





## Disaster risk reduction in mountain areas: an initial overview on seeking pathways to global sustainability

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**Abstract:** As disasters cripple the world's prospects for sustainable development, protecting the most vulnerable groups exposed to hazards is one of the main challenges facing humanity. Owing to the systemic nature of risk and the interactions and interdependencies between upland and lowland systems, healthy and productive mountain households and livelihoods are essential to global sustainability. This paper argues that, building on existing international frameworks, and integrated knowledge and praxis, the development of a global policy agenda should be established to build sustainable peace, sustainable security, and development.

**Keywords:** Disaster risk reduction; Integrated disaster risk management; Global sustainability; International frameworks; Science-based policymaking

### 1 Introduction

Recent estimates indicate that if current trends

continue, the annual global number of disasters could rise from around 400 in 2015 to 560 per year by 2030, this means 1.5 disasters per day (UNDRR 2022). That being the case, the essential task of managing disaster risk from an integrated perspective and engaging in science-based policymaking cannot be further delayed.

Disaster risk and disasters are socially constructed systemic processes that unfold over time. Disaster risk stems from the combination of pre-existing conditions of vulnerability and exposure and hazards of various origins, and when they materialised, they become disasters (Oliver-Smith et al. 2016; 2017).

The root causes of disaster risk, and thus of disasters, are political and economic factors often linked to skewed development models, meanwhile the drivers of risk express vulnerability and exposure (Blaikie et al. 1994; Lavell and Maskrey 2014). Furthermore, vulnerability and exposure, along with some hazards (i.e. socio-natural (Lavell 1996) or anthropogenic hazards) result from human choices, perceptions and practices linked to development models and/or disaster response and disaster risk management practices, and the occurrence of hazards can trigger disasters (Lavell and Maskrey 2014;

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Oliver-Smith et al. 2016; 2017).

In summary, disaster risk can be described as the probability or latent condition that reveals the potential impact of one or more hazards of different nature on a society or a system characterised by various levels of vulnerability, occupying a territory exposed to the effects of such hazards; when adverse effects occur, the situation has turned into a disaster (Alcántara-Ayala et al. 2023).

The root or underlying causes of disasters and the drivers of vulnerability and exposure must be addressed to reduce disaster risk and, in parallel, the “construction” of new risks must be avoided to enhance sustainable development (UNDRR 2022; Alcántara-Ayala et al. 2021). Of paramount importance is this endeavour in upland systems since healthy and productive mountain households and livelihoods are essential to global sustainability.

The socio-territorial drivers of disaster risk in mountainous areas are also complex. These are characterised by particular socio-economic and socio-environmental factors and components derived from governance and institutional arrangements (Fig. 1).

While the root causes are linked to the development modes as in any other region, vulnerability and exposure reflect the interactions between highland and lowland systems (Wymann von Dach et al. 2017). This encompasses ecological legacies and is influenced by socio-economic contexts and socio-territorial trade-offs leading to environmental changes in accordance with prevailing disaster risk governance structures (Alcántara-Ayala and Geertsema 2022) (Fig. 2).

The unique context of disaster risk issues in mountain areas is also shaped by hazard dynamics. A series of aspects of hazard occurrence are linked to each other, creating a complex anatomy in which, in most cases, each hazard process is influenced by, and influences, all the others. Mountain systems are more sensitive to the effects of climate change in terms of intense and extreme precipitation leading to the occurrence of flash-floods, landslides, glacial lake outburst floods (GLOFs), etc., and favouring cascading impacts (Adler et al. 2022). This nature, together with pre-existing conditions of vulnerability and exposure typically influence a higher level of disaster risk in mountains than in lowlands (Fig. 3).

Protecting the most vulnerable groups exposed to hazards is one of the main challenges facing humanity, as disasters cripple the world's prospects for

sustainable development. Therefore, to achieve sustainability, disaster risk must be managed with an integrated transdisciplinary approach (Beer et al. 2019) and, to do so, renewed chains of alliances must be built between the scientific and technological community within the sphere of policy formulation (Aitsi-Selmi et al. 2016; Satake et al. 2018).



**Fig. 1** Main socio-territorial disaster risk drivers in mountain areas (Source: Alcántara-Ayala and Geertsema 2022).



**Fig. 2** Processes associated with drivers of disaster risk in mountain areas (Source: Alcántara-Ayala and Geertsema 2022).

In addition to the introduction, this paper is subdivided into three sections. The first one highlights the importance of building on existing



**Fig. 3** Disaster triggered by the debris flow occurred on August 8, 2010 in Zhouqu Town, Gansu Province, China. Zhouqu Town before (A) and after (B) the event. The giant debris flow caused enormous impact and property losses (C) (Photos by courtesy of Kaiheng Hu).

international frameworks, co-production of knowledge, and praxis, for the development and implementation of a global policy agenda. The second part contextualises the challenge of implementing research knowledge. The purpose of the final section is to briefly reflect on the need to identify potential ways to attract the attention of policymakers to ensure that policies and practices can be driven by scientific evidence in a sustained manner.

## **2 Tackling Sustainability: A Comprehensive, Transversal, Multicultural and Global Policy Agenda**

Global sustainability is tied to healthy and productive mountain households and livelihoods. In ensuring the long-term strengthening of the foundations of sustainability, integrated disaster risk management in mountain areas should be aligned with provisions to protect the most vulnerable groups. It is along these lines and in direct response to the

needs of this particular sector that policies should not be fragmented.

Due to the systemic nature of risk and the interactions and interdependencies between upland and lowland systems, unsustainable mountains influence sustainability elsewhere. Sustainable livelihoods in the highlands not only improve the quality of life in the mountains but help to grant direct and indirect access to basic needs in the lowlands by providing fresh water, food, biodiversity, geodiversity, forest products and energy.

While the definition of Post-2015 international agendas including the Sustainable Development Goals (UN 2015), Sendai Framework for Disaster Risk Reduction (UNISDR 2015), Financing for Development (AAAA 2015), Climate Change (UNFCCC 2015), the Agenda for Humanity (UN 2016), the New Urban Agenda (UN 2017), and the Post-2020 Global Biodiversity Framework (Convention on Biological Diversity 2022), has been done under specific subject matters, actions should be global and nonsegregated. The planet is an inextricable structure

that cannot be treated as a jigsaw puzzle since it is not divided into pieces; it functions as a system and understanding not only its physical nature, but also its social complexity requires holistic and transdisciplinary perspectives that must include all-inclusive schemes and resolutions (Fig. 4).



**Fig. 4** The establishment of multiple Post-2015 international agendas favour the disarticulation of commitments, responsibilities, the transdisciplinary co-production of knowledge, the mainstreaming of policies and practices, as well as the accountability of actions.

The unprecedented socio-environmental changes of our time call for a transformative engagement. Hence the need for a comprehensive, transversal, multicultural and global agenda that includes interlinkages, connectivity and interdependencies between policy issues leading to sustainable peacebuilding, sustainable security, and development. This roadmap must be designed in a spirit of commitment, responsibility, and accountability for one's own actions. It should not be an end, but rather a means to shift the balance of unsustainability in a complex world where the potential impact of disaster risk and disasters is also induced by emergent and complex hazards. This profound transformation of society and economic systems implies a new creation of values and ethos of social equity and the implementation of fundamental principles and development approaches different from those of the dominant model (Alcántara-Ayala et al. 2021).

Driven by the global disaster triggered by the COVID-19 pandemics (Alcántara-Ayala et al. 2021), the world has become more sensitive to changes of

contexts. The systemic nature of the social construction of disaster risk (Maskrey et al. 2021) turns out to be a central issue not only for integrated disaster risk management, but particularly for national and transboundary disaster risk governance. This is of great relevance to mountains due to the complex lowland-upland interactions regarding the dynamics of vulnerability, exposure and hazards and the way disaster risk is exacerbated (Alcántara-Ayala and Geertsema 2022).

On that account, the issue of disaster risk reduction in mountain areas has received considerable critical attention in the last years (i.e. Wymann von Dach et al. 2017; Szarzynski et al. 2022; Adler et al. 2022), including effective disaster risk reduction to address community and ecosystem health through integrated community and ecosystem-based perspectives (Klein et al. 2019).

In the recent Global Assessment Report on Disaster Risk Reduction (UNDRR 2022), reference is made to a series of topics which bring to the table visions and interests of the mountain communities. The report offers both an overview of the existing challenges and insights of how disaster risk has been reduced in mountain areas around the globe. Against this background, attention is given to the amplifying inaccessibility due to hazards, such as landslides, that isolate rural villages recurrently affecting livelihoods. Likewise, very often, mountain regions are also severely affected by blackouts derived from hurricanes. Nonetheless, despite such challenges, there are increasing signs of hopes and opportunities. Learning and innovation programmes to reduce disaster risk associated with floods and landslides have led to successful cases of integrated disaster management. Such type of efforts has benefited greatly from learning from indigenous knowledge and understanding the meaning of mountains for different cultures. Finally, and very importantly, it has been well recognized that transboundary governance of disaster risk implies the co-design of development pathways and policy strategies.

Along with demographic shifts, poverty, inequality, exclusion, and environmental degradation, climate change is one of the main drivers of disaster risk in mountain systems. In this vein, a more substantial approach to the longer-term significance of disaster risk reduction and climate change adaptation can be found in the new-fangled WGII Sixth Assessment Report Cross-Chapter Paper on

Mountains (Adler et al. 2022). According to this report, the increasing climate change impacts on mountain regions and their attribution to human influence in recent decades have been identified as major contributing factors to adverse consequences, affecting people, livelihoods, and ecosystems in many mountain areas.

These negative effects of climate change include diverse aspects, in particular disaster occurrence, changes in the water cycle, production and use of energy, tourism and recreation activities, agriculture, and pastoralism. What is more, it has also been documented that adaptation responses to climate-driven impacts in mountain areas vary significantly in accordance with goals, priorities, scope, depth and speed of implementation, governance processes, decision making modes, and the scale of available financial and other resources for implementation (Adler et al. 2022).

Climate change is just one of many issues that pose intricate challenges in the highlands. Disaster risk reduction is a daunting endeavour in the context of the systemic nature of disaster risk.

By drawing on the concept of systemic risk, Maskrey and colleagues (2021) have been able to show that disaster risk possesses “high levels of interdependency, nonlinearity, feedback loops and uncertainty” that can be expressed and materialised as “sequential, synchronous or simultaneous crisis and failings”. These can take place as “single and separate occurrences or in more complex, compound, multiple, concatenated or cascading and sequential forms”. Likewise, they can be driven by physical, biological, technological, environmental, socio-political and economic/financial constituents.

In this sense, the complex processes involved in the social construction of risk and the concern for disaster risk reduction are intimately related to the functioning of livelihoods, which are highly influenced by the dynamics of the sphere of systemic risk.

While a variety of definitions of the term livelihoods have been suggested, this paper will use the definition suggested by Chambers and Conway (1992), who considered that "a livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base".

According to the Sustainable Livelihoods Framework (SLF), there are a number of important issues that help to conceive livelihoods in a holistic perspective, recognising their diverse complexities, along with the constraints and windows of opportunity that they own. While the vulnerability context encompasses the space where people inhabit, livelihood capital or assets can be human, social, natural, physical, and financial in nature, and transforming structures and processes portray the institutions, organisations, policies, and laws that configure livelihoods. The framework also considers livelihood strategies shaped by the combination of activities and choices that people carry out to achieve specific livelihood goals, such as additional income, improved well-being, reduced vulnerability, better food security and a more balanced use of natural resources (Chambers and Conway 1992; DFID 2000; Devereux 2001).

The multidimensions of disaster risk in mountain systems are difficult to depict. However, based on some aspects of the SLF (DFID 2000), the Pressure And Release (PAR) Model (Blaikie et al. 1994), the social construction of disaster risk perspective (Lavell and Maskrey 2014; Oliver-Smith et al. 2016; 2017), and the systemic nature of risk (Maskrey et al. 2021), an attempt to illustrate the complexity and diversity of livelihoods in mountain linked to the global interlinkages and interdependencies with the lowlands in a context of disaster risk is presented (Fig. 5).

Not only are human lives lost, but livelihoods in mountains are severely affected or destroyed due to disasters. Constructing healthy and productive households and livelihoods in mountains involves a series of sustained processes. In effect, these processes must be created as virtuous cycles that aim at the establishment and implementation of policies and legal frameworks to ensure disaster risk reduction through integrated management. High-quality education (Hoffmann, and Blecha 2020), capacity building (Hagelsteen and Becker 2013) and appreciation of cultural heritage, indigenous and traditional knowledge (Mercer et al. 2010) are essential to build and maintain such cycles. Consequently, integrated knowledge of disaster risk should be oriented towards the co-production of knowledge, promoting community participation and adequate risk communication (Lejano et al. 2021).

These processes do not materialise out of thin air. Effective organisational, institutional, administrative,

and social structures are required to enable societies to enforce good governance (Tsukahara 2018) and best practices in integrated territorial management of mountain systems. This is based on the recognition of the economic, social, and territorial cohesion that must be interwoven with grassroots community organisations, community committees for disaster risk reduction, intersectoral alliances, inter-agency bodies, disaster risk stakeholders' platforms, civil society etc.

The root causes of disaster risk and disasters, mainly shaped by skewed patterns of development (Lavell and Maskrey 2014), do not have a single spatio-temporal scale. Despite the myriad of disaster risk drivers characteristic of mountain systems (see Fig. 1), a number of universal and critical drivers determine the increasing vulnerability and exposure of societies and environmental systems. Largely driven by poverty, inequality and exclusion, demographic changes that lead directly and indirectly

to land degradation (Olsson et al. 2019) and climate change are reflected in emergent and cascading hazards. The consequences of such interlinkages are intensifying, in particular, water scarcity, food insecurity and migration processes (Fig. 5).

These are in addition to the systemic nature of disaster risk, which rises issues associated with interdependent infrastructure systems, global supply chains, simultaneous crisis from compound hazards, existential risk in global systems and the not less significant, the role of everyday experience of systemic risk (Maskrey et al. 2021) (Fig. 5).

Therefore, with the current understanding of the complex interactions between what happens upstream and downstream concerning the social construction of disaster risk and its impact on development, the scientific and technological community recognises that major and innovative efforts must be intensified to guide policy formulation and practice.

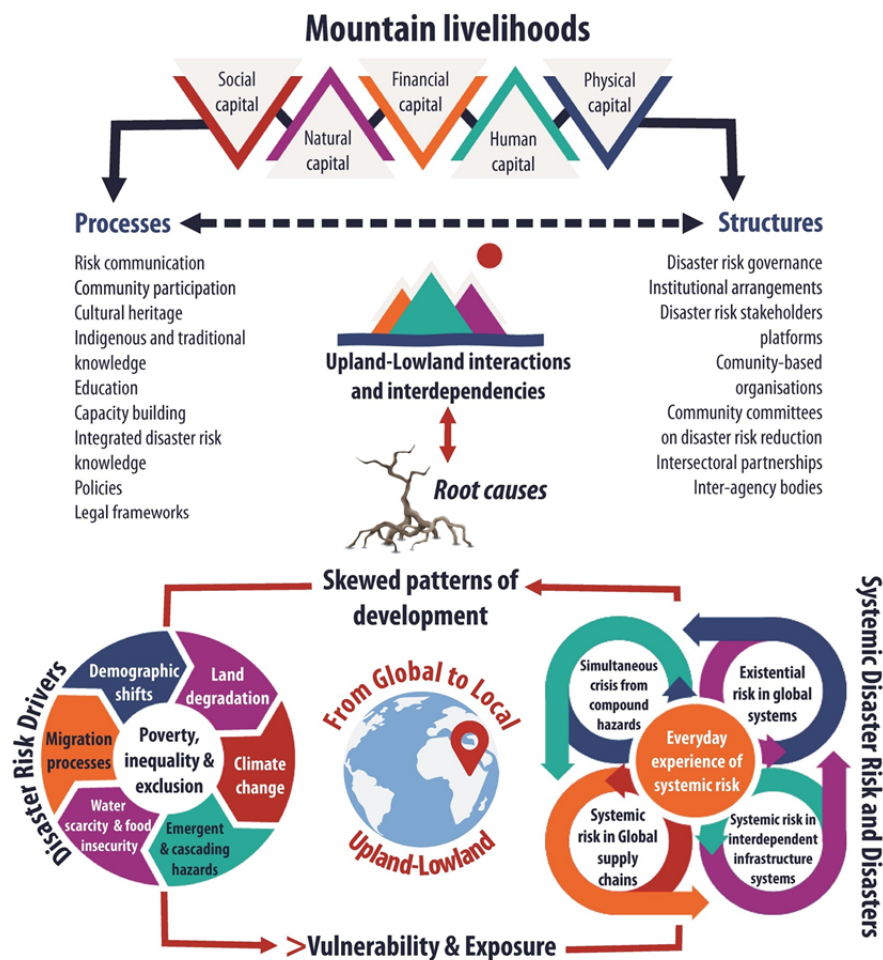


Fig. 5 Multidimensions of disaster risk in mountain livelihoods.

### 3 Evidence-Based Policy Making

It is now well established from a variety of studies, that evidence-based policy making is fundamental to reduce existing risk and avoid the development of future risk scenarios (Cutter et al. 2015). Mountain regions are not an exception. Exposure and vulnerability to mountain hazards has been shown to be related to adverse effects in socio-economic development of communities.

While the third priority of the Hyogo Framework for Action encouraged using knowledge, innovation and education to build a culture of safety and resilience at all levels (UNISDR 2005), one of the guiding principles of the Sendai Framework for Disaster Risk Reduction (UNISDR 2015), argued the necessity of “a multi-hazard approach and inclusive risk-informed decision-making based on the open exchange and dissemination of disaggregated data, including by sex, age and disability, as well as on easily accessible, up-to-date, comprehensible, science-based, non-sensitive risk information, complemented by traditional knowledge”.

In this framework, attention has been given to supporting a paradigm shift in disaster science, from research on individual hazards and risk assessment conducted with geoscientific approaches to an action-oriented, transdisciplinary research perspective that enables the co-production of knowledge (Ismail-Zadeh et al. 2017). However, this is not an easy task (Gall et al. 2015). While financial means are often tailored to the prevailing socio-economic contexts in each locality, high-quality human resources are essential to being able to initiate dialogues to develop integrated and transdisciplinary approaches and practices.

Integrated and transdisciplinary research requires a proper comprehension of how indigenous and traditional knowledge can enhance scientific understanding. Yet, certain stakeholders are less willing than others to work as a team in which individuals are treated and listened to in the same way. Likewise, transdisciplinary angles demand a continuous effort and a great investment of time. This is especially important when efforts are directed at better reflecting mountain disaster risk reduction concerns in policy arenas such as development (Wehrli 2014), climate change (Adler et al. 2022), biodiversity (IPBES 2019), and sustainability (Tucker et al. 2021).

The scientific community has played an

important role in supporting the implementation of international milestones, in particular the Sendai Framework and the Sustainable Development Goals (SDGs). Lei et al. (2018) identified a series of challenges and opportunities associated with disaster risk reduction and the achievement of the SDGs derived from the development of the Chinese national Belt and Road Initiative strategy, aimed at global economic, political, and cultural collaboration and exchange along the ancient Silk Road. Likewise, by using in-depth research and systematic analysis on natural hazards and disaster risk in China, Cui et al. (2021) documented the high level of dependence of current societies on critical infrastructure and networks that enhance the spread of disaster impact through socio-economic systems.

Long lasting alliances between the academic sphere and the policy domain do not take place everywhere. Nonetheless, experiences in countries such as Italy provide evidence of the social benefits of this type of efforts that transcend political purposes. The Italian scientific and academic community is heavily involved in activities to support decision makers and consultancy at every administrative level on hazards such as earthquakes, tsunamis, volcanic eruptions, extreme meteorological events, floods, landslides, wildfires, and chemical and industrial accidents. The work of a National Committee for Major Risks, made up of recognised scientists, works at the central level to provide technical and scientific advice to the Head of the National Department of Civil Protection (Pasuto and Schenato 2021). These activities are so important because they aim to provide not only information for disaster response, but also for planning and disaster risk management.

However, strong partnerships need to be consolidated. For example, factors found to be negatively influencing integrated planning in Nicaragua included several fragmented processes and functions of the national disaster risk management system. This made it impossible to consolidate the information produced by multiple government authorities at different scales and transfer it to the local level (Rivera et al. 2015).

In an era of global change, concerns about disaster risk and the sustainability nexus are more than evident (Peduzzi, 2019). Local actions connecting the transformations in the globe are embedded into a world of systemic risk. Accordingly, understanding the spatial boundary conditions, time

frames and interdependencies of nodal systems of risk involves not only complexity, non-linearity and uncertainty, but also understanding how humanity has been shaped, and the way it will continue to address major societal challenges.

Undoubtedly, one of the major defies faced by many scientists is the use of research insights in the structure and operation of governance arrangements in order to generate systems knowledge, objective knowledge and transformational knowledge (UNDRR 2022).

#### 4 Concluding Remarks

Initial analysis of data reported by United Nations Member States through the Sendai Framework Monitor reveals that the achievement of Sendai Framework target for 2030 is already jeopardised (UNDRR 2022; Lucatello and Alcántara-Ayala 2022). Disaster risk is not being managed in accordance with the requirements derived from current global environmental change. As the world plunges into uncertainty, the implementation of science-based policy making in mountains, and elsewhere, must reflect their attachment to collective ownership and the global significance to future generations in both lowlands and in the highlands.

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The global disaster triggered by COVID-19 provided an opportunity to reflect on the future we want and value. Nevertheless, disaster risk management policy in only few countries was supported by scientific evidence and there appears to be no real attempt to transform either attitudes or actions. Still submerged in the crisis with seeming indifference, the social construction of risk continues its perpetual course.

What has remained unclear for years, however, is how to attract the attention of policymakers to ensure that such policies and practices can be driven by scientific evidence in a sustained manner. The renewed impetus for implementation will urge fertile ground to build a global framework that leads to greater positive impacts expressed in social transformations and more vigorous environmental actions. This process would allow to strengthen economic and social cohesion to curb the imbalances induced by current patterns of development, and therefore, inequality.

Last but not least, the reflections presented here on seeking pathways to global sustainability through disaster risk reduction in mountain areas call to mind a quote from Mami Mizutori, Special Representative of the United Nations Secretary-General for Disaster Risk Reduction: "Nothing erodes sustainable development like a disaster" (UNDRR ROAMC 2022).



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