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Ten key pathways for fostering innovations in disaster and climate resilience in a changing global risk landscape

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Abstract

The global disaster risk landscape is becoming increasingly complex, influenced by a combination of natural hazards, human-induced risks, technological and geo-political risks and systemic vulnerabilities. World Economic Forum (WEF) shows the emerging new risks in recent years, while in longer term the environmental risk remains as the top risk. The interconnectedness of the risks and system urges systemic approach in disaster risk reduction. Based on the current state of knowledge, ten key pathways are suggested for future resilience building: 1) incorporate all hazards approach, 2) make adaptive governance a part of resilience framework, 3) blend digital and analogue tools to enhance inclusiveness, 4) enhance urban rural collective resilience, 5) make innovation affordable, 6) enhance participation and decision making through citizen science, 7) promote concept of phase free: an innovative way to preparedness, 8) promote equity based on gender, disability and other vulnerable groups, 9) implement immersive learning and education using technologies, and 10) foster youth innovation and entrepreneurship. these are not exclusive ten road maps and there will be more future opportunities, frameworks and new policy directions. However, from the current state of knowledge in disaster and climate change, these are considered as the core areas of focus for resilience building.

Keywords: disaster resilience, complex risk landscape, adaptive governance, innovation and entrepreneurship, inclusive risk reduction

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Complex and Evolving Global Risk Landscape

The global disaster risk landscape is becoming increasingly complex, influenced by a combination of natural hazards, human-induced risks, technological and geo-political risks and systemic vulnerabilities. Rapid urbanization, climate change, environmental degradation, geopolitical conflicts, and socio-economic inequalities have intensified the frequency, severity, and impact of disasters across regions. While advances in early warning systems and disaster risk reduction (DRR) strategies have saved lives, the overall trend points toward escalating risks and mounting challenges in achieving sustainable development goals. DRR, mentioned in this paper is "aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development." [1]. Climate change has become one of the most significant driver reshaping global disaster patterns. The world

continues to experience more frequent and intense weather-related events such as heatwaves, droughts, cyclones, floods, and wildfires.

The year 2024 witnessed record-breaking global temperatures, leading to droughts in parts of Africa, Europe, and Latin America, and devastating floods in Asia. The IPCC 6th Assessment Report [2] and other scientific bodies consistently warn that without urgent mitigation and adaptation measures, such extremes will become the norm rather than the exception. Sea-level rise is also threatening low-lying coastal regions and small island states, leading to displacement, loss of livelihoods, and irreversible environmental damage. This paper analyzes evolution of disaster risk landscape and provides some key and emerging concepts which are essential for resilience building for both disaster and climate risks.

World Economic Forum (WEF) publishes Global Risk Outlook every year in its landmark Davos Meeting in January. The report provides an analysis of the previous year global risks. The reprot started to be published form 2007, after the Lehman Financial Shocks. In the report, the risks are chaaarterized into five types: economic, environmental, geopolitical, societal and technological. A close look at the reports from 2007 to 2020 (2020 report is the analysis of 2019) reveals that in the recent years like 2017 onward, the environmental risks (like extreme risks, climate action failure, natural hazards, biodiversity losses etc.) become top risks in terms of both likelihood and impacts [3]. Fig. 1 shows this global time series trend. The same report of 2021 shows infectious disease as the top risk in terms of impacts which is a reflection of COVID-19 in 2020 [4]. However, two top new risks arise, which are digital divide and digital power concentration. The lifestyle change due to COVID-19 has prompted work from home, online education, health care, online shopping, which neds a good digital public infrastructures. Not the whole world is equipped with equal digital public infrastructure, and there is a north south divide in this, where developing countries have major digital challenges. There are also urban rural divide and age divide related to digital penetration. This is considered and reflected as the new risks. WEF 2022 pointed out cybersecurity as a new risk [5] and WEF 2023 [6] highlighted energy crisis and cost of living as new emerging risks, due to Russia Ukraine war of 2022. Thus, between 2021 to 2023, several new global risks emerged: infectious disease, digital divide, digital power concentration, cyber security, energy crisis, cost of living etc. The WEF 2024 [7] identified

Fig. 1. Global risk trends in terms of likelihood and impact. Adapted from WEF [3] with permission of the copyright holder.

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mis- and dis-information and societal polarization as two major risks, due to major technology drive of artificial intelligence (AI) based mis and disinformation which have been used in major elections globally.

A classic case of mis and dis-information in a disaster situation was in 2024 Noto Peninsula Earthquake and Tsunami. The earthquake and tsunami happened on 1st of January 2024, during the holiday time in Japan. After the event, there were around 370,000 posts (both twit and re-twit) in social media X that it was an "artificial earthquake" due to many mid-leading reasons, including the nuclear explosion in North Korea. Fig. 2 shows the number of posts in first three days. It went into such an extent that the Japanese Prime Minister had to appeal for not to spread rumours in the press conference.

In 2025 report [9] state based armed conflict, extreme weather events, geo-economic confrontation and mis and dis-information became top risks. The analysis shows that while in short terms, new risks are emerging, in the longer terms, we need to address environmental risks like extreme weather, climate change, biodiversity losses etc.

With this background of the complex risk landscape, the purpose of this paper is to review some of the critical challenges and provide a few critical proactive pathways. Needless to say that it is not a fully comprehensive review of all the issues, however, the paper does critically analyze some of the new and evolving concepts of DRR and climate change adaptation. This paper can be useful for the academic / researchers, as well as policy makers. Therefore, a few prescriptive statements are used for describing the pathways.

Systemic Risk Approaches

The growing complexity and interdependence of modern societies demand a shift from traditional, siloed approaches to a systemic risk framework for understanding and managing disaster and climate risks. Systemic risks arise when the failure or shock in one part of a system triggers cascading effects across other sectors or regions. This is particularly relevant in the context of climate change, where extreme weather events, rising sea levels, and environmental degradation interact with social, economic, and political systems in unpredictable and often compounding ways.

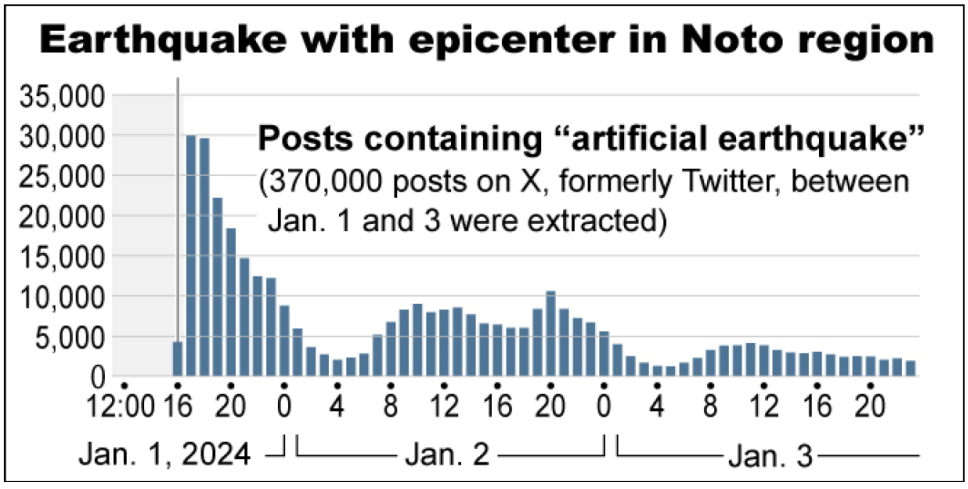

Fig. 2. Posts containing "Artificial earthquake" after the Noto Peninsula Earthquake and Tsunami. Adapted from NHK [8] with permission of the copyright holder.

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The importance of systemic risk is highlighted in Global Assessment Report of United Nations Disaster Risk Reduction (UNDRR) in 2019 [10]. A systemic risk approach emphasizes interconnectedness, recognizing that vulnerabilities are not isolated to physical hazards but are shaped by urbanization patterns, supply chains, governance structures, ecosystem health, and socio-economic inequalities. For instance, a cyclone disrupting a major port can lead to global trade delays, food insecurity, and energy shortages far from the impacted zone. Similarly, a drought can trigger conflict over resources, mass migration, and public health crises.

The WEF 2025 [9] report also pointed out the interlinkage of different risks and inequality and decline in health and well-being as two top societal risks (Fig. 3). Social, economic, and gender-based inequalities continue to shape vulnerability and resilience outcomes. Marginalized communities often reside in high-risk areas and lack access to information, resources, and services that could help them cope with disasters. The global south, particularly Sub-Saharan Africa, South Asia, and parts of Latin America, bears the brunt of both climate-related and conflict-driven crises, exacerbating poverty, food insecurity, and forced migration.

By adopting a systemic lens, policymakers and planners can identify hidden interdependencies and potential tipping points, enabling more robust scenario planning and risk-informed decision-making. It also promotes cross-sectoral collaboration, bringing together climate scientists, engineers, economists, health experts, and community leaders to co-design solutions. Importantly, a systemic risk approach aligns with the goals of the Sendai Framework [11], the Sustainable Development Goals [12] and the Paris Agreement [13] by promoting integrated risk governance. It supports a move from reactive disaster response to anticipatory and preventative action, enhancing resilience across entire systems rather than individual

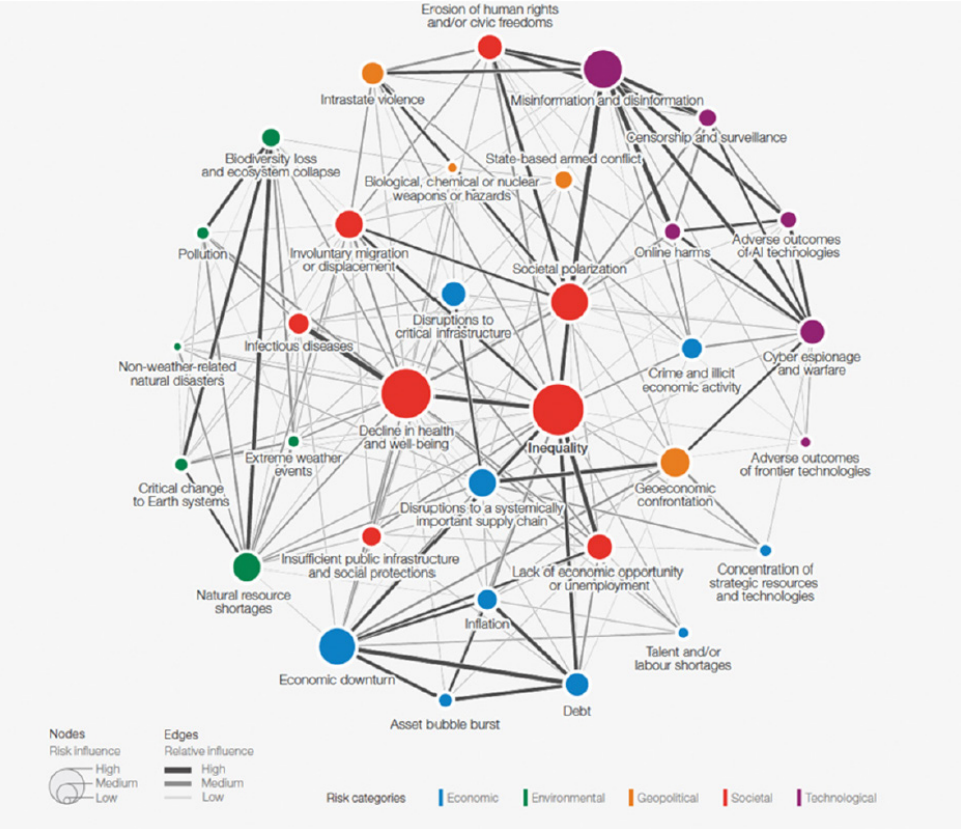

Fig. 3. Inter-connectedness of systems and systemic nature of risks. Adapted from WEF [9] with permission of the copyright holder.

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components. In a world of accelerating change and compounding risks, embracing a systemic risk approach is not just beneficial, it is essential for building resilient, adaptive, and sustainable societies. In their analysis, [14] observed a positive shift in the recognition of systemic disaster risks, but they also underscore the need for further maturity in its management and governance. To increase holistic management of disaster-related systemic risks and coordinate an effective policy response, their research proposed the essential design principles and conceptual framework for Integrated disaster resilience (IDR) based on a 'Whole Systems Approach'. IDR refers to the ability of a system, community, or society to prepare for, absorb, adapt to, and recover from the impacts of hazards, while also maintaining or restoring its essential functions and structures [15]. In another approach, in another analysis, [16] analysed the national policy of India and state policies of two coastal states which are prone to coastal hazards. They came out with the assessment framework for port infrastructure resilience.

Ten Key Pathways for Resilience Building

To address the changing and complex global risk landscape, traditional approaches in DRR or climate change adaptations are at stake [17–21]. Following ten pathways are drawn from author's past and current work, several others past and current literatures as well as from the discussions in different international forum, including Global Platform for DRR in 2025 and 2022, as well as Asia Pacific Ministerial Meeting in Brisbane in 2022 and Manila in 2024. There is no specific methodology used to draw these ten key pathways, and the author does not claim that these are the only ten. There may be more evolving pathways, which will evolve in future. There is a strong need for innovation and making proactive approaches in resilience building. Following are the ten key pathways for resilience building.

Incorporate all hazards approach (AHA)

Over last several years, apart from natural hazards, we have also experienced new types of hazards, including biological, technological, radiological, nuclear, cyber etc. This has urged to think of all-hazards approach (AHA) as the core of complex risk management framework. The AHA in DRR is a comprehensive strategy that addresses a wide range of potential hazards—natural, technological, biological, and human-induced—under a unified risk management framework. Rather than treating each hazard in isolation, this approach recognizes that the preparedness, response, and recovery mechanisms often share common processes, resources, and institutional capacities. There exist two major arguments evolved AHA. One group of researchers focus on AHA of critical infrastructures by citing risk from health hazards, cyber security hazards etc. The other group of researchers argue the concept of top hazards, and the core to that argument is hazards may be common, but the risks are context specific based on the exposures and vulnerability [22].

The core challenges of AHA are: 1) risk assessment, 2) risk perception and 3) risk mitigation and 4) governance. A proper risk assessment needs high resolution of different hazard related data. Regarding data, the core issue is ownership of the data. In many cases the data belong to different ministries and sharing of data in a common platform often becomes a challenge. For risk perception, it is important to enhance awareness of invisible hazards (like biological hazards, radiological and nuclear hazards) with transparent information sharing. Resource prioritization is the key and foremost challenge for risk mitigation. There, the top hazards approach is critical, which may help in prioritizing resources for undertaking mitigation measures. Finally, AHA needs a strong governance push, which is linked to evidence based decision making.

The AHA also emphasizes flexibility and adaptability, ensuring that systems are robust across a range of scenarios. This is vital in the face of climate change, which intensifies multiple hazards and introduces new uncertainties. It also promotes multi-stakeholder coordination, fostering collaboration between sectors such as health, infrastructure, environment, and security. Furthermore, it strengthens community resilience by encouraging inclusive risk assessments and integrated preparedness activities that consider the most vulnerable populations, who often face multiple hazards simultaneously.

Make adaptive governance a part of resilience framework

Adaptive governance is a dynamic, flexible, and inclusive approach to decision-making that is especially suited for managing complex and uncertain challenges such as climate change and disaster risks. It emphasizes continuous learning, stakeholder participation, and institutional flexibility, making it a vital component of resilience building at local, national, and global levels. Unlike rigid, top-down governance models, adaptive governance supports decentralized decision-making, allowing local actors to respond quickly to emerging risks and changing conditions. It encourages multi-level coordination between governments, civil society, academia, and the private sector, creating networks of actors who can share knowledge and resources during times of crisis. This collaborative environment enables more context-specific, innovative, and socially acceptable solutions [18].

In case of Japan, adaptive governance becomes quite critical for small and medium sized cities [23]. Sometimes, it is increasingly becoming difficult to evacuate to the designated evacuation center due to sudden change in rainfall pattern. Thus, it becomes critical to designate new areas where people take shelter, and that needs adaptive governance. Shelter management during COVID-19 was also a classic example of adaptative governance where around 40% occupancy were maintained in the evacuation center, which urged to make new designated centers.

Moreover, adaptive governance prioritizes inclusivity and equity, engaging marginalized communities who are often most affected by disasters. By integrating diverse perspectives and local knowledge into planning processes, it enhances the legitimacy and effectiveness of resilience strategies. In the context of climate change and increasing disaster frequency, uncertainty is the norm. Adaptive governance enables systems to remain functional and responsive under stress, reducing the likelihood of collapse and enhancing long-term resilience.

In summary, adaptive governance provides the institutional foundation for resilient societies: ones that can anticipate, absorb, recover from, and transform in response to shocks and stresses. It shifts the focus from managing events to managing uncertainty, which is central to resilience in the 21st century [24,25].

Blend digital and analogue tools to enhance inclusiveness

While both urban and rural areas have progressed significantly on digital public infrastructures, still there exist a gap of 20% to 25% between urban and rural areas globally. Also, in the developed countries like Japan, there is a strong ageing population in the rural areas, which has relatively low digital access. Thus, if the early warning system is provided only through digital network, it needs an analogue link, which is mostly the human network to bring this warning to the ageing population and evacuate together. This issue is also discussed by Kanbara & Shaw [24], citing example of the Noto Peninsula earthquake and tsunami.

Enhance urban rural collective resilience

Urban and rural areas are deeply interconnected through economic, ecological, and social

systems. There are different types of flows between urban and rural areas, including food, energy, water, human resources, information, technology etc. Enhancing urban–rural collective resilience to disasters and climate change requires recognizing these linkages and developing integrated strategies that address shared vulnerabilities while promoting mutual support and collaboration.

One of the key strategies is regional and integrated planning that goes beyond administrative boundaries. This includes joint disaster risk assessments, land-use planning, and shared early warning systems that cover entire river basins, coastlines, or ecological zones. Cities and rural areas must work together to co-manage resources such as water, energy, and food, which are critical during crises. Decentralized and participatory governance plays a vital role. Local governments, civil society, and communities in both urban and rural areas should be engaged in planning and decision-making. Establishing regional coordination platforms can help align policies, pool resources, and organize joint training, simulations, and emergency response.

Investing in shared infrastructure such as transportation, healthcare, communication systems, and evacuation routes strengthens collective resilience. Urban centers can support rural areas with access to technology and markets, while rural regions can serve as refuge zones or suppliers of essential goods during urban disruptions. Blended digital and analogue solutions are crucial for ensuring inclusive communication across diverse populations. Mobile apps, community radio, and local knowledge networks should be combined to ensure information reaches all segments of society. Nature based solution is the core to this issue [26].

In a paper [27] made an interesting analysis from Nagpur, India to show the urban rural connectivity of food, energy and water and argues that a shift in the governance mechanism is essential for enhancing collective resilience. This is also reflected in the example from Japan where Regional Circular Ecological Sphere (RCES) is applied for enhancing payment of ecosystem services from the urban areas to maintain forest and water resources in the rural areas and to enhance collective resilience.

Finally, building resilience must be equity-focused, targeting the needs of vulnerable populations across both geographies, and supporting sustainable, resilient livelihoods. Youth engagement, women's leadership, and citizen science initiatives can foster innovation and trust across the urban–rural divide.

Make innovation affordable

Innovation in disaster and climate resilience is the key to cope with the complex risk landscape. There are different levels of innovations, some are with traditional knowledge, some with conventional knowledge and technologies and some with emerging knowledge system. [28] developed "30 innovations" in DRR with 14 products and 16 process innovation, which have changed the course of DRR over years. Each innovation was evaluated with six factors: (1) number of death/affected people, (2) reduction of economic losses, (3) cost of effectiveness, (4) level of application/penetration of innovation to the mass, (5) environmental friendliness and (6) behavioral changes. It was found that some innovations like GIS/remote sensing or drones have been used effectively for level of penetration/application, cost-effective as well as environmentally friendly, but not that effective to reduce the casualty. On the other hand, concrete/steel building materials were able to save many people lives but are not environmentally effective.

[29] has analyzed the Asian landscape of science and technology, which focused on understanding disaster risks, strengthening risk governance, investing in disaster resilience and enhancing preparedness for better response. These were the four priority areas in Sendai Framework. The book analyzed the progress in science and technology in four Sendai

frameworks. [30] have given different examples on emerging technologies in DRR. It also argued that while the technology domain evolves very fast, there needs to have proper governance mechanism to support the implementation of the technology.

There have been significant improvements in innovations in disaster and climate change. A few critical areas water, energy, sanitation and early warning system. WOTA, a start-up has invented an AI based water purification system which can be used for hand wash as well as for taking showers in the evacuation center. This has been used in 2018 West Japan Flood, and very recently in 2024 Noto Peninsula earthquake and tsunami. Similarly, there is another innovation on high powered battery storage system, which can be used for the emergency situation for more than 72 hours. This high energy storage device can be used in the public buildings, schools, hospitals etc. The other innovation is on emergency toilet, which is used in the emergency shelter, hospitals etc. Also, there are new innovations on water battery, which can be used for early warning system in different parts of Japan. All these innovations are used in different parts of Japan however the key issue is affordability and usability in wider communities in different countries worldwide.

Enhance participation and decision making through citizen science

Citizen science is considered as the active involvement of non-professional volunteers in scientific data collection, analysis, and dissemination—plays an increasingly important role in DRR. By engaging local communities directly, it enhances both the scope and the relevance of risk information while empowering people to participate meaningfully in building resilience. One of the most significant contributions of citizen science is in risk identification and monitoring. Communities often observe early signs of hazards such as unusual river behaviour, soil movement, or temperature changes. Through simple tools like mobile apps, SMS, or even manual observations, citizens can collect valuable real-time data that supports early warning systems and improves the spatial and temporal resolution of scientific assessments. Projects such as "Community-Based Flood Monitoring" or earthquake sensing using smartphones are examples of this democratization of science [30].

Citizen science also strengthens local ownership and trust in DRR initiatives. When people are involved in generating data, they are more likely to understand and act upon risk information. This leads to improved preparedness and response behaviour, especially in vulnerable communities where top-down communication may be limited. Furthermore, citizen science fosters inclusive and context-specific knowledge, blending scientific methods with indigenous and local understanding of hazards. It also helps identify localized vulnerabilities that may be overlooked by conventional assessments, such as specific needs of elderly, disabled, or socially marginalized groups.

Several attempts have been made for utilizing citizen science in DRR. One of the significant attempts was made in Varanasi, India where a citizen based app was made for reporting the inundation level of the floods in the city through augmented reality (AR) based device through smart phone, and uploading the photo with GPS location in the map. This was also used as an educational tool in the schools to enhance the awareness of the school children for flood risk reduction.

Promote concept of Phase Free: an innovative way to preparedness

The concept of "Phase-Free" in DRR represents an innovative approach that blurs the traditional boundary between normal life and emergency phases. It emphasizes designing everyday products, services, and systems that are equally functional in both daily life and during disasters. The goal is to make preparedness seamless, unobtrusive, and embedded in regular

routines, thereby reducing vulnerability without requiring constant attention to risk. Originating in Japan, the phase-free philosophy promotes dual-use design: products and infrastructure that serve regular purposes but become critical during emergencies. For example, a solar-powered lamp used in households daily can serve as an emergency light during blackouts. Similarly, furniture designed for comfort can also be earthquake-resistant. This approach helps normalize preparedness and ensures people are equipped without needing to store or remember special emergency gear.

In DRR, phase-free design enhances accessibility and inclusiveness, particularly for the elderly, persons with disabilities, and marginalized communities, who may struggle with traditional emergency systems. It also supports resilience through redundancy, ensuring essential functions continue even when systems are stressed. Phase-free thinking can be applied to urban planning, public spaces, transport systems, and consumer goods, making cities more disaster-resilient without large-scale investments. For instance, public benches that convert into emergency beds or vending machines that dispense free supplies during a crisis exemplify this approach.

Moreover, the phase-free concept fosters a culture of everyday resilience. It shifts the narrative from fear-based disaster preparedness to smart, design-integrated readiness. This approach is especially relevant in the context of increasing climate and disaster risks, where unexpected disruptions are becoming more common. By embedding resilience into daily life, Phase-Free strategies provide a practical, inclusive, and sustainable pathway for advancing DRR in both developed and developing contexts.

The Phase Free movement provides a tag to the products which follows the Phase Free principles, including shoes (which are normal shoes, can be used during disasters for long distance walking), bags (which are normal bags, but can be used as buckets for carrying water during disaster), pen (which is a normal pen, but can be used during disaster and can write on wet papers) etc. All these are very important examples for making products using phase free principles. This is also basic principle that if something is used in normal time, can be used during disaster. To bring this principle into daily preparedness is very important.

Promote equity based on gender, disability and other vulnerable groups

Promoting equity in disaster resilience means ensuring that all individuals, regardless of gender, disability, age, income, or social status, have equal access to information, resources, protection, and participation in DRR. Vulnerable groups often face disproportionate impacts during disasters due to systemic inequalities, limited access to services, and exclusion from decision-making processes. Addressing these disparities is essential for building truly inclusive and resilient societies.

Gender equity is critical in DRR because women and girls often face unique risks, such as limited mobility, caregiving responsibilities, and gender-based violence during and after disasters [31]. At the same time, women possess valuable local knowledge and leadership skills that can strengthen community resilience. Empowering women through leadership roles, education, and access to resources not only reduces vulnerability but enhances the overall effectiveness of DRR strategies. While women's vulnerabilities in climate discourse are increasingly documented, gender minorities, including transgender, non-binary, and intersex individuals remain largely invisible in mainstream policy frameworks across Asia-Pacific. The legal recognition of third gender identities in India, Nepal, and Pakistan offers some symbolic progress, yet this has not translated into protective measures during climate disasters. In India, transgender individuals displaced during floods or cyclones frequently face exclusion in shelters

due to lack of gender-neutral facilities, stigma from staff, or the absence of documentation that matches their gender identity.

Nepal, a regional pioneer in gender diversity, has recognised a third gender category in its citizenship laws and has included LGBTQIA+persons in its National Climate Change Policy 2019, yet ground-level implementation remains uneven. In contrast, Thailand and the Philippines possess vibrant queer movements, but queer individuals still lack institutional protection during disaster relief or climate migration. In the Pacific Islands, gender-diverse communities such as fa'afafine in Samoa or Tonga are socially acknowledged but seldom consulted in formal planning processes, particularly in conservative rural areas.

People with disabilities are often left out of emergency planning and evacuation procedures. Inclusive resilience requires adopting universal design principles, ensuring accessible infrastructure, and involving persons with disabilities in planning and drills. Disability-inclusive DRR must go beyond physical accessibility to include communication, service delivery, and social participation.

Other vulnerable groups**,** including children, the elderly, migrants, Indigenous communities, and low-income populations, also face intersecting risks. Equity-based approaches must be grounded in the principles of participation, protection, and empowerment, ensuring these groups are not seen as passive recipients of aid but as active agents in resilience-building. Policies must be informed by disaggregated data, community engagement, and intersectional analysis to identify specific vulnerabilities and capacities. International frameworks like the Sendai Framework for DRR emphasize the need for inclusive policies. By placing equity at the centre of resilience efforts, we can ensure that no one is left behind in the face of growing disaster and climate risks.

Implement immersive learning and education using technologies

The education and learning is the core of disaster and climate resilience. Through AR, extended reality and mixed reality, it is possible to provide immersive learning of the children and provide ownership of the process to the children. COVID-19 has made a significant change in the new realization of the DRR education [32].

Immersive learning, using technologies like virtual reality (VR), AR, and extended reality (XR) is transforming disaster risk education by making learning more engaging, experiential, and impactful [33]. Traditional methods such as lectures and manuals often fail to convey the urgency and complexity of disaster scenarios. Immersive learning addresses this gap by placing users in simulated environments where they can experience hazards like earthquakes, floods, or fires in real-time. This hands-on approach enhances risk awareness, decision-making skills, and emotional preparedness. For example, students using VR simulations of a tsunami evacuation are better able to understand spatial risk zones, evacuation routes, and the psychological pressure of emergencies. These simulations are also valuable for training first responders, planners, and community volunteers. Importantly, immersive learning promotes inclusive and accessible education. Visual and interactive formats can overcome language, literacy, and cognitive barriers, making disaster education more effective for children, elderly, and persons with disabilities. It also fosters empathy and social cohesion by allowing users to experience others' perspectives in a crisis. By combining technology with behavioral insights, immersive learning can foster a deeper understanding of disaster risks and encourage proactive behavior, ultimately contributing to more resilient individuals and communities. The new learning method is to empower the children with the VR/XR and engage them to foster the link to the adults, parents and communities. This new method of engaging children at the core of disaster education is found to

be the most effective process.

Foster youth innovation and entrepreneurship

Engaging youth in disaster and climate resilience is critical for building future-ready, adaptive communities. Young people bring creativity, digital fluency, and a fresh perspective that can drive innovative solutions to complex risks. By fostering youth entrepreneurship, we not only empower the next generation but also accelerate the development of scalable, community-based innovations that strengthen resilience. Youth can contribute to a wide range of resilience-building initiatives, designing mobile apps for early warning systems, creating low-cost water filtration solutions, or launching social enterprises that promote climate-smart agriculture. Providing platforms such as innovation labs, hackathons, and incubation centres can help translate ideas into viable solutions. Mentorship, funding opportunities, and integration into policy dialogues are essential to move from awareness to action. Embedding disaster and climate education in school curricula and vocational training also equips youth with the knowledge and skills needed for leadership in risk reduction. Importantly, fostering youth innovation ensures intergenerational equity in resilience strategies. When young people are engaged as solution-creators rather than passive recipients, they drive social change, promote peer-to-peer learning, and help build inclusive, technology-enabled, and sustainable resilience pathways for the future. Investing in youth is, ultimately, investing in long-term resilience. Social innovation is critical to youth innovation and entrepreneurship [34].

[35] has provided excellent examples of co-producing knowledge innovation system through establishment of thematic incubators in different academic institutions, which needs to be linked to private sector to foster innovations. Several of these incubators were established in India in different Indian universities. [36] also provided examples of social innovation hackathon in the universities to drive innovation in DRR and climate change adaptation.

Postscript

As mentioned in the initial part of the paper that the global risk landscape is becoming complex, and there are several interconnected risks and therefore systemic approach of risk reduction become essential. Also, new risks emerge every year and therefore, adaptive governance is important to address the new emerging risks. However, in longer term perspective, the environmental risks remain at the top of the risks, and these issues need to be addressed in an integrated way. This paper argues traditional approaches of risk reduction is no more an option, and we need more proactive, inter-connected, trans-disciplinary approach in risk reduction and resilience building. The paper also shows ten specific pathways for enhancing resilience. Of course, these are not the only ten pathways, and there are possibly many more. There will be new future pathways, frameworks and operational principles in future too. However, these ten key points can be considered as core of DRR principles in the current state of knowledge.

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