GUIDANCE ON

Critical Facilities

Tsunami Global Lessons Learned Project

DISASTER RECOVERY TOOLKIT

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1) Handbook for Disaster Recovery Practitioners
2) Training Manual – Learning Workshop on Recovery and Reconstruction
3) Guidance on Critical Facilities
4) Guidance on Housing
5) Guidance on Land Use Planning
6) Guidance on Livelihood

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FOREWORD

Ten years have passed since the Indian Ocean Earthquake and Tsunami of December 2004. The consequences of this disaster have continued to unfold in the minds of individuals, the collective lives of affected families and communities, and within the framework of nations and the region as a whole. Indeed, the memory of this great tragedy is imprinted on the global mind. The loved ones of the more than 228, 000 people who perished look back on this disaster every day. For the rest of us, the 10th anniversary provides an opportunity to reflect on the memory of these departed souls, and to think of those who were left behind in devastated families, communities and environments.

The recovery of the affected areas in the months and years since the event itself is an affirmation of human resilience and creativity in building solutions- and finding ways out- of the most challenging situations. It is out of respect to those who perished or suffered that we should take what lessons we can from such experiences, and use them to design better strategies for disaster response and recovery in the future. With climate change proceeding apace, the notion of environmental vulnerability is becoming increasingly broad and hard to pinpoint: everybody is vulnerable, and because of this, our incentive to learn from what came before should be heightened.

The Tsunami Global Lessons Learned Project (TGLLP) was created with a view to gathering, learning from and sharing experiences relating to the 2004 earthquake and tsunami, and other disasters in the region that occurred between 1993 and 2013. The project sought to deliver three principle outcomes: a global lessons learned study, a Discovery Channel documentary tracking the recovery, and a disaster recovery toolkit for recovery practitioners.

The first of these outcomes was a report entitled *The Tsunami Legacy: Innovations, Breakthroughs and Challenges* which was officially released on 24 April 2009 at a ceremony at the United Nations Headquarters in New York. A few months later, in December 2009, a documentary on lessons learned, produced independently, was aired on the Discovery Channel.

At the launch of *The Tsunami Legacy* in 2009, an announcement was made regarding the development of a suite of handbook and guidance notes targeted specifically at recovery programme leaders and practitioners. The Disaster Recovery Toolkit forms the third deliverable, and it is this that has been developed by the Tsunami Global Lessons Learned Project Steering Committee (TGLLP-SC) in partnership with the Asian Disaster Preparedness Centre (ADPC). The 'Toolkit' is targeted at practitioners responsible for implementing recovery programmes, its objective to provide a 'how to' guide on development, implementing and managing complex post-disaster recovery programmes.

This document, *Guidance on Critical Facilities*, has been framed as a reference document to provide strategic guidance on incorporating DRR measures in critical infrastructures during the post-disaster phase. It also aims to accompany and enrich the handbook and the learning workshop module with key considerations on 'why and how' to bring DRR in recovery and reconstruction of critical facilities.

Introducing this guidance, the TGLLP Steering Committee hopes it will enhance the capacities of government agencies, especially central level agencies engaged in policy and strategy formulation for critical facilities in recovery and reconstruction and supporting local level agencies. The Steering Committee also hopes that the guidance will serve as a reference tool for development partners who work alongside the above agencies in land use planning in recovery and reconstruction.

- Steering Committee of The Tsunami Global Lessons Learned Project

CONTENT

ABBREVIATIONS

AADMER	ASEAN Agreement on Disaster Management and Emergency Response
ADRM	Aceh Disaster Risk Map
ARTF	Afghan Reconstruction Trust Fund
ASEAN	Association of Southeast Asian Nations
BMTPC	Building Materials Technology Promotion Council
BRR NAD-Nias	Badan Rehabilitasi dan Rekonstruksi NAD-Nias (Indonesia) *(Agency for the Rehabilitation and Reconstruction of Aceh and Nias)*
CBA	Community Based-Assessment / Communication-based Assessment
CBO	Community-based Organization
CCA	Climate Change Adaptation
CFAN	Coordination Forum for Aceh and Nias
CSO	Civil Society Organization
CZMA	CZM Authority
DAD	Development Assistance Database
DALA	Damage and Loss Assessment
DRMS	Disaster Risk Management Strategy
DRR	Disaster Risk Reduction
DRR-A	"Making Aceh Safer Through Disaster Risk Reduction in Development"
ECHO	European Commission for Humanitarian Aid and Civil Protection
EIA	Environmental Impact Assessment
ERRA	Earthquake Reconstruction & Rehabilitation Authority (Pakistan)
GFDRR	Global Facility for Disaster Reduction and Recovery
GIS	Geographic Information System
GoTN	Government of Tamil Nadu'
GPS	Global Positioning System
GSDMA	Gujarat State Disaster Management Authority (India)
HRNA	Human Recovery Needs Assessment
IASC	Inter-Agency Standing Committee
ICT	Information and Communication Technologies
IRP	International Recovery Platform
KPI	Key Performance Indicator
LIFT	Livelihoods and Food Security Trust Fund
MDF	Multi Donor Fund for Aceh and Nias
MDTF	Multi-Donor Trust Fund

M&E	Monitoring and Evaluation
MHJ	Ministry of Health
MoU	Memorandum of Understanding
MPTF	Multi-Partner Trust Fund
NCRC	NGO Coordination and Resource Centre (Nagapattinam, India)
NDRF	National Disaster Response Force (India)
NDRF	National Disaster Response Framework (USA)
NWFP	North-Western Frontier Province
OCHA	Office for the Coordination of Humanitarian Affairs
ODA	Official Development Assistance
OSD	Officer of Special Duty
OSDMA	Orissa State Disaster Mitigation Authority
PAK	Pakistan-Administered Kashmir
PDNA	Post Disaster Needs Assessments
PHC	Primary Health Centre (India)
PONJA	Post-Nargis Joint Assessment
PONREPP	Post-Nargis Recovery and Emergency Preparedness Plan
PR	Periodic Review
RADA	Reconstruction and Development Agency (Sri Lanka)
RAN	Recovery Aceh-Nias Database (Indonesia)
RIAS	Recovery Information and Accountability System
R&R	Recovery and Reconstruction
SAARC	SAARC South Asian Association of Regional Cooperation
SIFFS	South Indian Federation of Fishermen Societies
SIM	Social Impact Monitoring
SLF	SL framework or SLA framework (according to IFAD)
SNEHA	Social Need Education and Human Awareness
TCCC	The Coca-Cola Company
TCG	Tripartite Core Group
TGLL	Tsunami Global Lessons Learned
TGLLP	TGLL Project (UNDP publications never wrote TGLLP)
TGLLP-SC	TGLL Project Steering Committee
TRIAMS	Tsunami Recovery Impact Assessment and Monitoring System
UN ECHA	United Nations Executive Committee for Humanitarian Affairs
UNF	United Nations Foundation
UNISDR	United Nations International Strategy for Disaster Reduction
UNORC	United Nations Office of the Recovery Coordinator for Aceh and Nias
USD	United States Dollar
VTC	Volunteer Technology Community


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INTRODUCTION

1 BACKGROUND

The world has witnessed some of history's worst disasters in the recent past, including the 2011 East Japan earthquake and tsunami, the 2010 Haiti earthquake, the 2008 Sichuan earthquake, Cyclone Nargis of 2008, the 2004 Indian Ocean tsunami, the 2005 Pakistan earthquake, the 2003 Bam earthquake, the 2001 Gujarat earthquake and the 1999 Orissa Super Cyclone. Unplanned urban growth, increased exposure of populations in vulnerable areas and climate change are reconfiguring risks. Thus, over the past few decades, there has been an increase in the rate of disaster events. These disasters claimed precious lives and destroyed developments gained the previous years etc or even centuries.

These developmental gains included critical facilities such as hospitals, fire stations, blood banks, power stations and transport networks. The disruption of critical facilities has multiple implications, especially as these facilities are of utmost importance for affected countries and populations in the aftermath of disaster. Relief and recovery responses are highly dependent on these facilities. For example, during the 2001 Gujarat, India earthquake, the Bhuj and many other hospitals were damaged, which not only led to more deaths but also impacted response capacities.

Furthermore the absence and disruption of critical facilities can even lead to secondary disasters; for example, the 2011 East Japan earthquake and tsunami led to the secondary disaster of nuclear leakage.

In this context, the disaster resilience of critical facilities is of high importance. Recovery and reconstruction programmes often involve reconstruction of critical facilities, which provides an opportunity to build back better and safer. This chapter looks at how to take advantage of this opportunity.

2 PURPOSE OF THIS GUIDANCE

This guidance is framed as a reference tool for incorporating DRR measures into the recovery and reconstruction of critical facilities. It draws upon some valuable lessons from previous recovery and reconstruction efforts, in particular from the 2004 Indian Ocean tsunami. It emphasises the need for adopting a participatory and flexible approach to support affected people, ensure a smooth recovery process and support long-term development and resiliency.

3 STRUCTURE OF THE GUIDANCE

This guidance on DRR considerations in recovery and reconstruction of critical facilities aims to:

- Discuss critical facilities and their importance, identify factors contributing to critical facilities vulnerability, discuss current practices in post-disaster recovery and reconstruction of critical facilities.
- Give a rationale for integrating DRR in recovery and reconstruction strategies of critical facilities.
- Offer key considerations for integrating DRR in recovery and reconstruction of critical facilities to support the overall objective of 'Build Back Better'.

4 TARGET AUDIENCE

The guidance serves as a reference guide to a wide variety of stakeholders, including government agencies and development partners. However, it is primarily targeted at central level government agencies engaged in recovery and reconstruction policy and strategy formulation, as well as supporting local level agencies undertaking recovery and reconstruction of critical facilities. In addition, it serves as a reference tool for development partners who work alongside the above agencies in supporting the overall recovery and reconstruction of critical facilities.


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CRITICAL FACILITIES

The concept of critical facilities and infrastructure is continuously evolving, with no common definition existing for either term. The table on the following page lists critical infrastructure, facilities and key assets according to the U.S. government. However, the list of critical facilities may vary from country to country and between communities according to availability and needs. For example, educational facilities (schools) are not listed in the table on the next page, although in many communities in Asia and other developing regions, educational facilities are key assets that house hundreds of children for schooling as well as act as evacuation shelters during emergencies.

Critical infrastructures can encompass a vast array of engineered systems, assets and facilities which are essential for day-to-day functions, as well as continued economic and societal function in the aftermath of a disaster event.

This guidance focuses on critical facilities for water supply, food supply, public health, telecommunications, emergency services, government facilities, evacuation, energy, banking and finance, all of which are essential for the functioning of a society.

CRITICAL INFRASTRUCTURE AND KEY ASSETS

Infrastructure
Agriculture and Food
Water
Public Health
Emergency Services
Defense Industrial Base
Telecommunications
Energy
Transportation
Banking and Finance
Chemicals and Hazardous Materials
Postal and Shipping

Assets
National Monuments and Icons
Nuclear Power Plants
Dams
Government Facilities
Commercial Key Assets

SOURCE: White House, 2003

1 IMPACT OF DISASTERS ON CRITICAL FACILITIES

Critical facilities and their services play an important role in the socio-economic development of communities. With increasing dependence on modern-day provisions like electricity, water supply, and telecommunication services, people become more vulnerable in case these services are destroyed by natural hazards. The box on the next page shows the impact of recent disasters on critical facilities and infrastructure in Asia.

THE IMPACTS OF DISASTERS ON CRITICAL FACILITIES AND INFRASTRUCTURE IN THE ASIAN REGION

The 2001 Gujarat earthquake in India caused widespread damage to health and education infrastructure, with two district hospitals and more than 1,200 health clinics (mostly in rural areas), and 11,600 schools destroyed or damaged. There was similar destruction of both rural and urban water supply schemes. Other infrastructure services such as electricity and telecommunications were extensively damaged.[i]

In Aceh, Indonesia, the 2004 Indian Ocean tsunami destroyed 3,415 schools, 517 health facilities, 669 government buildings, 22 ports, and 8 airstrips/airports.

The 2005 Kashmir earthquake in Pakistan caused widespread damage. In the water and sanitation sectors, more than 4,000 public and community-owned drinking water supply systems and 25 kilometers of sewage systems, drains, solid waste management systems and street pavements were partially or totally damaged. More than 10,000 school buildings collapsed.

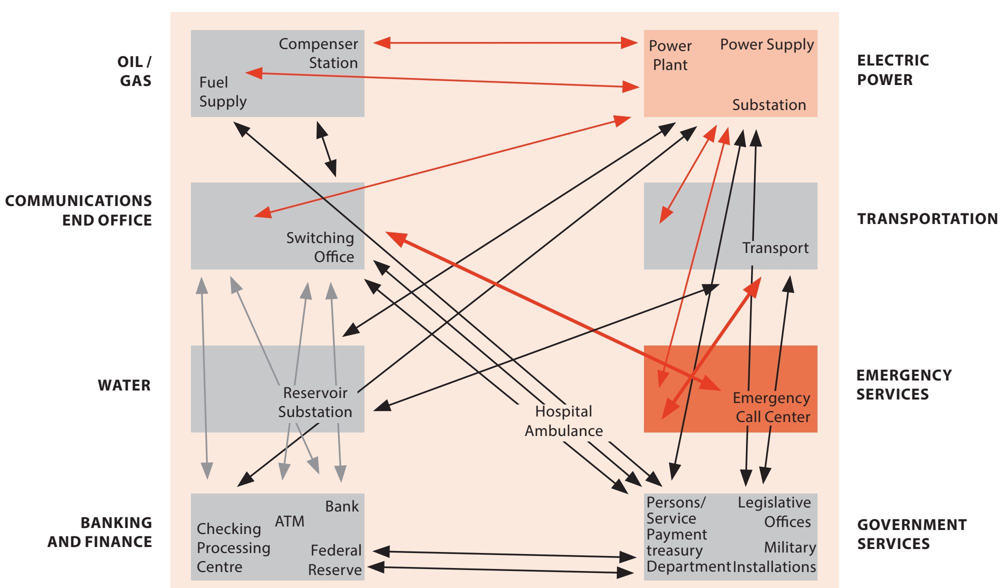
During the 2006 Yogyakarta earthquake in Indonesia, educational facilities, considered some of the best in the country, were seriously affected with more than 3,000 buildings, partially or totally losing their function for extended periods (including schools and university buildings). Healthcare facilities were also hit hard, resulting in the closure of 17 hospitals in Yogyakarta city alone. The estimated damage to government structures and public administration buildings was about USD15 million.

The direct economic loss of damaged infrastructure after the 2008 Sichuan earthquake in China was estimated at CNY 1.94 million (USD 279.9 million). Damage to transportation facilities (including railway lines) alone cost some CNY 712.3 million (USD 102.6). Another CNY 499 million (USD 71.89 million) went toward water supply and power generating facilities. The loss of education facilities was estimated at CNY 278.7 million (USD 40.15 million), with 7,000 classrooms destroyed.

The 2011 Japan earthquake and tsunami caused extensive and severe structural damage to roads and railways. One dam collapsed and homes were flooded or washed away. Around 4.4 million households were left without electricity and 1.5 million were without water. Several oil, gas and coal production plants had to halt operations because of damage. Many electrical generators were taken down, and at least three nuclear reactors suffered explosions when their cooling systems failed. Although internet services were largely intact, cellular and landline phone services suffered major disruptions.

While critical facilities are generally designed and built as standalone facilities for specific purposes, their ability to function depends on other facilities. Impacts of natural hazards on critical facilities can be far reaching, beyond mere direct and immediate damages, but including damages to other dependent or interdependent facilities, creating second- and third-order cascading effects in areas not directly exposed to the hazard.[ii] For example, the interdependent relationship of water supply or health facilities with power grids can have broad impacts over a geographic region.[iii]
Similarly, the disruption of a transportation network can lead to an increase in the price of commodities in disrupted geographic areas, while prices may fall in production.

SCHEME SHOWING INTERCONNECTED INFRASTRUCTURES AND THEIR QUALITATIVE DEPENDENCIES AND INTERDEPENDENCIES[IV]



2 VULNERABILITY OF CRITICAL FACILITIES

Generally, there are certain key factors that can contribute to the vulnerability of critical facilities (for both structural and nonstructural elements) to natural hazards. The following section highlights these key factors. As critical facilities are numerous, the following section highlights common and general vulnerability issues.

LOCATION

Development is a sign of progress but unplanned or poorly planned development can lead to the loss of valuable investments. Location is one crucial factor that determines exposure and vulnerability to hazards and can threaten the safety, serviceability, and longevity of critical facilities. Conventionally, facilities are built to be as close as possible to human settlements. Facilities need highly functional and well-connected public transportation systems to carry supplies and other resources. It is convenient and economical to have them in close proximity, but at the same time it must be understood that proximity also creates greater vulnerabilities to disaster, which could trigger a cascading impact on the operations of all facilities.

Since the majority of critical facilities are owned and operated by the government, although with increasing participation of the private sector, the site selection process often focuses on available government-owned land to reduce acquisition costs and minimise resettlement. With no proper land use plan, risk assessments, and/or environmental assessments prior to construction, facilities are likely to be subject to various natural and man-made shocks and can themselves constitute new forms of risk. For example, structures constructed over landfills (reclaimed area) or along steep slopes and roads constructed over flood plains, can reconfigure the hazard itself. Risk creation is primarily due to a lack of understanding or knowledge of the link between environmental and DRR issues and long-term development. The priority of risk and environmental assessments is often low *(for more information, please refer to the Guidance on Land Use Planning).*

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Many utility-based facilities such as electricity, water and gas supply plants tend to be located in close proximity to one another due to their operational inter-connectivity, which can compound risk.

Inappropriate or inadequate design also increases facilities' susceptibility to natural hazards, as discussed in the following section.

STRUCTURAL VULNERABILITY

While it is not possible to construct critical infrastructure that is entirely resistant to hazards (especially considering socio-economic planning requirements), susceptibility to hazards is shaped by the planning, design, and construction practices and enforcement of building codes, as well as the quality of materials, age of the structure and maintenance of a facility. In general, the structural vulnerability of infrastructure remains the critical factor as does the age of the facility, particularly considering the possibility of designs using obsolete parameters, improper materials used, and poor maintenance of the structure. Lessons from past disaster events reveal that inadequate planning and design, or poor construction quality are the primary causes of damage to critical facilities. In theory, health facilities, schools and government offices should be constructed with higher safety standards and quality controls. However, due to weak oversight and enforcement mechanisms, these are often ignored and maintenance is often compromised, resulting in dilapidated conditions which increase the vulnerability of the structure.

VULNERABILITY IN NON-STRUCTURAL ELEMENTS

Critical facilities house equipment that sustains day-to-day operations. For example, health facilities have life-saving equipment and electrical appliances, and water supply facilities have pumps and treatment capabilities. In addition to structural vulnerability, critical infrastructure is susceptible to damage to these non-structural elements. Damages to non-structural elements can result in the disruption of basic functions and at times can potentially create other collateral hazards compromising the structural safety of the facility.

DAMAGE TO HEALTH FACILITIES[V]

26 January 2001 Gujarat (India) earthquake:
A magnitude 7.7 earthquake destroyed 227 health facilities.

8 October 2005 Pakistan earthquake:
About 574 health facilities were partially damaged or destroyed.

26 December 2004 earthquake and tsunami:

Aceh, Indonesia – 30 of 240 health clinics were destroyed.
77 others were seriously damaged and 40 suffered minor damages.

Sri Lanka – 92 health facilities were destroyed, including 35 hospitals.

Maldives – One regular hospital, 2 atoll hospitals and 20 health centres were destroyed.

India – 7 district hospitals, 13 primary health centres and 80 sub-centres were damaged in the southern Indian states of Tamil Nadu, Andhra Pradesh, Kerala, the Union Territory of Pondicherry and the Andaman and Nicobar Islands.

2010 Pakistan floods:
515 health facilities (5.3 per cent of the total) were partially damaged or completely destroyed.

POOR MAINTENANCE

Unlike other general facilities, critical facilities need routine maintenance as they provide day-to-day support for social functions. The unceasing demands for such services as water, energy, telecommunication and transportation all require continuous functionality and durability. Poor maintenance due to a lack of human, financial or technical resources can lead to day-to-day service interruption and significant disruption during natural hazards; in turn leading to cascading failures of other services. For example, a failure to supply energy after an earthquake can lead to an insufficient water supply to hospitals.

INADEQUATE AWARENESS OF DRR AND RESILIENCE

Critical facilities are important to societal needs during and after disaster events, but many people often ignore the demands of critical facilities from the post-emergency perspective, both in relation to for individual facilities and cascading impacts. While critical facilities need to be resilient, there is a limited understanding of the facilities' vulnerabilities or of their inter-connectedness and role in society. As a result, the importance for resilient structures is often overlooked in policy, design and operations.

LACK OF DISASTER PREPAREDNESS AND BUSINESS CONTINUITY PLANS

In addition to the structural and non-structural vulnerability of critical facilities, there is also a lack of disaster preparedness and response plans to protect and mitigate disaster impacts, as well as a lack of business continuity plans to sustain operations during and after a disaster recovery phase. With the increasing interdependency of critical facilities, there is a greater need for knowledge and planning to address cascading failure of systems.

RATIONALE TO INTEGRATE DRR INTO CRITICAL FACILITIES R&R

It is clear from the last chapter that impacts on critical facilities could be far reaching, not just restricted to direct immediate damages to the facilities and occupants, but also to overall societal recovery. As the concepts of critical facilities and infrastructure, building back better and resilience are evolving, greater emphasis has been placed on critical infrastructure. The table on the following page covers key elements of resiliency for critical facilities in relation to the technical, organisational, social and economic dimensions of critical facilities.[vi]

> Resilient physical and social systems must be robust, redundant, resourceful, and capable of rapid response.

It is important to understand that mainstreaming DRR in critical facilities (in design, reconstruction, retrofitting and maintenance) entails not only addressing structural vulnerability but also enhancing technical, organisational, societal and economic aspects. It is necessary to address both structural and non-structural factors of critical facilities during recovery and reconstruction in order to:

- Minimise damage to structural and non-structural elements and protect occupants.
- Minimise service disruption and mitigate cascading failure to other critical facilities and services.
- Promote DRR and safeguard investment, which contribute to sustainable development.

MATRIX OF CRITICAL INFRASTRUCTURE AND DISASTER RISK REDUCTION

Interdependencies, and Resilience Qualities with Examples Pertaining to Technical, Organisational, Social, and Economic Dimensions[vii]

DIMENSION/ QUALITY	Technical	Organisational	Social	Economic
Robustness	Building codes and construction procedures for new and retrofitted structures	Emergency operations planning	Reduced social vulnerability and degree of community preparedness	Extent of regional economic diversification
Redundancy	Capacity for technical substitutions and 'work-arounds'	Alternate sites for managing disaster operations	Availability of housing options for disaster victims	Ability to substitute and conserve needed inputs
Resourcefulness	Availability of equipment and materials for restoration and repair	Capacity to improvise, innovate and expand operations	Capacity to address human needs	Business and industry capacity to improvise
Rapidity	Downtime, restoration time	Time between impact and early recovery	Time to restore lifeline services	Time to regain capacity, lost revenue

1 MINIMISING DAMAGE AND PROTECTING OCCUPANTS

Structural and non-structural damage to critical facilities can lead to service disruptions. Depending on the facility and type of occupancy, damage can also lead to fatalities. Facilities such as hospitals, schools, and government buildings can house large numbers of people as well as vulnerable groups. The box below highlights the vulnerability of educational facilities during recent earthquakes in the region.

CRITICAL FACILITIES: VULNERABILITY OF EDUCATIONAL FACILITIES

During the 2001 Gujarat, India earthquake, 971 students and 31 teachers died.

In Aceh, Indonesia, after the 2004 Indian Ocean tsunami, 2,237 teachers and staff (13 per cent) were missing or dead, and 38,644 students were missing or dead (11 per cent).

The 2005 Kashmir earthquake killed 18,000 children in schools.

In Sichuan, China, the 2008 Wenchuan earthquake killed about 7,000 students in schools.

Health facilities also represent a high level of vulnerability as they house sick and weak people. They are also crucial as they store life-saving equipment.

While it may not be possible to have a hazard-proof facility, it is important to ensure that facilities protect occupants and continue to function in the aftermath of any event. This requires adequate design and planning to address vulnerability and exposure to natural hazards. Protecting non-structural elements, such as equipment sustain the function of operations.

2 MINIMISING SERVICE DISRUPTION AND MITIGATING CASCADING FAILURE

Considering the importance of critical facilities in development, as well as emergency response and recovery efforts, it is important to ensure that facilities and services are functional at all times to provide support after disaster events. For example, damaged schools can disrupt classes but also increase dropout rates and decrease the quality of education. Facilities such as hospitals, emergency services, telecommunications, and airports have a critical role in supporting rescue and life-saving activities. As facilities are highly interdependent, they need to be designed with higher performance standards and with backup facilities to ensure redundancy and continued operation during any event. Reducing the downtime of a facility by adequate planning and provisions to expand services can improve critical response functions and restore normalcy. Special attention is required regarding the location, detailing and fixture of nonstructural elements in the critical facility to limit primary and secondary failures. Planning scenarios for disaster preparedness and business continuity should encompass multiple-hazard scenarios as well.

3 PROMOTING DRR AND SAFEGUARD INVESTMENT

Critical facilities are often resource intensive and have a longer life span compared with other infrastructure. Incorporating DRR elements into design and planning will enhance the longevity of a facility by making it resilient to recurrent hazard effects. Facilities such as schools and hospitals are places where vulnerable groups congregate. By ensuring resilience in these facilities, the vulnerability of those groups can be reduced and the sense of safety and DRR-related awareness can be increased. For example, ensuring schools are resilient can promote DRR knowledge of children and the wider community. Schools can also act as emergency shelters. Ensuring its resilience with additional costs can also safeguard investment during reconstruction.

KEY CONSIDERATIONS

Critical facilities play an important role in the daily economic and social functions of a society. These facilities will trigger both positive and negative impacts during emergency response, recovery and reconstruction processes. As critical facilities are interconnected, they have far-reaching impacts when their services are disrupted. Post-disaster recovery and reconstruction provides an opportunity to improve the resilience of critical facilities and their network. Transportation, water supply, health services, and power supply sectors in particular are crucial to re-establishing normal operations within a community in the aftermath of a disaster. Therefore, it is critical to ensure that service interruption caused by disasters is kept to a minimum in future disasters to aid the recovery of the economic sector and the restoration of daily lives and livelihoods. This should be done through institutionalisation of DRR considerations in both structural and nonstructural elements of facilities. It also requires consistent, cooperative partnerships between the owners and operators of critical infrastructure and the stakeholders dependent on the facilities.

With the likelihood of future hazards expected to increase in both severity and frequency due to climate change, making critical infrastructure safer will have a profound impact upon the success and sustainability of current and future development initiatives. Moreover, less damage to these structures during disasters allows greater saving in resources during repair and restoration, as well as more investment towards long-term development goals.

INFRASTRUCTURE RECONSTRUCTION POLICY AND STRATEGY – ACEH, INDONESIA[VIII]

Of the total losses of USD 4.7 billion, the infrastructure sector alone suffered 19 per cent of the destruction. Some of the key elements of the infrastructure reconstruction policy and strategy are highlighted below, in particular, the prioritising of reconstruction and improvement with DRR elements.

Policy and Strategy:

- Prioritising the provision of infrastructure and facilities to fulfil basic needs and the uninterrupted operation of logistics.
- Assisting and conducting rehabilitation and reconstruction of housing and its supporting basic infrastructure and facilities for survivors.
- Reconstructing adequate transportation and communication systems to support uninterrupted communication within and between provinces and with foreign entities.
- Rehabilitating energy and electricity distribution facilities in order to support the resumption of social and economic activities.
- Supporting efforts to maintain food availability.
- Recovering security for the communities affected by the disasters by increasing the resilience of facilities and infrastructure against disaster threats.
- Applying principles of investment based on economic, technical, environmental, social, cultural and religious feasibility consistently.

During the reconstruction of infrastructure damaged or destroyed during these events, the Government of Indonesia made several efforts to ensure that the effect earthquakes and tsunami would have was reduced in rehabilitated facilities and systems.

The improvements made addressed the following:

- Increased capacity of national ports and increased transportation access to and from ports for commerce. This, in turn, allowed for uninterrupted and more efficient logistic distribution and improved regional development.
- Rehabilitation and upgrading of the existing telecommunication facilities and construction of new communication facilities that placed a greater emphasis on wireless technology, which together provided a vast improvement in local, regional, and international telecommunication access.
- Rehabilitation and improvement of electricity grids.
- Increased diversification of the nation’s electrical energy sources, including alternative (renewable) energy sources.

1 IMPORTANCE OF DRR IN CRITICAL INFRASTRUCTURE R&R*

The foremost priority after an emergency is to assess the extent of damage to critical facilities and to prioritise facilities that need to be repaired or retrofitted in order to sustain relief and recovery operations. Considering the need for resilient facilities, it is important to integrate DRR and resiliency elements into the early recovery process as part of the 'build back better' strategy. While the requirements and priorities of each critical facility may differ in terms of design, scale, time and resources needed, recovery and reconstruction policy should identify the types of critical facilities needed to support the recovery process. It should similarly emphasise the creation of new resilient facilities and the retrofits of existing ones. The policy should encourage the participation of communities in identifying suitable locations for the construction of new facilities. The box on the previous page presents infrastructure reconstruction policy and strategy in Aceh, and highlights some of the key elements that were needed in the local context.

The policy should also address the vulnerability of dependent and interdependent critical facilities, so facilities are designed and addressed through a holistic approach, and so that provisions of redundancy are made in terms of operations and the overall resiliency of the facility and infrastructure. The key message here is that efforts should be made to ensure that disaster risks are assessed before the planning and design of recovery and reconstruction activities.

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** see Handbook for Disaster Recovery Practitioners, Chapter 2 for details*

PERFORMANCE-BASED CRITERIA FOR DIFFERENT TYPES OF BUILDINGS FOR SEISMIC SAFETY, CALIFORNIA BUILDING CODE

Facility Type	Earthquake Event		
	Upperbound (1000yrs)	**Maximum Probable (500 yrs)**	**Likely (100yrs)**
Hospitals	LS	IO	O
Police Stations	LS	IO	O
Fire stations	LS	IO	O
Emergency Communications Centres	LS	IO	O
Schools	CP	LS	IO
Public facilities	CP	LS	-
Private commercial – emergency response	LS	IO	O
Private commercial with hazardous materials	LS	IO	O
Private commercial – essential operations	LS	IO	O
Private commercial - ordinary operations	CP	LS	-

O – Operational: No significant damage has occurred to structural and nonstructural components. Building is suitable for normal intended occupancy and use.

IO – Immediate Occupancy: No significant damage has occurred to structure, which retains nearly all of its pre-earthquake strength and stiffness. Nonstructural components are secure and most would function if utilities were available. Building may be used for intended purpose, albeit in an impaired mode.

LS – Life Safety: Significant damage to structural elements, with substantial reduction in stiffness. However, margin remains against collapse. Nonstructural elements are secured but may not function. Occupancy may be prevented until repairs can be conducted.

CP – Collapse Prevention: Substantial structural and nonstructural damage. Structural strength and stiffness substantially degraded. Little margin against collapse. Some falling debris hazards may have occurred.

2 UTILISING DAMAGE ASSESSMENTS AND RISK INFORMATION

Damage assessments following an emergency phase should not be limited to structural damages but should also include nonstructural elements of the critical facility. In addition, assessments should focus on the exposure and vulnerability of facilities to related hazard events and to the cascading effects of other critical facilities.

Critical facilities and infrastructures need to be designed with higher safety standards. Damage assessment needs to be comprehensively analysed by relevant specialists to provide specific guidance on the design of structural and non-structural elements, protection measures, options for redundancy, and new and retrofitted facilities. While conventional building codes prescribe minimum safety standards, there is an increasing recognition for the need of higher performance standards for critical facilities to withstand higher levels of impacts while sustaining operations. Based on the type and functionality of a critical facility, the operational and performance levels need to be determined for both existing and new facilities. For example, the table on the previous page illustrates the performance-based criteria for different types of buildings for seismic safety per the California Building Code.

3 MINIMISING EXPOSURE OF HAZARDS

While natural hazards are omnipresent in the environment, their spatial and temporal intensity varies depending on the local geographic and climatic conditions. It is important to limit the exposure of critical facilities to recurrent hazards and to future climate change associated risks. As critical facilities have a longer life span they will be more exposed to risks associated with climate change in the future.

Existing critical facilities need to be evaluated to assess their exposure to natural hazards, based on damage assessment findings as well as available risk information. The findings should determine options to limit the physical exposure of a facility through structural and nonstructural mitigation measures or relocation. Relocation or construction of a new facility needs to be based on proper land use planning, taking into consideration disaster risks and environmental considerations *(see Guidance on Land Use Planning)*. Relocation or construction of essential community facilities needs to be prioritised based on local needs and in consultation with the local community. Furthermore, access to these facilities needs to be adequately assessed from a disaster risk point of view in order to ensure the safe movement of communities and the capabilities of emergency support functions (emergency services). One example is taking evacuation routes into consideration.

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While it may not be possible to select a place which is generally safe from hazards (for example, cyclones and earthquakes are regional-scale phenomena), appropriate site-specific considerations (design controls) can be taken into account to minimise the exposure of critical facilities to recurrent and future hazards.

Addressing the exposure component of a critical facility helps ensuring structural safety and continued functionality during a time of emergency.

4 INCORPORATING RESILIENCY IN DESIGN

As discussed above, there is a need to ensure a high level of operational and performance standards in critical facilities, as well as to minimise hazard exposure. It is increasingly recognised that appropriate architectural and structural designs for buildings can minimise their susceptibility to hazards such as floods, cyclones, earthquakes and tsunamis. However, there is still a need to improve the operational and performance levels of both existing and new facilities. Historically, building codes were based on a prescriptive approach that was limited by compliance, but performance-based design has also become an important consideration.[ix] *(see box on the next page)*

PRESCRIPTIVE VS. PERFORMANCE-BASED DESIGN

Building codes typically seek to ensure the health, safety and wellbeing of people in buildings, as they set minimum design and construction requirements to address structural strength, adequate means of egress, sanitary equipment, light and ventilation, and fire safety. Traditional building codes (prescriptive) are limited by compliance and are easy to understand, follow and monitor. While compliance with a prescriptive building code may satisfy the requirements to protect the facility's occupants, it may nonetheless be insufficient to ensure its continued operation.

The nature of services provided by critical facilities requires that designers and decision makers define an objective of building performance levels above the minimum requirements prescribed by the building code. Performance-based codes define acceptable or tolerable levels of risk for a variety of health, safety, and public welfare issues. The performance-based design process explicitly evaluates how building systems are likely to perform under a variety of conditions associated with potential hazard events. The process takes into consideration the uncertainties inherent in quantifying potential risks and assessing the actual responses of building systems, as well as the potential effects of the performance of these systems on the functionality of critical facilities. Identifying the performance capability of a facility is an integral part of the design process and guides the many design decisions that must be made. Currently available are the Performance Code for Buildings and Facilities by the International Code Council (ICC, 2006), 101 Life Safety Code (NFPA, 2006a), and the NFPA 5000 Building Construction and Safety Code (NFPA, 2006b) by the National Fire Protection Association (NFPA). The table on the next page illustrates the performance level of buildings for various design events.

MAXIMUM LEVEL OF DAMAGE TO BE TOLERATED

	Performance Group 1	Performance Group 2	Performance Group 3	Performance Group 4
Very large Event (very rare)	**Severe**	**Severe**	**High**	**Moderate**
Large Event (rare)	**Severe**	**High**	**Moderate**	**Mild**
Medium Event (less frequent)	**High**	**Moderate**	**Mild**	**Mild**
Small Event (frequent)	**Moderate**	**Mild**	**Mild**	**Mild**

Performance →

RELATIVE MAGNITUDE AND RETURN PERIOD FOR SEISMIC, FLOOD, AND WIND EVENTS[XI]

	Seismic Group	Flood	Wind
Very large Event (very rare)	**2,475 years**	**Determined on site-specific basis**	**125 years**
Large Event (rare)	**475 years** (not to exceed two-thirds of the intensity)	**Determined on site-specific basis**	**100 years**
Medium Event (less frequent)	**72 years**	**500 years**	**75 years**
Small Event (frequent)	**25 years**	**100 years**	**50 years**

There is no single procedure mandated for the planning, site selection and design of critical facilities, as no such procedure would be universally applicable. The decision to build a critical facility depends on many factors and requires a rigorous and comprehensive analysis of all the conditions that may affect the operation of a facility.[x] This guidance document is not meant to enumerate design specifications. However, the box below provides a list of useful references for hazards.

RELEVANT TECHNICAL DESIGN GUIDELINES

Protection and Mitigation from Tsunami - A Strategy Paper, National Disaster Management Division, Government of India, 2006. http://nidm.Tgov.in/PDF/safety/flood/link1.pdf

Guidelines for Design of Tsunami Escape Buildings - Sea Defence Consultants, 2009.

Guidelines for Design and Construction of Cyclone/Tsunami Shelters, Ministry of Home Affairs, India, 2006. http://www.preventionweb.net/files/7664_GUIDEFORCYCLONESHELTERS.pdf

Design Guide for Improving Critical Facility Safety from Flooding and High Winds: Providing Protection to People and Buildings, FEMA, http://www.fema.gov/library/viewRecord.do?id=2441

International Journal of Critical Infrastructures, http://www.inderscience.com/info/ingeneral/forthcoming.php?jcode=ijcis

When designing a structure, it is important to introduce resilient elements into the architectural design, such as minimising plan irregularities, soft story and overhangs. Likewise, facilities and infrastructures need to be designed for additional (specific) load cases, such as debris and scouring, in the event of a tsunami *(see table on the next page)*, and also take into account climate change. Furthermore, architectural and structural design should consider appropriate building materials to ensure the structures' serviceability and longevity.

GENERIC DESIGN SOLUTIONS TO TSUNAMI HAZARDS BASED ON THEIR EFFECTS[XII]

Phenomenon	Effect	Design Solution
Inundation	• Flooded basements. • Flooding of lower floors. • Fouling of mechanical, electrical and communication systems and equipment. • Damage to building materials, furnishings, and contents (supplies, inventories, personal property). • Contamination of affected area with waterborne pollutants.	• Choose sites at higher elevations. • Raise the building above the flood elevation. • Do not store or install vital material and equipment on floors or basements below tsunami/flood inundation levels. • Protect hazardous material storage facilities that must remain in hazard areas. • Locate mechanical systems and equipment at higher locations in the building. Use concrete and steel for the portions of the building subjected to inundation. • Evaluate the bearing capacity of soil in a saturated condition.
	• Hydrostatic forces (pressure on walls caused by variations in water depth on opposite sides).	• Elevate buildings above flood level. • Anchor buildings to foundations. • Provide adequate openings to allow water to reach equal heights inside and outside of buildings. • Design for static water pressure on walls.
	Buoyancy (flotation or uplift forces caused by buoyancy).	• Elevate buildings • Anchor buildings to foundations.
	Saturation of soil causing slope instability and/or loss of bearing capacity.	• Evaluate bearing capacity and shear strength of soils that support building foundations and embankment slopes under conditions of saturation. • Avoid slopes or provide setback from slopes that may be destabilised when inundated.
Currents	Hydrodynamic forces (pushing forces caused by the leading edge of the wave on the building and the drag caused by flow around the building and overturning forces that result from it).	• Elevate buildings. • Design for dynamic water forces on walls and building elements. • Anchor building to foundations.
	Debris impact	• Elevate buildings. • Design for impact loads.
	Scour	• Use deep piles or piers. • Protect against scour around foundations.
Wave break and bore	Hydrodynamic forces	• Design for breaking wave forces.
	Debris Impact	• Elevate buildings. • Design for impact loads.
	Scour	• Design for scour and erosion of the soil around foundations and piers.
Draw-down	Embankment instability	• Design waterfront walls and bulkheads to resist saturated soils without water in front. • Provide adequate drainage.
	Scour	• Design for scour and erosion of the soil around foundations and piers.
Fire	Waterborne flammable materials and ignition sources in buildings.	• Use fire-resistant materials. • Locate flammable material storage outside of high-hazard areas.

5 INCORPORATING NON-STRUCTURAL MITIGATION MEASURES

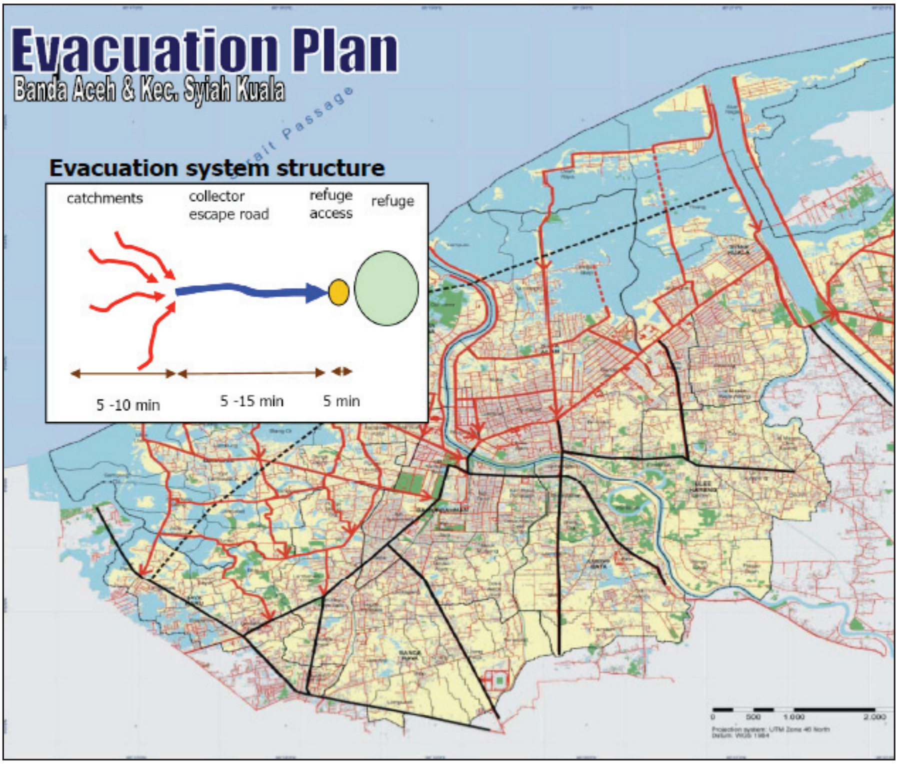
In addition to appropriate structural design, there is a need for comprehensive non-structural mitigation measures to avoid collateral damage and to sustain the operations of critical facilities. Non-structural mitigation measures need to take up additional considerations of facility components and equipment to avoid injury to occupants and loss of equipment. Depending on the nature of the equipment, components, and serviceability requirements, non-structural components must be designed for sustained operation as well as meeting any surge requirements. An appropriate backup system also needs to be established.

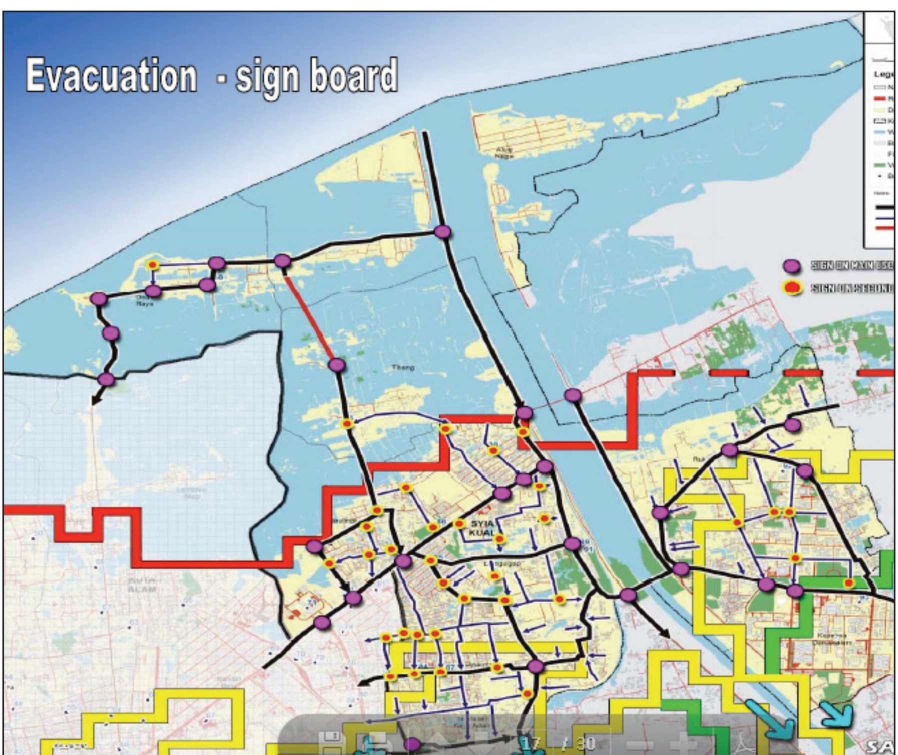
Furthermore, there is a need for contingency planning for different scenarios, interdependent systems and improved coordination and partnership with stakeholders. The planning should work within broader community-level planning as well as with overall recovery and development planning.

6 ENHANCING ACCESS TO CRITICAL FACILITIES

Access during normal and emergency times will be critical for any facility's operation, particularly facilities associated with emergency response functions such as hospitals and evacuation shelters. Access to critical facilities, including both outside and inside access routes, needs to be carefully planned based on the specific function of the facility. It is important to minimise the hazard exposure of access routes so that emergency functions can be carried out with zero or minimal interruption. Existing access routes need to be evaluated based on their hazard exposure, considering potentially unstable locations (for example, potential collateral damage zones with debris or mud flow), traffic movement and flow.

Outside access routes to facilities need to be considered within the broader contingency plan of the community, as well as within the recovery and development strategy. Appropriate signage needs to be provided along the access route for safe evacuation, particularly for access associated with schools, hospitals and emergency shelters. The figures on the next page show emergency evacuation planning to safe areas (shelters) in Aceh, including time estimated from feeder roads from the community to the main access route to safe shelters, with signage for evacuation along primary and secondary escape routes.


Evacuation Plan
Banda Aceh & Kec. Syiah Kuala
Evacuation system structure
catchments
collector escape road
refuge access
refuge
5 -10 min
5 -15 min
5 min


Evacuation - sign board

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ENDNOTES

i http://siteresources.worldbank.org/INDIAEXTN/Resources/Reports-Publications/gujarat-earthquake/full_report.pdf
ii The Infrastructure Security Partnership, Infrastructure Resilience, and Interdependencies,
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v World Health Organization
vi Rourke, 2007
vii Rourke, 2007.
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ix (FEMA 445, 2006.
x FEMA 445, 2006
xi FEMA 424, 2010
xii Tsunami Mitigation Strategies, Pacific Disaster Center. 2005.
xiii Source: TDMRC Rules for Supporting InaTEWS (PPT), Tsunami Workshop by Sentinel Asia, 2012

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