Learning Lessons

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Making Infrastructure Disaster-Resilient

Hazards of nature—floods, earthquakes, typhoons, and climate change—pose growing risks to development. When infrastructure fails during a natural disaster, it can interrupt vital services, magnifying the need for well-functioning systems beforehand (Chang 2009). For example, power failures may disrupt water supply and transport during typhoons. Damaged roads after a strong earthquake can hamper the swift transport of people to safer areas, provision of life-saving medicines and supplies to hospitals, and timely distribution of emergency relief (Intergovernmental Panel on Climate Change [IPCC] 2012).

Making infrastructure resilient to natural disasters is a daunting challenge, not least because of the vast area of coverage that includes transport, electricity, water supply and sanitation, and buildings and other structures. Resilience refers to a system's ability to anticipate, absorb, and recover from a hazardous event in a timely and efficient manner (IPCC 2012).

For development practitioners, the discourse on resilience is increasingly framing sustainable futures in the context of natural disasters and climate change. The issue has developed as a fusion of ideas from several bodies of literature— engineering, ecosystem stability, behavioral sciences, disaster risk reduction, vulnerabilities to hazards, and urban and regional development.

Consequently, resilience spans a spectrum of disciplines and goes beyond the emphasis of conventional engineering systems on the capacity to control and absorb external shocks. This paper offers evaluative lessons for making infrastructure disaster-resilient based mainly on the experience of countries in Asia and the Pacific. It also shares practices associated with the multifaceted dimensions of resilience by drawing on publications from international and national organizations.

Lessons in Taking Action

Making infrastructure disaster-resilient encompasses structural and nonstructural measures. Structural ones include flood control systems, protective embankments, seawall rehabilitation, and retrofitting of buildings. Nonstructural measures refer to risk-sensitive planning, hazard mapping, ecosystem-based management, and disaster risk financing.

Structural Measures

Actions taken in the aftermath of disasters have major impacts on processes that follow, and need to be planned and implemented accordingly. During reconstruction, the sensitivity of governments and the affected population to disaster risks is at its highest (Global Facility for Disaster Reduction and Recovery [GFDRR] and World Bank 2012). This provides a valuable opportunity for incorporating disaster-resistant features into infrastructure. Choices made immediately following a disaster—on roads and the restoration of critical services, among other things—affect subsequent choices for longer-term solutions.

In Nepal, the School Earthquake Safety Program (1997–2001) evolved from a simple school retrofit to a comprehensive program of earthquake safety involving the entire community (Asian Disaster Preparedness Center [ADPC] 2003). Builders received on-the-job training in earthquake-resistant design and retrofitting. The training convinced them of the benefits and affordability of earthquake-resistant buildings—and this had an important multiplier effect: the builders then convinced homeowners to construct earthquake-resistant houses. In several countries, better standards for construction helped in enabling stronger resistance to natural disasters (Thomas and Luo 2012). In Turkey and Colombia, earthquake-resistant building codes, enforced construction standards, and oversight of materials procurement practices paid off. In Sri Lanka, the Tsunami Emergency Recovery Program not only enabled homeowners and artisans to meet housing reconstruction targets with higher quality, but also strengthened the local construction industry by assuring a relatively steady supply of additional skilled labor.

Adjusting engineering designs and standards to reflect disaster risk is crucial to infrastructure resilience. Public infrastructure, such as schools, roads, and hospitals, is often built according to standard design templates (ADB 2013). These can be adjusted to reflect site-specific considerations, including the local hazard environment, to increase their resilience to disasters. Post-disaster construction can also consider upgrading the infrastructure rather than merely restoring it to pre-disaster levels (Independent Evaluation Department [IED] 2006). Here are some examples:

Housing. In Armenia, temporary shelters were built to slightly higher standards after the 1984 earthquake so that they could later be used as housing for the poor. Shelters built using disaster-resistant construction techniques are not only safer, but they also provided decision-makers with an option for future construction choices.

In India, the Maharashtra Emergency Earthquake Project promoted simple earthquake-resistant features based on building regulations that villagers could understand and apply. In informal settlements, which typically do not comply with building codes, safer building practices need to be disseminated in easily understood ways (Independent Evaluation Group [IEG] 2006).

In flood-prone areas, raising houses above flood levels—by putting them on pillars or using higher foundations, for example—can reduce the vulnerability of residents. In Bangladesh, a post-flood housing reconstruction project introduced capping of traditional earth plinths with cement-stabilized soil, which proved effective in subsequent floods (Department for International Development and Practical Action Bangladesh 2010). Bangladesh has also built multi-storied cyclone shelters in coastal regions, providing refuge from storm surges for coastal inhabitants (IPCC 2012). In Southern India after the 2004 tsunami, World Vision built tsunami extendable houses with earthquake-resistant structural cores that allowed building another floor without compromising the strength of the structure (Ahmed 2011).

Schools. In Nepal's Kathmandu Valley, retrofitting a typical "brick in mud mortar" school was done at about half the cost of demolishing and building similar-sized schools (ADPC 2003). Even so, buildings with weak materials tend to benefit less from retrofitting than newer buildings constructed with good materials.

Roads. In Timor-Leste, measures to reduce the risk to roads of erosion from extreme waves included constructing earth levee banks with rip-rap protection and installing larger drains and additional culverts to accommodate heavier runoff (Asian Development Bank [ADB] 2010b).

Energy. Engineering measures to improve resilience include more robust designs, safe temperature and humidity limits for power generation plants and their components, higher wind and seismic stresses, multiple transmission routes, and system improvements to improve supply-side efficiency. In Ho Chi Minh City, retrofitting high-risk power infrastructure was identified as a means of protecting against storms, flooding, and increased temperature and salinity (ADB 2012).

Water Supply and Sanitation. In Bangladesh, access to hygienic water and sanitation facilities is vital for helping communities cope with disasters. Providing elevated tube-wells and flood-proof latrines has ensured year-round safe water and hygienic sanitation in the flood-prone districts of Bogra, Gaibandha and Sirajganj (Department for International Development and Practical Action Bangladesh 2010). Where impounding reservoirs exist, as in Khulna, Bangladesh, increasing the size of the impounding reservoir or relocating the water intake point further upstream was a measure to boost the resilience of the water-supply system (ADB 2011).

Dikes. In Japan, dikes are necessary for protection against ordinary tsunamis. The 2011 tsunami, however, exceeded expectations, leading to the collapse of 190 of 300 kilometers of dikes in the Tohoku region. Nonetheless, these dikes decreased the force of the tsunami and, in some areas, delayed its arrival inland. Japan is now placing heavier emphasis on designing and managing systems that mitigate damage to the greatest extent possible including prevention of overflow of Tokyo's major waterways and rivers during disasters (GFDRR and World Bank 2012). Preparing for the unexpected is an important realization.

Highly vulnerable groups need special consideration in reducing disaster risk. In terms of social vulnerability, this includes the very young and old, the disabled, and ethnic minorities (United Nations International Strategy for Disaster Reduction [UNISDR] 2012). Explicit recognition of gender-related issues in natural disasters is also essential. In major disasters in Asia, the death toll for women is often substantially more than for men, because women have less control over key survival and recovery resources, including shelter and transport. Women comprised 91% of Cyclone Gorky victims in Bangladesh in 1991 and 67% of the tsunami victims in Banda Aceh, Indonesia in 2004.

The Metropolitan Area Outer Underground Discharge Channel, also known as the G-Cans Project, is an underground water infrastructure project in Kasukabe, Saitama, Japan. It is the world's largest underground flood water diversion facility, built for preventing overflow of the city's major waterways and rivers during rain and typhoon seasons. Photo credits: Adapted from the Wikimedia Commons: http://commons.wikimedia.org/wiki/File:Kasukabe2006_06_07.JPG by Dddeco

School children and youth are also more vulnerable to disaster when their schools have not been built to resist natural hazards. Schools are sometimes built on less valuable land that is often susceptible to flooding, earthquakes, or landslides. This helps explain why 10,000 schools collapsed during the 2005 Kashmir earthquake, killing 17,000 students and seriously injuring 50,000 (ADB 2010a).

The challenge is to rebuild stronger by retrofitting existing structures or by putting up new ones that can better withstand natural hazards. Moreover, facilities that are essential for an effective disaster response need to be connected with networks that will not fail them so that the injured and the disabled can have access to immediate medical attention. Hospitals, for example, must be sited and built for disaster-resilience, assured of uninterrupted power supply, have a network of secure access routes, and safe water and sanitation.

Nonstructural Measures

Planning ahead for disasters and investing in resilience to reduce vulnerability to multiple hazards requires resolve. Irregular consideration of risks in disaster-prone countries has sometimes led to the construction of infrastructure that is insufficiently resilient to disasters. The increasing frequency of natural disasters with large human and economic losses calls for recognizing disaster risks (IED 2012) and concerted action to strengthen resilience. This needs to be implemented within an integrated disaster risk management framework that combines climate change adaptation, disaster risk reduction, disaster preparedness, post-disaster relief, early recovery, reconstruction, and disaster risk financing goals (ADB 2013).

Investments in resilience will be far-reaching if they are integrated into development policies, strategies, plans, and assistance programs. Although certain recurrent disasters are foreseeable for many countries, they are not always considered in country strategies and lending programs. Disaster risk assessment and hazard mapping provide an initial step to informing investment decisions. Risk reduction, in addition, must have a central role in the sustainable development strategy of disaster-prone countries (IEG 2011).

Enabling institutional frameworks and sustained commitment are pivotal to resilience. Institutional frameworks—policy, legal, and regulatory—and sustained commitment are essential to ensure direction, coordination, and accountability in resilience efforts, and must translate into actual resource allocations. The Indian State of Maharashtra totally revamped its disaster risk management policies after the devastating Latur earthquake in 1993, drawing on both international and local expertise in designing improved administrative legislation and building standards (UNISDR 2004). Indeed, various Indian state governments have revised disaster policies and adopted more comprehensive disaster risk management, in keeping with good governance practices.

Effective action requires strong partnerships among governments, development partners, the private sector, civil society, and local communities. Stakeholders, nonetheless, must be aware that the political economy can present risks or opportunities. These include awareness of how certain players are using their position to strengthen their political or economic interests. Well-placed, high-level political champions are crucial to gaining broad commitment to resilience. Their influence, however, may not always be permanent (Williams 2011). Demands for greater resilience are reinforced when coalitions of academic institutions, scientific bodies, the media, and advocacy organizations push strongly for it.

Ecosystem-based disaster risk management complements engineering measures to make infrastructure disaster-resilient. Healthy ecosystems provide natural barriers and buffers against many hazards. Mangroves, for example, dissipate the energy and size of waves during storms, reducing loss of life and property. When typhoon Wukong struck Viet Nam in 2000, mangrove-buffered areas remained relatively unharmed, while the investment of $1.1 million to rehabilitate and protect 12,000 hectares of mangroves has saved about $7.3 million a year in sea-dyke maintenance (Reid 2011). In Timor-Leste, re-vegetation and reforestation of unstable slopes has helped reduce soil erosion and contributed to road stability (ADB 2010b). In Hubei Province in the People's Republic of China, a wetland restoration program reconnected lakes to the Yangtze River and rehabilitated wetlands to store floodwaters, boosting flood prevention (UNISDR 2012).

Investments in infrastructure are compromised by failure to fund and carry out maintenance. Governments in developing countries tend to borrow to rebuild but, quite often, make inadequate provision for maintenance, which is essential for long-term sustainability. Budget constraints and a lack of "maintenance culture" within institutions partly explain this (IED 1997). The Flood Damage Restoration Project in Pakistan demonstrated that adequate maintenance and sound asset management to reduce risks from subsequent disasters should complement facility restoration (IED 1996). Levels of past maintenance, the state of repair of facilities, and vulnerability to disasters are all linked (IED 2007).

Adequate maintenance is also crucial for schools and other community facilities that double as evacuation centers during disasters.

Maintenance funding for infrastructure could be increased by raising budget appropriations for this purpose, by setting aside a portion of development partner support for subsequent maintenance purposes or, where appropriate, by drawing on user fees, tariffs, and other mechanisms (ADB 2013).

Disaster risk financing can help reduce liquidity gaps that hamper the capacity of governments, households, and businesses to recover from disasters. Financial protection strategies include programs to increase state capacity for responding to emergencies. These can also help deepen insurance markets at sovereign and household levels. Developing countries in Asia and the Pacific, however, have generally lagged behind other regions in disaster risk financing and in developing regulatory support to enable stable and solvent risk transfer markets to serve governments, businesses, and homeowners.

In the Caribbean region, a regional catastrophe risk insurance facility has provided short-term liquidity to governments to better respond to emergency needs arising from severe hurricanes and earthquakes. In Mexico, a state fund for natural disasters has demonstrated that reinsurance and catastrophe bonds can be combined with sound budgetary practices to provide support to federal and state governments affected by natural disasters (ADB 2013).

Conclusion

Making infrastructure resilient calls for engineering and non-engineering measures that take into account the links between built and natural environments and among institutional frameworks. Careful consideration of development goals, prevailing situations, resources, and opportunities is needed to push the resilience agenda forward. Given the multifaceted dimensions of resilience, coordinated action from various sectors and stakeholders is imperative for achieving a safer future.

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