A framework for considering justice aspects in integrated wildfire risk management

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Editorial Summary
Climate and socioeconomic change are reshaping wildfire patterns and increasing risks globally, leading to potential new conflicts and equity issues. Incorporating justice considerations from different perspectives into integrated wildfire risk management is essential to address these new challenges.

Abstract
There is increasing evidence that anthropogenic climate change and socioeconomic development are altering the dynamics of extreme wildfire events, leading to increasing wildfire risk globally and causing potential new conflicts in wildfire risk management (WFRM). Managing these risks in increasingly complex governance settings raises important equity concerns; in particular, what is perceived as just in terms of outcomes and processes. We develop a framework for identifying and categorizing along the WFRM cycle (prevention, preparedness, response, and recovery & adaptation) crucial and generally applicable aspects of distributional, procedural, and restorative justice. We argue that policy and decision makers should proactively consider all three justice aspects within collaborative governance policy processes to successfully innovate integrated WFRM strategies that respond to equity concerns.

Competing interest statement: The authors declare no competing interests.

Author contribution statement: T.S. conceived the study and prepared the manuscript. C.B. contributed extensively to the conceptual framework design and writing of the manuscript. J.H, T.D.-H., E.P., J.L.-B., A.S., M.S., E.P. contributed equally to the conceptual framework design and the editing of the manuscript. All authors applied the conceptual framework, discussed the implications, and commented on the manuscript at all stages.

Data Availability Statement: Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

Self-archiving statement: This document is the accepted version of the following publication:
Schinko, T., Berchtold, C., Handmer, J. et al. A framework for considering justice aspects in integrated wildfire risk management. *Nat. Clim. Chang.* (2023). https://doi.org/10.1038/s41558-023-01726-0

1. Introduction

Wildfires materialize in an evolving context of risk[1], where physical (e.g., land-use changes) and sociocultural dynamics of hazard, exposure and vulnerability (e.g., ways of living on land) interact[2]. Differential social vulnerabilities [3–5] and exposure[6,7] to wildfires, in combination with prevailing issues of intersectional justice[8,9], i.e., the ways in which systems of inequality based on gender, race, ethnicity, sexual orientation, gender identity, disability, class and other forms of discrimination intersect, cause an unequal distribution of wildfire risk across societies today[8,10,11].

Climate and socioeconomic change substantially alter wildfire dynamics and wildfire risk globally [1,12,13]. The emerging (neither known nor pre-planned) risk scenarios may, therefore, increase societal risk, existing inequalities, and the complexity of wildfire governance by exposing new parts of society to wildfires, due to demographic and land use changes[14]. In addition, extreme wildfire events such as the Australian bushfires in 2020, California 2022 or in the European context the big wildfires in 2017 in Portugal, 2018 in Greece, and 2022 in Spain and France have brought wildfires to the top of the risk-related political agendas.

From this, a need for more integrated and inclusive wildfire risk management (WFRM) approaches arises. Lacking a universally agreed upon definition of integrated WFRM, the following overarching characteristics emerge from the literature:

- Integration across **risk dimensions**, such as social, economic, cultural, and ecological (e.g., the aim of the Sendai framework[15]),
- Integration across the **four phases of the WFRM cycle:** prevention, preparedness, response, and recovery & adaptation[1] (Ideally, change and adaptation would occur throughout the cycle. However, in practice, most change occurs in the recovery phase[16,17,18].),
- Integration across **sectoral policies** that directly/indirectly influence risk creation/reduction (e.g., Priority 3 of Sendai framework[19])
- Integration of the full **spectrum of stakeholders** in decision-making through inclusive governance structures[20]

While this need for more integrated and inclusive WFRM approaches has been highlighted in the literature[15,21,22] and is being called for by policy making (e.g., at the EU level[23]), the comprehensive integration of diverse risk drivers, actors, and measures across all phases of the WFRM cycle remains a challenge[24]. Conflicts and trade-offs may arise on this transition to more integrated and inclusive approaches[25], as policy making is a constant discursive struggle over the boundaries and conceptual framing of problems[26–28] – especially in highly contested or 'wicked' issue arenas such as those related to risk management.

To proactively address potential conflicts and harness possible synergies between different actors (or stakeholder groups)[29] through compromise-oriented decisions, it is key to identify and understand what these diverse actors and stakeholder groups perceive as just outcomes and just processes in WFRM, as there might be very different ideas of justice at work in different fire-prone communities and among their diverse members. While the existing WFRM literature has paid only little attention to individual justice issues so far[30–32], there is some literature focusing on justice aspects in relation to management of other hazards, such as floods, hurricanes, tsunamis, and earthquakes[18,33–36]. Building on this literature and on the broader environmental justice literature[37], we argue that three domains of justice need to be considered for the transition to integrated and inclusive WFRM approaches: distributional justice, procedural justice and restorative justice[38]. The objective of this perspective is thus to provide a comprehensive categorization of these dimensions of justice against the four phases of the WFRM cycle.

2. Increasing wildfire risk and changing dynamics of its drivers

Wildfires can be understood as a socio-ecological hazard[39], as they are driven by a combination of natural factors (e.g., lightning, droughts, and heatwaves) and anthropogenic factors (e.g., fuel build up due to land use and environmental change, such as the abandonment of forestry and mosaic landscapes or the expansion of highly flammable species). Moreover, wildfire risk is exacerbated by climate change[40–42], and fires themselves, are gaining importance as drivers of climate change through their carbon dioxide emissions and the reduction of sink capacity[43]. Not only do wildfires put at risk carbon sequestration activities but also account for approximately 70% of the global biomass burned annually and hence constitute a large global source of atmospheric trace gases and aerosols [44,45]. Most studies point toward an increase of fire intensity and frequency due to increased drought, higher air temperatures, lower relative humidity, dry lightning, and stronger winds; resulting in hotter, drier, and longer fire seasons as well as new areas affected by wildfires[1,13].

The 2019-2020 Australian wildfires demonstrated that compound climatic events (long-lasting record high temperatures combined with record low precipitation) can lead to unprecedented large-scale impacts, with 80% of all Australian residents being affected by the fires in some way[46,47], creating conflicts over e.g., access to reconstruction funding and retreat to alternate, lower risk areas.

Accordingly, fire prone conditions are increasing both where wildfires previously occurred and in new regions that previously did not experience wildfires. The new risk conditions posed by climate change are exacerbated by socioecological changes, which can lead to an increasing fuel load or flammability[48], which act to increase the chance of extreme wildfire events. Changes include agricultural abandonment, fire-suppression centered policies (focusing on short-term risk prevention may cause the emergence of even worse fires in the long-term – the so-called fire paradox[49,50,51]), invasive species[52] (both insects that kill trees, with unhealthy trees being less fire resistant than healthy ones, and vegetation that is more flammable than local species), forest plantations[53] or above ground electricity distribution infrastructure (which can also pose an ignition risk, especially when not well maintained and/or in dry windy conditions[54]).

3. Mounting challenges and conflicts in WFRM

Driven by the social-ecological complexity of wildfire phenomena, WFRM approaches are confronted with new challenges with differential impacts and important justice implications along all risk management phases (Table 1). Those areas previously adapted to wildfire occurrence may find that their current approaches are not suited to the changing fire regime (such as California, Southeast Australia Southwest Europe[55,56]); similarly, areas where wildfires were very rare are now having to adapt (such as Northern Europe and the UK). This raises the issues of potentially high additional costs and who should bear these costs as well as the benefits and downsides associated with adaptation; some of the many salient justice questions in the WFRM context.

Table 1: *Challenges due to changing climatic, socio-economic, and ecological conditions that integrated WFRM needs to consider along the four WFRM phases and their relation to distributional (D), procedural (P) and restorative (R) justice. Source: Adapted from*[57,58].

WFRM-phase	Challenges for integrated WFRM
Prevention	- Need of re-analysis and updating risk management planning tools to the increasing and/or unprecedented risks (and multi-risk) scenarios (D, P). - Limits of modelling increasing and/or unprecedented risk scenarios (D, P, R). - Development of a "culture of prevention" in new fire-prone areas to compensate suppression-centered policies that may motivate a fire paradox (D, P, R). - Increase of fire-prone areas and risk of funding collapse "to protect all" (D). - Engagement of stakeholders especially in new fire-prone areas (P). - Reinforcing private-public collaborative schemes for risk mitigation to face increased wildfire risk scenarios (that cannot be protected anymore only from public bodies budgets) (D, P, R). - Increasing restriction of activities through land use management policies and legal requirements in fire-prone areas (D, R). - Challenges for societal acceptance of "living with wildfires" and the use of prescribed burns as a major preventive tool (D, P, R). - Need for new models of wildfire risk reduction "responsibility sharing" between agencies and residents (D, P)
Preparedness	- Adapt civil protection protocols to extreme events and new multi-risk situations meeting different levels of expertise and competences (e.g., wildfires jeopardizing forest and avalanche protection functions in mountain areas or areas set aside for carbon storage/sequestration) (D, P). - Adapt early-warning systems to increased potential of damaging wildfires to impact on exposed population, buildings, and roads (e.g., international tourist and resorts) (D, P). - Adapted drills to extreme events needed despite lack of risk literacy and experience (P). - Need for effective communication about emergency management decisions (e.g., triage), to be conducted before the events (D, P, R)
Response	- Ensuring exposed population, fire-fighters, and emergency bodies safety in case of extreme events (D). - Simultaneous and/or more severe and/or longer wildfire events, which ask for more resources and potentially leading to triage situations (D, P, R). - Collapse or malfunction of defensive systems (fuel breaks, defensive irrigation in wildland urban interface, etc.) (R). - Unprecedent events are adding complexity and uncertainty to emergency management and stressing the decision-making and credibility towards society (D, P). - New fire prone areas with professionals without previous experience, neither adapted equipment and protocols to deal with wildfires. Risk of collapse and frustration of emergency services (D, P, R).
Recovery & adaptation	- Increase of residual risk and disruption to communities due to "extreme" and/or unprecedented damaging wildfire events (R). - Potential irreversible effects on people's livelihoods and on sensitive ecosystems due to high (or low)-intensity or recurrent wildfires (desertification, gaps on species adaptation to unprecedented wildfire regimes in traditional and new fire-prone areas, etc.) (D, R). - Cascading effects in ecosystem services (biodiversity conservation, water provision, etc.) (D, R). - Impacts on the insurance sector (D, R). - Potential for stakeholder resistance against recovery measures (e.g., promotion of new tree species) adapted to new conditions imposed by climate change (e.g., future drier conditions) (P).

In addressing wildfire risk, current wildfire risk management (WFRM) practices focus on a diversity of sometimes only loosely connected actor groups, measures and approaches, ranging from preventive activities to preparedness and response operations and recovery or restorative strategies[59–61]. As risk amplifies, so does the number of government, market and civil society actors directly affected by wildfire risk. This mounting heterogeneity of actors calls for more diverse counteracting measures, increasing the potential for escalating inequalities and conflicts in WFRM. For example, detection and response are central to managing wildfires but also compete for resources for investments into forest

management and fire prevention measures, leading to salient questions regarding distributional justice. Likewise, conflicts may arise between fuel reduction through prescribed burns to protect human lives and properties in risky zones and to rejuvenate ecosystems (e.g., by consuming old and diseased trees and thereby making space for an ecological rejuvenation of the tree population), and those who argue that this creates smoke with attendant problems of health and carbon emissions that disproportionately affect already vulnerable communities outside these regions[62]. Planning and building controls in identified high wildfire hazard areas can also lead to tensions, such as balancing historic living patterns with the need for relocating houses from risky areas[63], limiting the use of prescribed fire in public lands to protect the non-wildfire aspects of adjacent private spaces[63,64] or different understandings of how fire protection responsibility is allocated between government and individuals[65,66]. Broader issues that reflect important social disparities include resource allocation to WFRM that can benefit some groups at the expense of others. For example, minority households, indigenous communities (including First Nations), or low-income homeowners may be left with little access to both prevention and/or post-fire recovery funds or routes to influence the decision-making processes around what risks get prioritized[67,68].

4. A framework for addressing aspects of justice in WFRM

Building on existing literature[69], we suggest that integrating aspects of justice with risk management concepts, could add value for developing more integrated WFRM approaches by considering aspects of (social) vulnerability, intersectionality and stakeholder engagement more generally.

We distinguish three main dimensions of justice that are considered key in the fields of environmental, climate and disaster justice, and apply these dimensions to the WFRM context (see Figure 1): distributional justice (Who should bear the costs and benefits of WFRM? How are hazard, exposure and vulnerability patterns distributed and who is responsible for their reduction?); procedural justice (Does policy selection inclusively address stakeholder interests and inputs, either via institutional co-generation measures or ad hoc integration of views? Which stakeholders are heard when developing WFRM policies and measures?); and restorative justice (How does the WFRM policy or measures address past or expected harms or wrongdoing? Which restoration and compensation mechanisms including insurance mechanisms exist?).
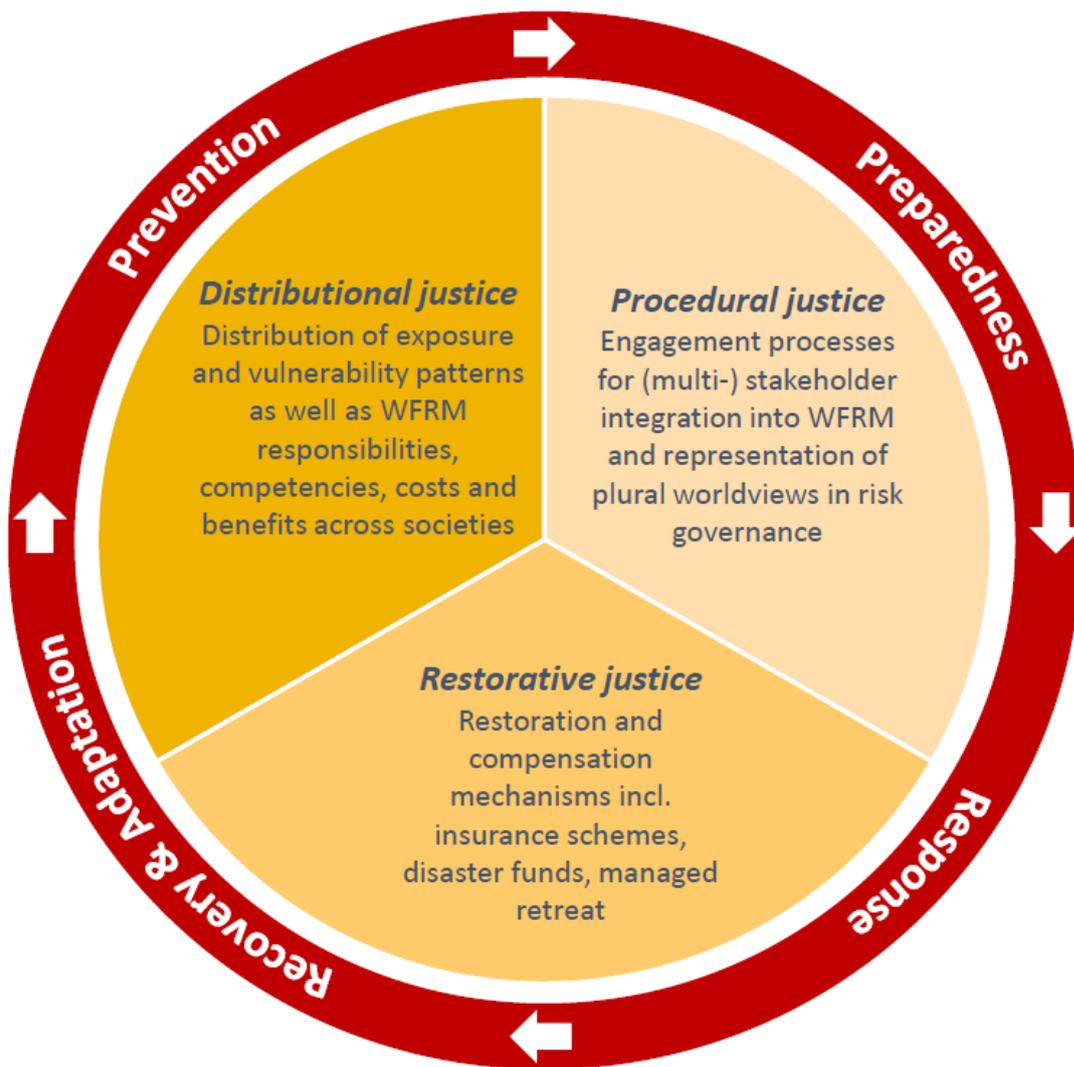
Prevention

Preparedness

Response

Recovery & Adaptation

Distributional justice
Distribution of exposure and vulnerability patterns as well as WFRM responsibilities, competencies, costs and benefits across societies

Procedural justice
Engagement processes for (multi-) stakeholder integration into WFRM and representation of plural worldviews in risk governance

Restorative justice
Restoration and compensation mechanisms incl. insurance schemes, disaster funds, managed retreat

Figure 1: Aspects of distributional, procedural, and restorative justice applied to the WFRM context. Source: own figure, based on[69]

Applying this framework for categorizing aspects of justice against the dynamically evolving WFRM context, the subsections below describe in detail which justice aspects (distributional, procedural and restorative justice; marked bold) play a role and are currently under investigated across the four risk management phases (prevention, preparedness, response, and recovery & adaptation).

4.1 Prevention

Distributional justice in the prevention phase of integrated WFRM relates importantly to the distribution of costs and benefits of wildfire prevention across society[70]. Potentially differing effects of climate change on individual preventive capacities, on inequalities in exposure and vulnerability to wildfire as well as on individual preventive capacities and the effects of socio-economic contexts should be considered. In addition, the effects of different biomass management schemes play a role[32]. Activities related to the diverse functions of forests, such as economic use, recreational purpose, ecosystem services, etc. and the related stakeholder groups need to be analyzed[71]. Similarly, mechanisms to "compare" the (negative) impacts of biomass management and the impacts of fires across multiple impact categories (losses, health, and climate change mitigation) as they affect the many diverse stakeholders need to be integrated. While many ecosystems are fire tolerant and some even fire

dependent, this can obscure negative impacts on ecosystems and ecosystem services, such as local species extinctions due to frequent or frequent intense fires, and worse the last habitats of critically endangered species can be destroyed by fires (even by prescribed burns)[72,73]. Wildfires can affect human health, extending to serious human morbidity and mortality from air contamination, depending individual vulnerability and exposure [74].

In the prevention phase, justice issues can center around aspects of **procedural justice**, especially concerning equal access to knowledge, resources and information needed to prevent wildfires and reduce individual risk during wildfire events[75]. Moreover, the dimension of procedural justice requires the inclusive consideration of stakeholder knowledge, views and concerns in the policy and decision-making process, given its shifting focus from wildfire suppression to prevention[70]. In particular, attention needs to be paid to the reality that current wildfire information campaigns do not necessarily translate into action and often do not consider factors influencing whether individual action is or can be taken such as wealth, language (barriers), time and resources and differing local (environmental) contexts[11]. Moreover, provision needs to be made to ensure that local communities are considered in decision-making processes around risk priorities, acknowledging also the need for cross-boundary coordination[76].

Restorative justice concerns such issues as compensation for wildfire losses incurred and for risk reduction activities including urban and land-use planning, agroforestry development and fuel management. As one example, mandatory retreat from high-risk areas can be compensated with various eminent domain arrangements. Already in the prevention phase it is important to think about post-disaster loss compensation, which is typically provided by governments that support households and businesses in restoring lost assets, supplemented by private insurance arrangements. In the latter, it is important to note that insurance systems – private and public – can have solidarity arrangements embedded in their pricing structures in order to support poorer households[77,78]. Moreover, insurance systems for addressing extreme weather can be co-designed in inclusive stakeholder processes that explicitly address justice considerations[79]. Another issue relates to liability, raising the question whether there should be compensation for damages caused by prescribed burning, either from fires that "escape" or from negative health impacts from the smoke. Restorative justice is also about ameliorating the historical inequalities that lead to uneven starting places and burdens, including the recognition of Indigenous peoples' land rights and their preventive management practices[80].

4.2 Preparedness

In the preparedness phase crucial justice issues comprise the inclusive involvement of stakeholders in the development of preparedness tools and actions, and the **distribution** of capacities to act across society[81]. This relates, for example, to the knowledge on residual wildfire risk that remains even after prevention and preparedness activities, and the access to information such as emergency (incl. evacuation and confinement) plans, both crucial elements in shaping the specific risk culture of communities. Research and innovation activities aimed at developing preparedness tools need to reflect on the audience they address, the actions they need to take, and be explicit about presumptions regarding capacity, for example internet access and literacy, or time and financial resources[82]. From an emergency management perspective, the distribution of costs related to preparedness activities, for example, for helicopters and fire bombers, can become an important question of distributional justice, particularly in light of ecosystem, socio-economic and climate change.

Procedural justice again relates to the question of who is involved in which ways in the development and implementation of measures and strategies while **restorative justice aspects** concern, for example, the compensation of opportunity cost such as access restrictions for national parks or other areas of high interest for high fire risk days and subsequent disruptions to livelihoods.

4.3 Response

In the response phase there are difficult justice challenges related to the distribution and constitution of response capacities, differential vulnerabilities (e.g., those persons with mobility limitations), choices on prioritization in an emergency situation (e.g., what properties not to defend)[83], and compensation for losses caused by emergency response.

Distributional justice challenges can relate to available knowledge and resources determining individual behavior in response to warnings. Similarly, this justice dimension applies also to the distribution of capacities and resources among the affected workforce and institutions. For example, how are workload and resources distributed between career and voluntary emergency management services, how are the working conditions? Who pays for these services and who benefits (national, state, local level)[84]? Which capacities are public and which are private? In areas where fire-fighting is wholly or partly a local responsibility, poorer areas will be worse off, as they will have less and older equipment as well as possibly less expertise. This can include, for example, communities with high shares of immigrants or marginal local economies and livelihoods relying on tourism and recreation as well as more traditional farming pursuits that can be seriously impacted by fires. Marginalized rural people need particular attention, especially in areas with substantial farmland abandonment, which greatly increases the fire risk. Distributional aspects can also apply where the demographic is older, people have limited knowledge of fires or are physically further from support resources. Elderly people and people with underlying health conditions are a particularly vulnerable population group that must not be overlooked in the response phases, as their health is compromised by smoke from wildfires and prescribed burns[85].

Procedural justice brings to the fore questions of inclusive stakeholder consideration in the development of response strategies such as evacuations. Even if early warnings and information on appropriate response measures are universally accessible in theory, this does not necessarily mean that all population subgroups can turn the information into effective response actions. Procedural justice also addresses the question of who decides where to put emphasis in emergency situations and where to accept residual impacts? For example, firefighter services remain predominantly male and hence the female voice is often excluded in the response phase. Likewise, indigenous groups, who have stewarded their lands with fire for millennia, are often excluded from participating in firefighting activities and decisions. Similarly, and linked with aspects of distributional justice are questions related to the communication about the fact that certain losses will have to be accepted to avoid worse. One example is the decision of the Australasian Fire and Emergency Services Authorities Council adopted in 2005[86] (p.5): "(…) there will be circumstances when fire agencies are unable to provide firefighting resources in sufficient time and strength to prevent all loss of life and damage to property. Additionally, firefighting resources are likely to be allocated where they will be most effective at protecting lives, not necessarily where property losses are most likely. Firefighting resources are unlikely to be allocated to property that cannot be defended safely." This position illustrates that while authorities aim to protect people in the event of a wildfire, institutional capacities, circumstances and the nature of the hazard can conspire against response activity and thus have collateral side effects on procedural justice. This finally leads to discussions about **restorative justice**: should there be compensation for losses resulting from how emergency management resources are deployed? And what form may such compensation take?

4.4 Recovery and adaptation

In the recovery and adaptation phase, which can be designed to drive a reduction in vulnerabilities and inequalities, crucial justice issues include: the distribution of benefits and costs of adaptation measures, the potential of individual adaptation action causing maladaptive outcomes at a societal level, the distribution of adaptive capacities across societies, and the role of insurance as a solidarity mechanism to provide restorative support.

Underlying questions of recovery and adaptation raise difficult choices that can be viewed from a **distributional justice** lens, for instance, what consequences do the prevailing *biomass* management regime have on different societal groups? How do *urban and land-use strategies* affect the multitude of stakeholders? Are trade-offs between regulation/re-zoning and residual damage considered and how can "build-back-better", incorporating adaptations, be incentivized/enabled? Finally, aspects about the benefits of nature-based solutions or the overall *socioeconomic drivers* determining the distribution of residual impacts play a role here.

Procedural justice comes into play, for example, in terms of the consideration of adaptive capacities when designing policies to address past (recovery) and future (adaptation) harms and the question of

which recovery strategies will be considered just and by whom? The worst-off groups are, for example, less likely to have private insurance or to go through complex bureaucratic processes to secure post-disaster assistance. This is a major challenge but also opportunity to co-design more inclusive recovery and adaptation strategies that can potentially lead to greater equity in the distribution of benefits and costs, and greater acceptance of the decision procedures.

Restorative justice considerations can include the provision of post-disaster technical and financial assistance to homeowners, businesses and private forest owners with an eye to the quintessential question of "who pays"? For instance, who has access to restorative financial support, such as insurance, public assistance or international aid, and who can pay? We can distinguish three principles of fundamental importance for organizing insurance or public post-disaster compensation arrangements, each principle building on a different view of restorative justice or equity: mutuality, which is at the core of the private insurance concept, according to which the insured participate in a disaster pool and pay a risk-based premium; solidarity, a profoundly different concept, according to which losses are typically paid according to need, and contributions to the pool are not made fully in accordance with the risks but can be subsidized for those unable to pay; accountability, according to which there is a perceived ethical or legal obligation (often based on fault or negligence) for compensating those having experienced loss and damage[78]. In Europe's Mediterranean region, costs are widely absorbed by insurers (to some extent, mutuality) and taxpayers (solidarity); in the USA, Australia and South Africa, those responsible for ignition, or negligence in managing fuel loads, have indeed been held responsible for major costs (accountability)[87].

Invoking these principles raises fundamental trade-offs. As a case in point, by providing subsidized insurance or post-disaster assistance to private actors, are we not at the same time encouraging maladaptation activities such as (re)building in high-risk areas? However, not doing this is to deny support to those most in need of it – and thereby exacerbate existing inequalities. Hence, insurance and post-disaster assistance might incorporate incentives or requisites for risk reduction and prevention measures and are ideally supporting building back better. This again requires timely consideration of the above-mentioned aspects in relation to regional specificities, ideally already in the prevention phase.

5. Incorporating justice into integrated WFRM approaches

In response to the increasing complexity and paramount justice challenges in managing wildfire risk, new integrated WFRM frameworks, such as the so-called "living with fire" paradigm, are emerging that consider not only damaging fires but also beneficial ones as ways to engage a range of societal risks[15,22], although still predominantly at the conceptual level. The concept of 'resilient landscapes' with its focus on ecosystems and nature-based solutions for WFRM is also emerging as a potent narrative, although many challenges persist in characterizing resilience and pathways for implementation[88].

Integrated WFRM approaches should take a holistic perspective. This should comprise continuous assessment/monitoring of the risk situation, planning and implementation of protection/risk reduction measures as well as measures to deal with residual risks[59,89]. These measures consider different root causes and drivers of hazard, exposure, vulnerability and possible options to manage the resulting wildfire risk, ranging from risk reduction to emergency management and risk transfer. In this latter context, the potential cooperative and mutual role of the private and public insurance sector to redistribute and collectively finance disaster losses[90] may become more important within WFRM strategies to achieve resilient communities, particularly when facing extreme fire events[91]. Moreover, integrated WFRM frameworks utilize a variety of approaches for the assessment of risk and evaluation of options, combining methods from natural, engineering, economic, ecological and social sciences[20]. In addition to economic appraisal of risk management options, other considerations need to come into play when deciding about the implementation of integrated risk management strategies; importantly this includes equity aspects, such as the differentiated impacts on various stakeholder groups and the environment and multi-stakeholders/agency engagement[92,93].

A polycentric governance approach[94] that integrates different governance scales and provides for stakeholder engagement and policy co-design – from national to sub-national levels all the way down

to local levels – can foster managing wildfire risk in an integrated way. In integrated WFRM, the public bodies may be complemented with formal or informal collaborations with volunteers, including farmers and foresters organized in emergency service associations, volunteer fire-fighting organizations, or other volunteer platforms such as Virtual Operations Support Teams (VOST, which are associations of "digital volunteers" supporting authorities with security tasks in monitoring social media during or after major events, serious disasters or catastrophes[95]). Private sector stakeholders such as the tourism industry and land and forest owners, critical infrastructure operators, and environmental NGOs should also be included in co-developing effective WFRM strategies.

To date, the integration of stakeholders and their perspectives on the above-mentioned characteristics of integrated WFRM is only partially addressed in practice[96,97]. In many cases, the different agencies act in a fragmented way, without horizontal channels of cooperation and joint decision-making, and authorities responsible for risk management typically focus on emergency planning rather than on prevention[98].

Operationalizing integrated and just approaches to WFRM is urgently needed as societies deal with a fundamentally changing wildfire risk context – in all three dimensions of hazard, exposure and vulnerability, while at the same time scaling up their climate change mitigation ambitions and addressing other sustainable development challenges. Hence, we argue that more inclusive and integrative WFRM strategies can and should also be connected the Just Transition discourse.

Since the adoption of the Paris Agreement in 2015, there has been a growing focus on Just Transition to help achieve the economic and social changes necessary for sustainable development, while protecting workers and communities, and ensuring a more socially equitable distribution of benefits and risks of climate change (see e.g., [99] [100,101] [102] [103]). At the core of the JT approach lies the idea that justice must form an integral part of low-carbon and climate-resilient transitions in order to facilitate a more "profound transition that could transform the economic and political structures that reproduce and exacerbate inequalities and power asymmetries"[104]. These presumptions are slowly being mainstreamed into climate action discourses. For example, at the European level, JT has become a central concept intertwined with the European Green Deal. JT can hence be a vehicle for looking deeper into values and worldviews driving transformation and specifically aspects of operationalizing environmental justice such as distributive, procedural and restorative justice hold great potential for investigating justice aspects of development processes more broadly, including the management of climate-related risks.

However, a number of sectors that will have to face far-reaching transitions with potentially unequally distributed side-effects are still neglected in the current JT debate. For example, the Just Transition concept has so far not been enunciated in the rapidly evolving WFRM policy context, and the two discourses continue to be addressed in isolation. This would, however, be of particular importance since integrated WFRM involves a broad range of stakeholders across many sectors, all of whom are also undergoing mitigation-related transitions. Holistic WFRM can be interrelated with sectoral changes, for example in agriculture and forestry, energy production related infrastructure systems and the construction sector, leading to distributional implications through e.g., labor, goods or property markets. In addition to these transitions, integrated WFRM faces trade-offs, for example between nature conservation and vegetation management. For instance, some climate actions such as the '3 Billion Trees Pledge' reforestation initiative may influence future wildfire risk by creating additional exposure through those reforested areas[105].

We suggest that future research builds on our framework for identifying justice aspects in WFRM presented in this perspective to better connect the two discourses in research and practice. Looking at the distribution of risks across stakeholders, their role in the WFRM process and their interest and needs with respect to resources and/or compensation could allow for an in-depth integration of justice aspects into current risk management practices and support their transformation towards more just and integrated WFRM. Eventually, this can also add value on a broader scale to "transcend [Just Transition's] original strategic purpose"[38](p.1) and to pave the way for further application in other fields

and sectors that are currently not explicitly considered in the Just Transition discourse. Simultaneously, a broader application of environmental justice aspects and their operationalization in new contexts and sectors may also enrich the JT discourse.

6. Conclusions

Addressing the lack of systematic research on aspects of justice in the context of wildfire risk and its management, we have shown that distributional, procedural and restorative justice challenges arise along all four phases of the WFRM cycle, and across social, economic, cultural and ecological dimensions that impact the risk management process. They are linked to trade-offs arising from actions and inactions influencing hazards, exposures and vulnerabilities and may lead to conflicts among stakeholders.

To limit potential conflicts and increase the political feasibility of transitions in WFRM, potential justice issues need to be proactively addressed to establish integrated WFRM approaches that are perceived as just by relevant stakeholders – in terms of their outcomes as well as their procedures. Hence, in upgrading WFRM strategies at the local, national and regional levels, necessitated by fundamentally changing wildfire risks and dynamics due to climate change and socioeconomic development, we argue that policy and decision makers should explicitly address the often implicit justice considerations along the WFRM cycle.

By developing a framework grounded in the environmental justice literature for comprehensively identifying justice aspects across all four WFRM phases, this perspective sets out the conceptual basis for further in-depth and more context-specific justice analyses in WFRM, such as a focus on indigenous communities (e.g., First Nations) and specific wildfire events. It also lays out the basis for risk management and risk governance practice to start embedding crucial distributional, procedural, and restorative justice considerations when developing a just transition towards more integrated WFRM strategies and approaches.

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