Fostering resilience requires partnerships among scientists, practitioners, policymakers, boundary organizations, and communities

The hazards facing the world today – pandemics, climate change, environmental degradation – are inextricably linked to each other and to human and natural systems and actions. To counter, adapt, and thrive in the face of these global challenges requires research and solutions that account for these linkages and focus on the most impacted geographic communities.

The Resilience Challenge

Humans are inextricably connected to each other and to the natural environment. Because of these deep connections, natural hazards and human activities can over-stress systems, such as those related to water and food supply, waste management, and emergency services, among others. When multiple incidents strike at the same time, the hazards and resulting effects can be compounded.

Resilience[i] is the ability of systems and their parts — including people — to anticipate, respond, recover, and adapt when a disruption occurs. Improving resilience involves understanding and addressing issues of both *vulnerability*[ii] and *exposure* to such disruptions. Patterns of vulnerability and exposure reflect systemic inequalities distributed according to intersections of race, ethnicity, gender, class (or "socioeconomic status"), and ability.

Society's resilience will continue to be challenged as climate change, population growth, human migration, and land cover and land use change[iii] exacerbate the magnitude, frequency, and impacts of events such as hurricanes, extreme storms, floods, droughts, extreme heat waves, wildfires, sea level rise and disease[iv]. Disruptions are already becoming more complex in their short- and long-term environmental, social, and economic impacts.

The Path Forward

For the scientific community

- ***Pursue convergent science:***[v] Effective resilience research requires collaborations and training across geographic boundaries and among the natural and social sciences, engineering, humanities, and design fields. Modernized funding mechanisms, educational programs and institutional reward systems must incentivize and reward these collaborations.
- ***Leverage participatory research:*** Resilience strategies and investments that meet community priorities and are thus adopted by local and regional decision makers[vi] require projects to be co-developed with geographic communities and boundary organizations[vii], preferably based on sustained and mutually beneficial partnerships, especially with historically marginalized communities and Indigenous knowledge holders.

For policymakers and other stakeholders:

- ***Prioritize communities with high vulnerability:*** Resilience policies and programs that address the priorities of those experiencing the greatest vulnerability and threats posed by multiple hazards rather than single hazard events will most effectively improve disaster mitigation, preparedness, response, and recovery.
- ***Quantify the benefits of resilience planning:*** Investments in resilience planning are needed for both financial and structural benefits (e.g., the mitigation of dollars lost and buildings damaged), and social and environmental benefits (e.g., improved individual and community health and well-being, ecosystem restoration, and the economy).
- ***Connect risk management and adaptation to climate change:*** Building resilience and recovering from disasters requires adaptation to the effects of climate change that are already impacting systems and communities. It is vital to prioritize and connect nature-based solutions, sustainable development practices, ecosystem restoration and resource conservation across all sectors to realize the co-benefits of these practices.[viii]

For all stakeholders:

- ***Maintain effective communication:*** Effective communication requires time and resources for multi-directional listening and dialogue, and timely, culturally appropriate language and actions. Research results must be accessible to decision makers, society, and scientists, and policy decisions must be informed by and designed to be understood by all those impacted. Boundary organizations have a role in ensuring meaningful dialogue.
- ***Revamp funding opportunities to invest in both communities and scientists:*** Continued investments in training, scientific monitoring, and modeling as well as institutional incentives and rewards are necessary to advance resilience. Support for both communities and scientists can help ensure collaborations are inclusive and reduce barriers to participation and implementation.

Conclusion

Building resilience requires partnerships among scientists, policymakers, practitioners, boundary organizations, and geographic communities, among others. Research, policies, and funding opportunities must recognize the interconnected nature of social, technological, and environmental systems, prioritize vulnerable communities, reduce exposure and account for the complexity of current and future hazards.

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[i] This definition of resilience is modified from The World Bank Group's 2013 report on Building Resilience: Integrating Climate and Disaster Risk into Development, which drew on definitions from the Intergovernmental Panel on Climate Change (IPCC) 2012 report and UNISDR.

[ii] The definitions of exposure and vulnerability are modified from The World Bank Group's 2013 report on Building Resilience: Integrating Climate and Disaster Risk into Development, which drew on definitions from the Intergovernmental Panel on Climate Change (IPCC) 2012 report and UNISDR.-Vulnerability encompasses social issues (systemic inequalities in the distribution of resources, status, and risk) and physical ones (the fragility of systems and structures). Exposure refers to people's presence in harm's way, as well as that of the social, technological, and environmental systems in which they live and work

[iii] For example, deforestation contributes (~20%) to CO_2 emissions associated with global warming from climate change, while reducing the evapotranspirative cooling of the atmosphere.

[iv] For more information, see the AGU Position Statement on Climate Change.

[v] Convergent science is defined as "the integration of knowledge and ways of thinking from multiple fields to tackle complex challenges and achieve new and innovative solutions." (National Research Council. 2014. *Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond*. Washington, DC: The National Academies Press. https://doi.org/10.17226/18722.)

[vi] An example of community science is the AGU Thriving Earth Exchange, Thriving Earth Exchange.

[vii] For example, see Gustavson and Lidskog, 2018. Boundary organizations and environmental governance: Performance, institutional design, and conceptual development - ScienceDirect.

[viii] For example, see the UN Sustainable Development Goals, https://sdgs.un.org/goals.