet only seven have registered prevention and risk reduction plans in SIGRID. Of the seven regions studied, only Ayacucho, Cusco, and Junín have wildfire-specific DRM prevention and risk reduction plans; others rely on general instruments. Cajamarca prioritizes hydrometeorological hazards. Puno's contingency plan established response protocols but has expired. Apurímac's wildfire prevention plan, valid until 2021, included IFM actions absent from its current general plan. Huancavelica drafted but never finalized a wildfire plan valid through 2025, although preparedness and rehabilitation plans were approved.

This section examines wildfire DRM implementation, first reviewing actions in regional plans, then comparing them with officials' accounts to identify challenges and positive experiences across DRM processes.

4.2.1. Regional planning framework

Across seven regions, 359 planned actions cover prevention, preparedness, response, and rehabilitation (Fig. 5a). Huancavelica, Cajamarca, and Cusco account for approximately 60% of these actions. Overall, 71% are non-structural, primarily involving capacity building, institutional strengthening, information generation, and DRM tool development. Fewer structural measures include firefighting equipment, ranging from backpack sprayers to aerial systems, and natural infrastructure for prevention and rehabilitation, including reforestation, silviculture, firebreaks, and water storage. Actions concentrate on prevention, reduction, and response (Fig. 5b).

4.2.2. Implementation across disaster risk management processes

4.2.2.1. Risk assessment. Only 9% of recorded actions address risk assessment. CENEPRED evaluates wildfire risk nationally and regionally, identifying high- and very-high-risk districts, but subnational governments rarely use these assessments. Monitoring remains fragmented, tracking fire-prone conditions and hotspots (Q34, Q35). COEs therefore often verify emergencies by telephone with residents (Q34). Provincial and district risk estimation relies mainly on field assessments. The absence of an integrated, multilevel wildfire monitoring and recording system causes underreporting and uncertainty about the national scale of wildfire impacts.

4.2.2.2. Prevention and risk reduction. Prevention and risk reduction represent 31% of recorded actions, the largest planning category. Strategies promote alternatives to agricultural burning and strengthen DRM through awareness and capacity building. SERFOR promotes composting agricultural residues, long supported by NGOs but not explicitly linked to wildfire risk reduction. These initiatives remain intermittent and geographically limited (Q36, Q37, Q38, Q39), mainly due to SERFOR's budget constraints and short-term technical contracts (Q37, Q40). Adoption is hindered by burning's advantages for residue disposal (Q41), the need to demonstrate alternatives' effectiveness—"farmers need to see to believe"—and migration-driven rural labor shortages that constrain labor-intensive practices (Q42). NGOs in Cusco also promote regenerative pruning to reduce fuel loads, although residue management is harder where gas has replaced firewood (Q42).

Awareness and capacity-building campaigns vary regionally. Subnational governments often recommend controlled burning (Q43), despite its legal prohibition. Officials in Cusco, Puno, and Cajamarca reported school-based environmental education, while these regions and Ayacucho broadcast wildfire prevention messages in Quechua through community radio, particularly effective for agricultural producers (Q44). SERFOR instead emphasizes legal prohibitions, sanctions, and alternatives (Q45), as promoting controlled burning conflicts with its regulatory mandate (Q46).

4.2.2.3. Preparedness. Preparedness accounts for 18% of planned actions, mainly comprising technical assistance for emergency response, training and institutionalization of community brigades, and pilot early warning systems. Training and technical assistance extend from households (Q47, Q48) to regional institutions, although knowledge transfer

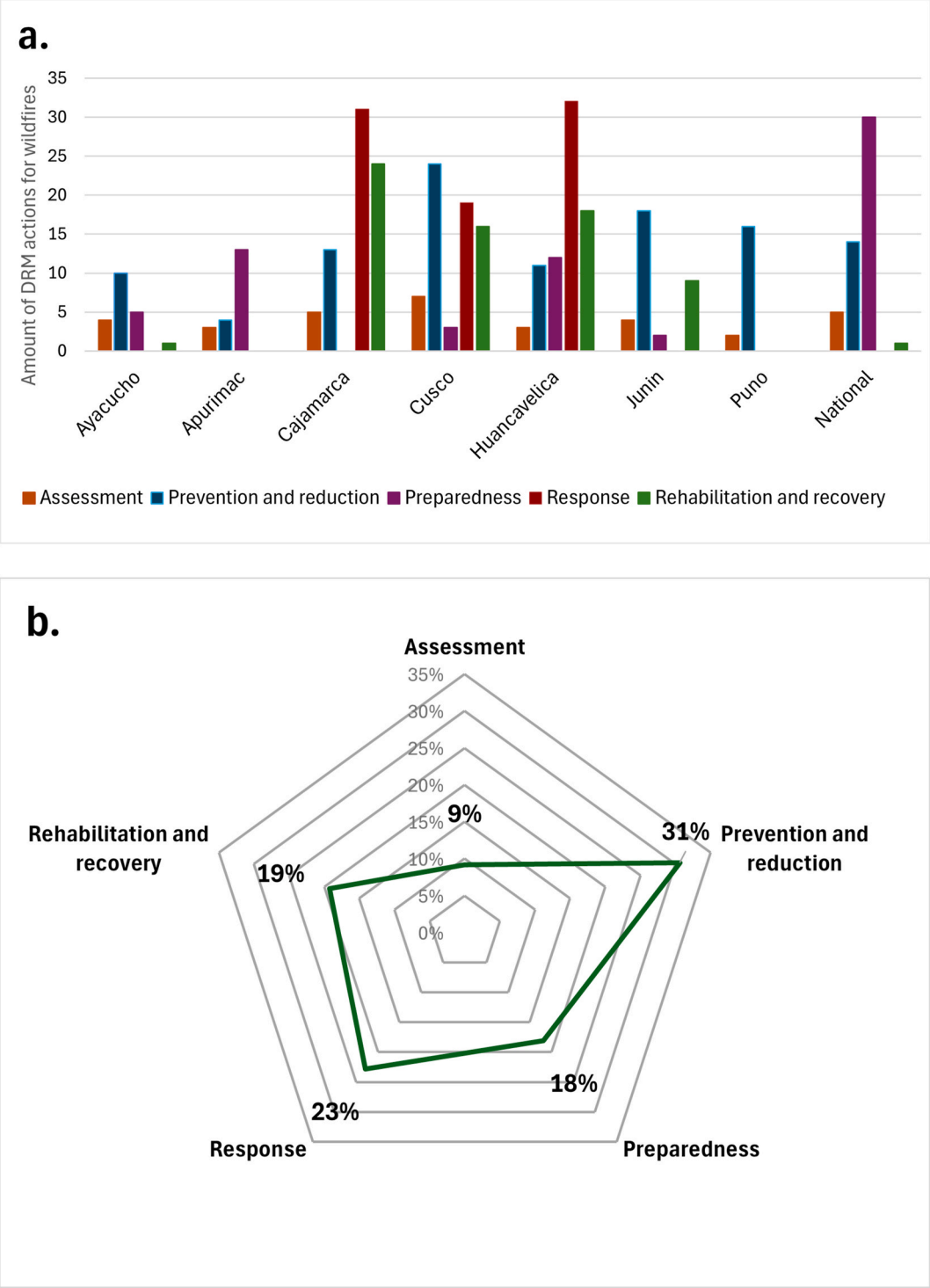

Fig. 5a. & b. Distribution of actions by (a) regions and (b) DRM processes identified in regional planning documents.

across levels is rarely monitored (Q49). Since 2025, a pilot wildfire Early Warning System (EWS) in Ollantaytambo (Cusco) has monitored hydrometeorological conditions linked to wildfire occurrence, involving rural communities and local leaders trained in prevention.

4.2.2.4. Response. Response measures account for 23% of planned actions, primarily targeting wildfire suppression. Despite implementation during emergencies, interviews revealed persistent institutional weaknesses. The 2024 wildfire crisis reinforced perceptions of state neglect (Q50) and exposed inadequate DRM guidance, prompting largely improvised responses by local governments (Q50, Q51, Q52, Q53, Q54) and the central administration. Failures in formal response mechanisms led by the Armed Forces (FF.AA.) and General Volunteer Fire Department (CGBVP) further revealed weaknesses in institutional coordination and operational capacity (Q55, Q56, Q57, Q58).

In practice, local residents typically respond first to wildfires, spontaneously forming "de facto brigades" without formal organization, specialized training, or adequate equipment (Q59, Q60, Q61, Q62, Q63,

Q64, Q65, Q66). Ethnographic evidence from Cusco shows that families rely primarily on neighbours during emergencies, making communities the main support networks despite limited preparedness (Q67). Participation is voluntary and largely shaped by the perceived value of threatened people, homes, livestock, and grazing lands.

4.2.2.5. Rehabilitation and restoration. Rehabilitation and restoration account for 19% of recorded actions, including humanitarian assistance—roofing materials, food, livestock feed, and forest seedlings—and recovery of infrastructure and agricultural livelihoods (Q68). Ethnographic evidence from Cusco suggests some post-fire assistance may inadvertently encourage deliberate fire-setting (Q69, Q70, Q71). Ecosystem restoration projects in Cusco, Ayacucho, Apurímac, and Cajamarca mainly involve investments in ecosystem services. Officials identified limited scientific understanding of post-fire dynamics in Andean ecosystems (Q72), overreliance on reforestation with exotic species (Q72), assumptions of natural grassland recovery, and insufficient funding for recent, low-priority initiatives (Q73). Nevertheless, restoration efforts increasingly recognize wildfires' systemic impacts on biodiversity and water availability.

4.2.3. Resources for implementation

4.2.3.1. Human resources. Human resources for DRM in subnational governments remain severely limited. Regional Civil Defense Offices typically employ five to fifteen specialists, while district offices often have only one to three staff members, insufficient to address multiple, recurrent hazards. Budget constraints further restrict staffing, operational continuity, and long-term planning, with most personnel employed on temporary contracts (Q83, Q84, Q85, Q86, Q87). Officials noted that frequent political turnover and concerns over staff competencies compound these limitations (Q7, Q53, Q88).

4.2.3.2. Financial and material resources. Peru allocates public funding through budgetary programmes (PP) linking resources to goods and services addressing public needs. PP068—Reduction of Vulnerability and Emergency Response to Disasters (formerly Risk and Emergency Management)—is among the country's largest programmes, financing eight hazards, including wildfires. Between 2014 and 2024, budget execution in the seven study regions (Fig. 6) showed substantial disparities.

Cusco recorded the highest expenditure among study regions. Over the last four years, Apurímac, Ayacucho, and Cajamarca executed annual budgets averaging just over 30 million soles (approximately USD 8.4 million). Expenditure declined in 2016, 2018, and 2021, partially recovered in 2023, and fell again in 2024. Officials noted that heightened attention to the 2024 wildfire emergency did not increase national or regional budget allocations for 2025.

Regional governments have limited wildfire response equipment. Specialized firefighting equipment remains scarce due to procurement difficulties (Q74, Q75), budget constraints (Q11, Q76, Q77, Q78, Q79, Q80, Q81), and poor budget execution. Officials often attributed these constraints to weak political commitment to DRM, as one interviewee stated: "Disaster risk management is the last priority in a municipality" (Q5, Q11, Q53, Q80, Q82). Insufficient investment consequently undermines wildfire management infrastructure and the retention of qualified technical personnel.

4.2.4. Emerging policy strategies

Despite institutional and financial constraints, interviewees identified emerging policy innovations across the Peruvian Andes to strengthen wildfire DRM, particularly prevention, risk reduction, and response. Three strategies emerged: formally integrating community organizations into DRM through subnational government recognition; incorporating controlled burning into capacity building despite lacking legal support; and embedding wildfire management in environmental programmes to restore ecosystem services and degraded landscapes. Within the latter approach, awareness of wildfire impacts on water availability (Q89, Q90, Q91) has promoted prevention through ecosystem conservation rather than solely punitive measures.

Interviewees proposed six priorities for strengthening wildfire DRM. First, they emphasized improving understanding of agricultural burning practices and wildfire occurrence (Q26, Q92, Q93), arguing that knowledge of the socioeconomic and environmental contexts of fire use would support more realistic, locally appropriate alternatives (Q94). Second, they advocated increased budget allocations (Q95, Q96) and

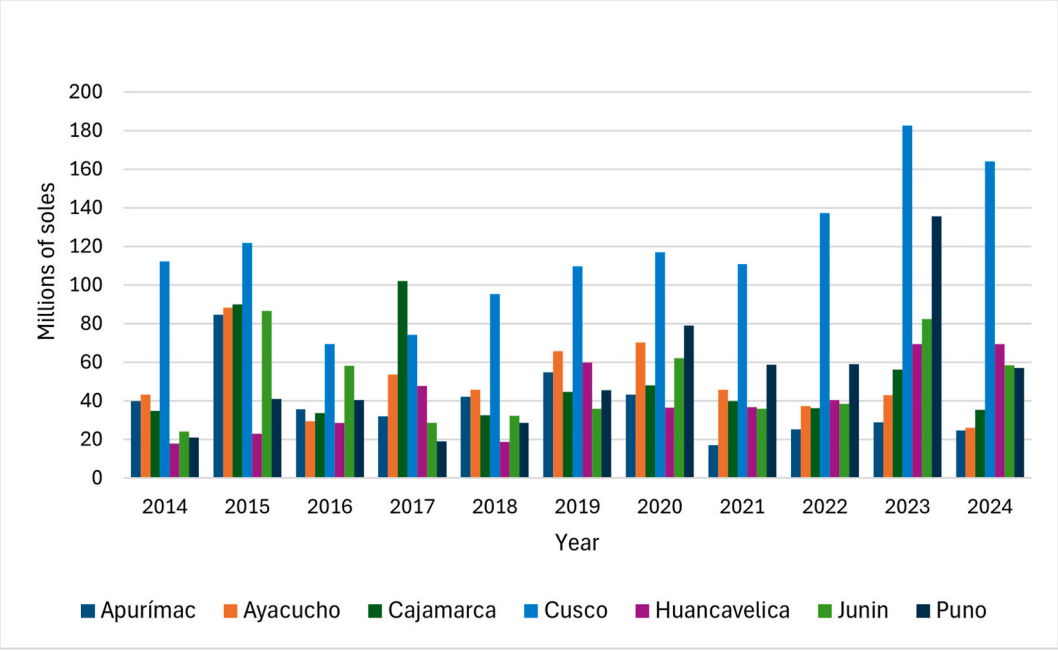

Fig. 6. Execution of DRM budget by region between 2014 and 2024. Source: Ministry of Economy and Finance (MEF)—Consulta Amigable.

improved execution (Q97) to extend funding beyond emergency response (Q98, Q99) and secure specialized personnel and adequate equipment (Q96, Q97, Q100, Q101, Q102).

Third, interviewees emphasized community-based early warning systems (Q94) and sustained awareness campaigns (Q103, Q104, Q105, Q106, Q107, Q108, Q109, Q110) through rural-accessible channels, including community radio (Q111, Q112, Q113). Fourth, they recommended stronger coordination across governance levels and sectors (Q114, Q115). Fifth, many advocated reconsidering Peru's punitive wildfire management approach (Q116). Some favored stricter enforcement (Q117, Q118), others locally adapted regulations. Broad agreement nevertheless emerged on strengthening community authorities' role in regulating and sanctioning fire use. Finally, officials recommended a dedicated national wildfire policy framework (Q26).

4.3. Institutional readiness for IFM

4.3.1. Alignment between wildfire DRM and IFM

Among the three core IFM components—fire culture, fire ecology, and fire management—few planned actions explicitly address the first two. Fire culture accounted for just 3% of identified actions, appearing only in Cusco, Apurímac, Ayacucho, Junín, and the national Multisectoral Plan. These actions involved documenting agricultural burning, promoting alternatives such as composting and agroforestry, and protecting pre-Hispanic cultural heritage associated with fire use.

Similarly, fire ecology accounted for just 4% of planned measures, appearing only in Junín, Ayacucho, and the Multisectoral Plan. These addressed fire behaviour, ecosystem interactions, restoration of degraded areas, and protected-area management. By contrast, 93% of actions concerned integrated disaster risk management, emphasizing wildfire suppression, emergency preparedness, institutional strengthening, and response.

4.3.2. Local knowledge and community organizations

Although IFM is not formally integrated into SINAGERD, several Andean initiatives reflect its principles, including local agricultural burning guidelines and the gradual inclusion of community organizations in wildfire management by subnational governments.

Officials reported difficulties identifying traditional fire knowledge in Ayacucho, Huancavelica, and Apurímac (Q119, Q120). Conversely, Puno interviewees considered such knowledge valuable for wildfire reduction and mitigation (Q121, Q122). Integrating community organizations into wildfire DRM was considered feasible and desirable, although interviewees stressed that lasting success requires stronger prevention capacities (Q123, Q124), greater financial support, and institutional mechanisms to sustain these organizations (Q125, Q126).

4.3.3. Institutional perspectives on controlled burning

The role of controlled burning within wildfire DRM generated some of the most divergent views among interviewees. Although agricultural burning remains a widespread practice throughout the Andes, most officials viewed it primarily as a source of wildfire risk rather than as a potential management tool (Q127, Q128, Q129, Q130, Q131). Several interviewees expressed concern that formally recognizing controlled burning could increase wildfire occurrence (Q132).

Nevertheless, respondents agreed that incorporating controlled burning into the institutional framework would require stronger fire management capacities (Q133, Q134), improved monitoring (Q135, Q136), and continued promotion of alternatives to burning (Q137). Officials also stressed that any authorization should be restricted to existing agricultural lands to prevent land-use change and expansion into natural ecosystems (Q138, Q139).

5. Discussion

5.1. Governance challenges for wildfire DRM

Although Peru has an extensive institutional and regulatory framework for wildfire disaster risk management (DRM), our findings indicate that its main limitation is fragmented governance rather than a lack of policies or organizations. Wildfire management involves institutions with overlapping responsibilities, uneven technical capacities, and differing priorities, complicating coordination in the decentralized Andean context. Similar challenges occur elsewhere in the Andes, where institutional complexity, resource constraints, and competing territorial priorities hinder integrated wildfire policies (Correa-Quezada et al., 2025; Luna-Celino et al., 2025). Rather than an integrated system, wildfire DRM comprises partially connected institutions whose effectiveness depends largely on local capacities and collaboration.

The study also reveals a persistent mismatch between institutional responsibilities and implementation capacity. Peru's tiered response system promotes subsidiarity by assigning primary responsibility to local and regional governments before national intervention. However, limited subnational personnel, equipment, and funding can delay emergency responses and widen the gap between policy and operational capacity. Consequently, local communities often become first responders, assuming responsibilities formally assigned to public institutions. Similar patterns occur in wildfire-prone regions worldwide, where communities compensate for institutional shortcomings, often without adequate training, resources, or sustained support (Paveglio et al., 2015; Neger et al., 2024). Community participation should therefore be recognized as a permanent component of wildfire governance, requiring institutional recognition and sustained investment rather than merely an emergency resource.

The contrast between state and community regulations illustrates the complexity of Andean wildfire governance. Although both use sanctions to discourage harmful fire use, their objectives and implementation differ. State regulations emphasize legal responsibility for wildfire ignition, while community rules prioritize conflict resolution, social accountability, and compliance with locally agreed norms. These reflect distinct governance logics rather than opposing systems. Similar tensions between centralized policies and local fire governance occur in other fire-prone socioecological systems, where external regulations often overlook cultural and livelihood dimensions of fire use (Carmenta et al., 2021; Paveglio et al., 2015). Strengthening complementarities between formal institutions and community governance, rather than relying solely on punitive enforcement, may improve institutional legitimacy and wildfire prevention.

Overall, our findings suggest that improving wildfire governance in the Peruvian Andes requires strengthening coordination across governance levels, building subnational capacities, and formally integrating community organizations into DRM rather than creating new institutions. These challenges also explain why, despite comprehensive planning instruments, wildfire management remains largely reactive and uneven across the study regions.

5.2. From planning to implementation: why wildfire DRM remains reactive

The analysis reveals a persistent gap between planning and implementation throughout the wildfire DRM cycle. Although regional plans include numerous wildfire-related actions, implementation remains uneven, focusing largely on prevention, emergency response, and post-fire assistance. Risk assessment, preparedness, and ecological restoration receive less attention, undermining DRM's cyclical and adaptive nature. This imbalance suggests that governance prioritizes managing fire emergencies over addressing underlying wildfire risk. Similar gaps occur elsewhere in the Andes, where institutional commitments often exceed available technical, financial, and organizational capacities

(Correa-Quezada et al., 2025; Luna-Celino et al., 2025).

Wildfire prevention illustrates this gap. Current strategies rely mainly on awareness campaigns, environmental education, and alternatives to agricultural burning, assuming behavioural change alone can substantially reduce fire use. However, our findings suggest that burning persists because it remains efficient and accessible within Andean farming systems. Similar findings elsewhere show that adopting alternatives depends on technical feasibility, labour availability, production costs, and livelihoods (Alvarez et al., 2025; Luna-Celino and Kainer, 2024). Expanding alternatives therefore requires systematic assessment of their long-term effectiveness, economic viability, and social acceptability, beyond information campaigns. Wildfire risk communication research also shows that greater awareness does not necessarily change behaviour, particularly where fire is embedded in agricultural production (Champ et al., 2013; Larsen et al., 2021; McCaffrey, 2015).

Limited financial and human resources reinforce this reactive pattern. Persistent shortages of specialized personnel, equipment, and operational funding constrain subnational governments' capacity to sustain prevention, monitor wildfire risk, and maintain preparedness. As institutional capacity weakens, emergency response increasingly falls to local communities, often acting as first responders despite limited technical support. Rather than replacing public institutions, these responses demonstrate how communities compensate for institutional gaps. Similar dynamics occur in other wildfire-prone regions, where resilient community networks emerge because formal response capacities remain insufficient, rather than through strong governance (Neger et al., 2024; Paveglio et al., 2015).

These implementation challenges persist after wildfires. Although ecosystem restoration increasingly features in public investment projects, post-fire interventions still prioritize humanitarian assistance and infrastructure recovery. Andean ecosystem restoration is constrained by limited ecological knowledge, funding, and long-term monitoring. Moving toward integrated landscape restoration therefore requires better understanding of post-fire ecological processes and stronger institutional commitment to restoring ecosystem functions and services, particularly water regulation. This approach is increasingly recognized as essential to the long-term resilience of fire-prone socioecological systems (Christmann et al., 2025; Kinoshita et al., 2016).

Overall, these findings suggest that the main challenge is not a lack of wildfire DRM actions but insufficient institutional capacity to implement them throughout the disaster risk management cycle. Closing this gap requires moving beyond reactive approaches by strengthening prevention, preparedness, ecological restoration, and sustained investment in subnational institutions. These efforts also lay the groundwork for a gradual transition toward Integrated Fire Management, discussed next.

5.3. *Towards integrated fire management in the Peruvian Andes*

Our findings suggest that wildfire governance in the Peruvian Andes is undergoing a gradual, largely implicit transition toward Integrated Fire Management (IFM). Without a dedicated national policy, several IFM principles are emerging independently through community participation, ecosystem restoration, local prevention initiatives, and recognition of the need to better understand agricultural burning. However, these efforts remain fragmented, lacking a coherent institutional framework. Wildfire management therefore remains dominated by conventional DRM focused on prevention, emergency response, and suppression rather than managing fire as a socioecological process. Similar patterns occur across the Andes, where IFM is gaining attention but remains constrained by institutional fragmentation and limited implementation capacity (Correa-Quezada et al., 2025; Luna-Celino et al., 2025).

A major challenge for advancing IFM is reconciling institutional perspectives on fire with rural livelihoods. Agricultural burning remains embedded in Andean production systems, fulfilling environmental, economic, and cultural functions. Yet wildfire governance largely treats fire as a hazard requiring prohibition and control. Similar tensions occur in other fire-prone landscapes, where suppression-focused policies often overlook fire's social and ecological functions and the knowledge systems historically regulating its use (Alvarez et al., 2025; Carmenta et al., 2021; Mistry et al., 2016). Transitioning toward IFM therefore requires moving beyond the dichotomy of permitting or prohibiting fire to develop governance arrangements that distinguish beneficial, inappropriate, and high-risk fire use.

The study also highlights the need to strengthen the evidence base for wildfire governance. Officials identified substantial knowledge gaps in fire ecology, ecosystem recovery, and the long-term impacts of agricultural burning under changing climatic conditions. These gaps constrain decision-making and reinforce precautionary, suppression-focused approaches. Expanding ecological research while documenting and critically evaluating traditional fire knowledge would strengthen the scientific and social foundations of adaptive fire management. Rather than treating scientific and local knowledge as competing systems, IFM integrates both through collaborative learning and context-specific decisions (Neger et al., 2024; Rodríguez et al., 2023; Mistry et al., 2016).

The transition toward IFM in the Peruvian Andes should be understood as an institutional transformation rather than adoption of a new technical model. Our findings indicate that essential building blocks—including community organizations, local regulations, ecosystem restoration initiatives, and inter-institutional collaboration—already exist. The challenge is not to replace the current DRM system but to connect these initiatives within a governance framework recognizing fire as both a risk and an ecological and cultural process. This would strengthen wildfire governance while enabling management strategies to reflect diverse Andean landscapes and livelihoods.

6. Conclusions

Our findings highlight three key challenges for wildfire DRM in the Peruvian Andes: fragmented governance, uneven implementation capacity, and limited integration across the DRM cycle. Responsibilities increase at lower levels of government while resources decrease and, although planning frameworks are well established, implementation remains predominantly reactive, with local communities frequently compensating for institutional limitations, even without adequate preparation or equipment. These findings underscore that strengthening wildfire governance therefore depends on improving coordination across governance levels, reinforcing subnational capacities, and recognizing community organizations as permanent partners rather than emergency responders.

A further key finding is that the transition toward Integrated Fire Management (IFM) has already begun, although in a fragmented and largely implicit manner. Community participation, ecosystem restoration, local regulations, and growing recognition of the need to better understand agricultural burning provide important foundations for this transition. Yet, their limited integration remains a central governance challenge.

Rather than replacing the existing DRM framework, our findings suggest that advancing IFM in the Peruvian Andes will require better integration of scientific and local knowledge, local fire practices, and institutional action within a coordinated governance system. Building on existing initiatives while strengthening ecological research, long-term institutional capacity, and collaboration across sectors offers a more realistic pathway toward adaptive wildfire governance in the Andean region.

Declaration of competing interest

The authors declare that they have no known competing financial

interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Rossi Taboada-Hermoza: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Alejandra G. Martínez:** Writing – review & editing, Supervision, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Sigrid Alvarez:** Writing – review & editing, Validation, Investigation, Formal analysis. **Lucy Giráldez:** Writing – review & editing, Validation, Formal analysis. **Vanessa Luna-Celino:** Writing – review & editing, Validation, Formal analysis.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pyro.2026.100032.

Data availability

Data will be made available on request.

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