Enhancing Disaster Resilience Through Public Private Partnership: from Collaborations, Integration to Practices for Business Continuity

協業と統合から事業継続の実践に至る官民連携を通じた災害レジリエンスの強化

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CONTENTS

List of Figures

LIST of ABBREVIATIONS

ADRC	Asia Disaster Reduction Center
4G	Fourth-Generation
AI	Artificial Intelligence
APEC	Asia-Pacific Economic Cooperation
APP	Application
BCM	Business Continuity Management
BCP	Business Continuity Planning
BIA	Business Impact Analysis
BMG	The Business Mobility Group
CAP	Common Alerting Protocol
CBS	Cell Broadcasting Service
CCTV	Closed Circuit Television Cameras
CEOC	Central Emergency Operation Center
CHT	Chunghwa Telecom
CIP	Critical Infrastructure Protection
CISR	Critical Infrastructure Security and Resilience
CTWG	Counter-Terrorism Working Group
DRR	Disaster Risk Reduction
EOC	Emergency Operation Center
EP	Eurasian Plate
EPCC	Emergency Preparedness Capacity Building Center
EPWG	Emergency Preparedness Working Group
ERM	Enterprise Risk Management
ERTF	Emergency Response Travel Facilitation
FTP	File Transfer Protocol
GDP	Gross Domestic Product
GIS	Geographic Information System
GNS	Government Service Network
GVCs	Global Value Chains
ICT	Information and Communication Technology
IFIP	The International Federation for Information Processing
IoT	Internet of Things

ISO	International Organization for Standardization
IT	Information Technology
ITDRR	Information Technology in Disaster Risk Reduction
LCD	Liquid-crystal Display
MNO	Mobile Network Operator
MSME	Micro Small and Medium Enterprise
NCDR	National Science and Technology Center for Disaster Reduction
NCHC	National Center for High-performance Computing
NGO	Non-Governmental Organization
NiTech	Nagoya Institute of Technology
NPO	Non-profit Organization
ODM	Original Design Manufacturer
OEM	Original Equipment Manufacturer
OSAT	Open-Source Appropriate Technology
PPP	Public Private Partnership
PSP	The Philippine Sea Plate
PWS	The Public Warning System
R&D	Research and Development
SC	Supply Chain
SCCP	Sub-Committee on Customs Procedures
SFDRR	The Sendai Framework for Disaster Risk Reduction
SME	Small and Medium Enterprise
SMEWG	Small and Medium Enterprise Working Group
SOP	Standard Operation Procedures
THSR	Taiwan High Speed Rail
TSMC	Taiwan Semiconductor Manufacturing Company
TPTWG	The Transportation Working Group
UMC	United Microelectronics Corporation
UN	United Nations
UNISDR	The United Nations Office for Disaster Risk Reduction
WCDRR	World Conference on Disaster Risk Reduction
WMS	Warehouse Management System
WRA	Water Resource Agency

ABSTRACT

The research is trying to utilize science and technology with strategic thinking for collaboration to mitigate disaster impact for business continuity. It focused on identify better strategies and approaches for disaster management. In managing economic activities on supply chain interruption, with review of the lessons learn, best practices and surveys of the major disasters (i.e. the 2011 Great East Japan Earthquakes) in the past decade, we are trying to build the cornerstone for human security and sustainable growth on public private partnership. Under APEC, public private partnership became the core of emergency preparedness for enhancing sustainable growth at a global landscape. Mitigating supply chain interruption from disasters becoming common interest and focal issues global-wide. The Sendai Framework for Disaster Risk Reduction and the Paris Agreement both encouraged international or regional collaborations as well as technology transfer in assisting the developing countries to implement disasters risk reduction countermeasure and climate change adaptation strategy.

To ensure synergy on efficient information sharing, resources allocation and risk governance for global disaster efforts, the common operating picture can to some extent uphold the interoperability of international collaborations for disaster management to channel the accountability of integrated science and technology through collaboration. With evidence-based decision making support, better emergency preparedness and disaster risk reduction can be ensured from public to private sector and/or from goods, services/labor allocation/mobility before, during and after the disasters. The research includes the discussions on:

1. *How to enhance the transparency of information on risk governance, technology transfer and capacity-building policies with open data assessment that helps conceptual design on DRR inter-government and inter-enterprise sharing mechanism;*
2. *How to benefit the national/business continuity planning to ensure development through practical and risk governance linkages;*
3. *How to enhance engaging public and private sector participation in the implementation phase with Capacity-building guided by lessons learned, cross-cutting and social-economic responsive;*
4. *How to requests/acquired scientific and technological advice from mitigation, preparedness, response and recovery;*
5. *How to enhance linkages and create synergy between, risk governance, mitigation, technology transfer and capacity-building;*
6. *How to facilitate implementation and coordination and take advantage of newly developed information technology, i.e. ICTs, GIS, Big Data, etc.*
7. *How to enable the environment and opportunities for coordination and collaboration on emergency preparedness and capacity building program on common interests.*
8. *How to synergies DRR efforts through cooperation.*

1. Introduction

Global Disaster at a Glance

On September 9, 2018, nine active storms; Hurricane Florence, Helene, Isaac, Olivia, Tropical Storm Paul, Typhoon Mangkhut and etc.; appeared simultaneously in the Atlantic Ocean and the Pacific Ocean [1]. In 2018, at least 1,000 earthquakes hit the APEC region with magnitudes 5.0 and above. [2] Environmental risk/natural disasters draw global attention to its increasing frequency and intensive. The "new normal"[3] shows tremendous challenges and threats of the potential global value chain or supply chain interruptions on operations, logistics, trade and investment across economies incurring disaster-related losses of over $100 billion every year in the past decade.[4] According to the annual Global Risks Perception Survey[5], the significant increasing risk of natural disaster threats ranked higher than average for both likelihood and impact for the upcoming 10 years.

Swiss Re report[6] indicated that the total economic losses from natural and man-made disasters reach up to $337 billion in 2017. On MunichRe geographical overview on 2017 natural disasters in Fig 1[7], the impact of the disasters went global wide in total of 710 events with insured losses almost three times higher than the average of the past 10 years and almost four times higher than the average for the past 30 years.

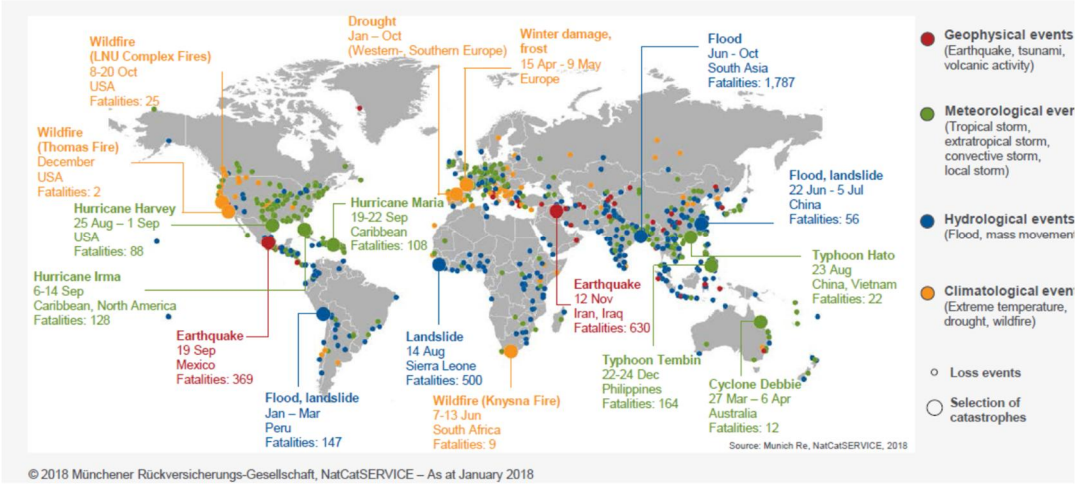

Fig. 1 Geographical Overview on 2017 National Disasters by MunichRe

On "Asia-Pacific Disaster Report 2017"[8], UN also highlighted that natural disaster become more destructive in Asia-Pacific region with the greatest impacts compared to the past decade (2007-2016), the 2010 earthquake in Haiti (222,500 deaths), the 2008 Cyclone Nargis in Myanmar (138,000 deaths), and the 2008 Sichuan earthquake (87,000 deaths). It also highlighted that Asia is the most vulnerable continent for floods and storms, with 44% of all disaster events, 58% of the total deaths, and 70% of the total people affected. "Lower mortality but higher cost" became the emerging trend of natural disaster events in 2017. APEC SME Monitoring report addressed the cost of the disasters on economic activities and disasters impact. The survey shows that SMEs account for 98% of total business, 64% of total employment and 41% of GDP in the Asia Pacific region. However, this region suffered from 70% of global natural disasters from supply chain disruptions of economic losses averaged 68 billion USD per year.

1.1 Businesses and Disaster Resilience

Disasters strike global value and supply chain causing interruptions which direct impact and jeopardized corporate profitability and existence. Enhancing emergency preparedness with global BCP/BCM capacity building for global supply chain resilience becomes the top priority mission for stakeholders, public and private sectors to achieve human security and sustainable development.

Both regulators and investors are increasingly demanding on businesses disclosure of their hidden risks, including disaster risks, and impact on their balance sheets. Vulnerable to the direct impact on economic activities and infrastructure, Moody's Investor Services incorporates climate change/natural disasters risk into its credit ratings for Moody-rated sovereigns Funds. [9] [10]

1.2 Response Dilemma

While disaster, it will escalate the intensity of a competitive market place. The strategy process among Micro Small and Medium Size Enterprises (MSMEs), SMEs, the large and global brands become more emergent than intended[11]. The threat comes from substitutes and bargaining power of buyers will higher the industry rivalry in the business environment to certain extent[12]. The emerging business continuity planning and management with supply chain resilience initiative can help stabilizing industries but cease to exist if disasters. BCP is a powerful approach to identify the strategy's potential profitability if mitigating impact from disasters.

Moreover, the financial markets tend to be highly sensitive and vulnerable if panic in the marketplace while disaster strike. Emergency preparedness and response required transparency to some extent on just-in-time, reliable and appropriate information disclosure to succeed the team effort while disasters preparedness, response and recovery. However, business sectors are having doubts and concerns to further respond or involve in the public private partnership engagement and tend to be hesitated to be transparent. The information disclosure to the market and their competitors may threat the corporates existence. The corporate financing may become difficult than before if credit rating downgrade for loss. The hostile takeover, financial buyouts, mergers and acquisitions will be active and possible through the financial markets if the stock prices goes down sharply. Respond or not respond to the risk information disclosure becomes the dilemma for corporate in the marketplace.

1.3 The Disaster Risk at Regional Level

For disaster risk reduction, prepare for the worst/historical scenario is important when it comes to managing disaster risk. Global supply chains can be thrown into disarray when disaster strikes. According to a survey in 2017, the majority of companies surveyed do not have full visibility on their supply chains. In the three months following the 2011 Great East Japan Earthquakes and Tsunami, automobile production declined as follows: Japan, 48%; Thailand, 20%; Philippines, 18%; and Malaysia, 8%. Meanwhile, the 2011 floods in Thailand crippled the global supply chain and the economic losses overall went global-wide. Many small and medium-sized enterprises do not have business continuity plans in place. The increasing demand from private sector, especially of whom go global or invest heavily on fixed assets (capital intensive industry), urge to seek collaboration or partnership with public sector (central or local governments) in managing disaster risks and seeking resilient critical infrastructure countermeasure for sustainable power supply, stable communications facilities and efficient logistics for operations toward the goal of Regional BCM. In this context, a visionary project initiated for SMEs on Business Continuity Planning (BCP) for strengthening their ability against natural disasters for sustainable and resilient global supply chains through public-private partnership collaborations since 2011.

1.4 APEC Summit on Resilience

A string of costly earthquakes and extreme weather, including the acceleration of the Pacific typhoon season, has prompted new action in APEC to enhance economic

security in the world most natural disaster-affected region. APEC member economies experience 70% of all disasters globally and sustain over USD 100 billion in related losses annually. Emergency management officials from the region have joined forces with affected sectors to promote more disaster-resilient trade. Emphasis is on helping businesses integrated in cross-border production and supply chains limit disruptions to their operations in as emergency – safeguarding job and growth in the Pacific Rim.

Convening in the industrial center of Nagoya, officials and representatives from auto, electronics, and insurance and finance firms assessed vulnerabilities and fleshed out strategies for encouraging wider, more effective business continuity planning in APEC economies to mitigate risks. They drew on lessons from disasters like the two magnitues-7 earthquakes in southern Japan in April 2016 that halted auto and semiconductor facilities still facing residual temblors.

The increasing frequency of extreme weather compounds the urgency of this efforts. Increasingly advanced production processes and new distribution patterns of raw materials, parts and services from global suppliers power modern manufacturing but are exposed to high risks including shocks caused by natural disaster, If a plant in Japan that makes irreplaceable car-control chips or shiny pigment used in auto paint cannot continue its normal operation due to an earthquake, for example, it can impact car production all over the world through the influence of global supply chains.

Personnel and capital shortages, damages to production equipment and infrastructure, power outages and elevated cybersecurity threats are among the challenges that can hamper business operations in a disaster. Boosting public-private policy coordination and development for community, trade and investment, the proper BCP/BCM in place is a must to operate as seamlessly as possible during an emergency. Delegates examines the business continuity planning of companies such as Nissan and Fujitsu, and the importance of routine checks and random, unannounced drills. They also explored the potential from firms to transfer risk through disaster risk financing as well as the rating of business continuity plans to create financial incentives for their adopting.

In Asia, small and medium enterprises play a greater role in production. In 2013, supply chains are a particular target during Super Typhoon Haiyan hit the Philippines which led to severe operational delays, inventory losses and declining sales within the sector. Failure to achieve progress could lead to more mass closures and bankruptcies such as those that followed the earthquakes and tsunami in northern Japan, and historic flooding in Thailand, 2011 – wiping out suppliers of goods ranging from hard-drives to component parts used in auto, cameras, copiers

and refrigerators. Public sector involvement in business continuity management is crucial to shielding local economic platforms such as business operations employment and corporate tax revenues from disruption after a disaster. Collaboration in APEC is setting new and welcome standards for securing livelihoods and sustainable growth in disaster-affected areas and beyond. APEC will contribute to gauge implementation of the region's disaster-resilient trade initiative with prospective.

Large corporates or global brands benefit from economic globalization and continues to grow in terms of comparative advantages across the borders with synergy from integrated supply chain. When the large-scale disasters and catastrophes strike the Asia-Pacific Economic Cooperation (APEC) region - such as the 2004 Indian Ocean Tsunami or 2011 Great East Japan Earthquakes and tsunamis, the impact on global value chain highlighted the needs to promote business continuity planning / management (BCP/BCM). However, the opportunities comes along with the extreme challenges and risks in the market place in the time of disasters. For mitigating the impact, most of the world leading corporate urge to allocate resources to limit global supply chains interruptions, control the loss and manage the shipping on time. With missionary vision on promoting BCP/BCM and deploying strategies at the various stages of preparatory work to managing risk and impact of large-scale natural disasters; APEC, as a pioneer, seeks to lead their deployment strategies in order to serve as learning points for interested economies who are in the midst of their own BCP/BCM implementation. At the regional scale, each APEC economy is unique in its geopolitical conditions, but common in its goal to be BCP/BCM capable. With review of the global and regional lessons learn from the large-scale disasters, this paper shared the regional efforts on disaster resilience and describe the strategic approaches via technology and collaboration for enhancing global supply chain resilience in APEC region.

1.5 Scope of Study

Regional BCP/BCM, PPP Engagement, Technology and Collaborations

APEC consistently promote and accelerating inclusive growth through technology and collaboration as well as public private partnership (PPP) in decades. Meanwhile, The 5th Global Platform for Disaster Risk Reduction of 2017 in Cancun, Mexico further highlighted the importance of DRR agenda with four priorities to declare the momentum 'From Commitment to Action" with special focuses on ' International Cooperation Initiatives' which emphasis on 'International Collaboration', 'Public Private Partnership (PPP)', 'Critical Infrastructure

Resilience' and 'active participation'.

SFDRR emphasized the necessity 'to continue strengthening good governance in disaster risk reduction strategies at the national, regional and global levels and improving preparedness and national coordination for disaster response……, supported by strengthened modalities of international cooperation. There is a need for the public and private sectors and civil society organizations to work more closely together and to create opportunities for collaboration, and for businesses to integrate disaster risk into their management practices. International, regional, subregional and transboundary cooperation remains pivotal in supporting the efforts of States, their national and local authorities, as well as communities and businesses, to reduce disaster risk. …..timely means of implementation in capacity-building, financial and technical assistance and technology transfer, in accordance with international commitments.'

It becomes the global trend to engage regional collaboration on capacity building for disaster risk reduction (DRR), emergency response, preparedness and recovery for the challenges. The emergent need of solutions on disaster-resilient business through the global supply/value chain for sustainable development and profitability such as BCP/BCM. APEC successfully story as best practice in promoting BCP and PPP after the 2011 Great East Japan Earthquakes and tsunamis, in March 2015, the Sendai Framework for Disaster Risk Reduction (SFDRR) enforced during the Third UN World Conference on Disaster Risk Reduction (UN WCDRR) promoted the value of business continuity planning as well as encourage the public private partnership (PPP) engagement and collaborations of stakeholders on BCP. The SFDRR also encourages innovation, science and technology DRR approaches such as big data and open data to facilitate the value-added information sharing on enhancing capacity building for multi-sectoral disaster resilience over higher public risk awareness and level of preparedness.

DRR is critical concerned in terms of national security, economic quality growth, environmental sustainability and people's livelihoods. For regional consideration, a large-scale disaster could impact the global supply/value chain and hamper the regional economic growth and corporate profitability. Hence, regional collaborative efforts on DRR have been a global challenge. After the 2011 Great East Japan Earthquakes and Tsunami, an emergent business continuity planning/management (BCP/BCM) approach help the small and medium enterprises (SMEs), the multinational or international corps to limit supply chain interruption and enhance cross border manufacturing, trade and investments. Base on the practical DRR project implementations and experiences over the years, the Asia-Pacific Economic Cooperation (APEC) identifies several key factors to promote disaster resilience in business sectors. Disasters in large-scale drawn the attention of global community.

Recall the economic impact of 2004 The South-East Asia earthquake and tsunami, 2011 Great East Japan Earthquakes and tsunamis coupled with the INES level 7 Fukushima nuclear power plants accident and 2016 Kaohsiung earthquakes; these earthquakes caused the greatest economic losses and challenged the continuity of business operations across the continents. APEC successfully stories on promoting BCP as a paradigm of regional collaboration are recognized.

How to uphold the values on long term sustainability through business resilience and supply chain connectivity, a disaster resilient approach need to be further developed on the topics of: 1) exploring the best practices from industrial aspects on supply chain management; 2) promoting BCP through public and private partnership; 3) developing "end-to-end" approach for disaster risk reduction in the digital age.

This Research focused on examining the practices of Taiwan and Hi-Tech industry to explore the possible public private partnership approach for enhancing disaster and business resilience. The case study, best practices and examples will provide a good reference for guiding direction toward future research in the targeted industry on public private partnership.

1.6 BCP/BCM

- Emergency Preparedness Capacity Building on Enhancing Connectivity for Safer Trade and Investment

APEC region suffered from 70% of global natural disasters, causing supply chain disruptions and economic losses averaged 68 billion USD per year. It is vital to secure sustainable economic development and resilience and minimize the potential interruptions from natural disasters by providing solid capacity building for better preparedness in private sectors to mitigate the impacts and maintain prosperity, economic sustainability, business continuity/operation and global supply chain resilience. The fruitful contributions of APEC Multi-Year Project on 'Improving Natural Disaster Resilience of APEC SMEs to Facilitate Trade and Investment' encourage the region in: 1) promoting business continuity planning (BCP), 2) facilitating resilient global supply chains by public-private partnership, 3) synergizing regional resources on common interests of global value chains (GVCs), 4) encouraging continuous investments and joint efforts on human capacity development, 5) building a win-win networking for information sharing on 'Ease and Safety of Doing Business'.

"Doing smarter and safer business" highlighted by APEC member economies are

a key momentum keeping the Asia-Pacific region growing prosperous and dynamic. In recent years, besides economic or finical issues, natural disasters are raising non-conventional considerations bringing adverse impacts and variety of interruptions to economic development. However, conducting integrated actions with disaster risk reduction and business operations is a new challenge requiring synergy among all stakeholders. As transboundary trades of raw materials, parts, services and products growing rapidly in the APEC region, a disaster-resilient trade environment is one cornerstone to ensure sustainable development and regional-wide prosperity. Since 2011, APEC has been broadly engaging key stakeholders through policy dialogues, training workshops, a guidebook on business continuity plan, principles related to global supply chain resilience and the APEC Disaster Reduction Framework. These activities successfully raised awareness and collaborations among relevant APEC working groups. To continue the momentum moving forward to improve emergency preparedness at business sectors through an actionable mechanism under APEC that will be ideal for safeguarding flourish trans-boundary trades. The proposed project will gather stakeholders ranging from business leaders, government officials, and insurance companies to disaster managers to discuss incentives, approaches and roadmap to fulfill APEC's priority agenda in facilitating trades and business with safety and sustainability.

1.7 Objectives of this Study

The primary objectives aimed at introducing feasible approaches based on multi-sectoral issues and outputs in recent years to meet the common interests with synergy. Meanwhile, it provided strategic approaches in fostering cooperation on capacity building in support of disaster risk governance and minimized supply chain interruption. Targeted on facilitate disaster resilience through better emergency preparedness, it also discussed the concept of how to engage public private partnership in managing disaster risk reduction as well as enhance transparency through information sharing mechanism to benefit the corporate in disaster. The objectives include:

(1) To analyze the status of outcomes, demands and supply related to risk and resilience of business operation in the Asia-Pacific. This process will picture the challenges and opportunities that concerns most;
(2) To disclose required information on disaster risk to identify feasible approaches to promote pro-active participation by business sector;
(3) To collect the best practices sharing that will favor global supply chain resilience by enhancing the quality of business continuity plan; and

(4) To formulate approaches and operational model for strategic process through public private partnership among business leaders, government officials, researchers and disaster managers (stakeholders) that will help to define appropriate science and technology for collaboration on disaster risk reduction.

1.8 Assumption

The project was proposed to identify threats of natural hazards to public business operation supply chain and their possible solutions to benchmark the important elements of BCPs on public private partnership base on the assumption of well-maintained infrastructure and IT environment. With priority focus on Hi-Tech industry, science park and APEC area of business continuity planning utilizing newly emergent technology such as ICT, smart device, big data and open data to leverage the resources from research outputs and networking; to share best practices of BCPs; to enhance business continuity in APEC region; and to raise risk awareness on public private partnership approach from data and information exchange and sharing.

1.9 Methodology

With review of the lessons learn and best practices in developing disaster risk reduction countermeasures in Taiwan and Hi-tech industries in the science park, this research paper explored the possible strategic approaches in helping the business continuity and sustainable growth at global landscape among stakeholders through public and private partnership. Furthermore, to echo the Sendai Framework for Disaster Risk Reduction on encouraging international collaborations and public private partnership, the disaster risk reduction approach will be discussed to bridge the gap of information sharing among stakeholders.

1.10 Effectiveness of PPP Model

To identify the strategic PPP approaches and critical elements related to information sharing and resources allocation effectively and efficiently, the common operating platform played an important role in channeling the accountability of integrated science and technology efforts. An evidence-based decision-making process with clear common operating picture will benefit business continuity planning, resources allocation prior to disaster strike with proactive

countermeasures before, during and after the disasters. Nevertheless, the limitations of this research paper are listed below:

(1) The limitation of scientific models applied to disaster risk management which including weather forecasting, monitoring, sensor networking, social economic aspects.
(2) The risk of misleading information or misinterpretation of scientific outputs which may possibly incur case by case.
(3) Issues involving cybersecurity, hackers, privacy and fake news.
(4) Critical infrastructure availability and its quality.

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2. Public and Private Partnership through Technology and Collaborations

To tackle the disaster risk management mentioned in the previous chapter at regional level, based on the key learnings from the APEC projects: 'Improving Natural Disaster Resilience of APEC SMEs to Facilitate Trade and Investment' and 'Application of Big Data and Open Data to Emergency Preparedness', the information sharing mechanism can bridge gaps of communication and enhance reliability, transparency, efficiency and effectiveness to incorporate partnerships with joint efforts at different levels. With integrated regional existing institutional efforts in decision making support of disaster risk reduction, we may have clear picture of the on-site near-real-time assessment and scenario-based drills/exercise in managing risk and developing disaster risk reduction activities for better preparedness in both public and private sectors.

Streamlining the disaster risk assessment guideline, identifying a partnership operation model of collaborative approaches on emergency preparedness and developing capacity building activities for the whole society can be expected. The interoperability of international collaborations and communication platform shows its potential role in channeling the accountability of verified integrated science and technology efforts in support of evidence-based decision making on risk governance perspectives. Collaborative approaches in developing partnership from public to private sectors before, during and after the disasters can synergize the mobility of resources and higher the risk awareness through capacity building activities. The best practices and case study showed effective strategic approaches on enhancing capacity building and digital preparedness in APEC. An efficient strategic process can facilitate better preparedness in managing disaster risks.

2.1 Enhancing Disaster Resilience through Global Supply Chain Connectivity

Since the 2011 Great Eastern Japan Earthquake and Tsunami, Asia-Pacific Economic Cooperation (APEC) has been promoting disaster resilience in business sectors. The fundamental effort was aimed at formulating guidelines for business continuity planning (BCP) for small and medium enterprises (SMEs), 10 clear and

easy steps to follow. The actions taken by APEC was a regional momentum to enhance disaster resilience at private sectors to incorporate the cross-border supply chain resiliency concept. Business needs resilient buyers and suppliers to sustain its operations. It is a survival contest for the industry if global supply chain interruption. Hence, how to mitigate impacts on business interruptions brought by natural disasters is a focal regional issue addressed by APEC Leaders. A collaborative synergy among APEC working groups calls joint efforts on exploring the vulnerabilities of the global supply chain in terms of natural hazards. In light of this, Chinese Taipei proposes to establish the APEC Emergency Preparedness Capacity Building Center (EPCC) with a view to bringing in regional synergies and resources to meet the needs of ensuring sustainable economic developments. Through the EPCC, we planned for capacity building programs and collaborative train-the-trained events to further implement public-private-partnership on disaster risk reduction. Under the APEC umbrella, EPCC provided an ideal platform for information and best practices sharing on innovative science and technology for disaster management among political leaders, business leaders, disaster management officials, researchers and practitioners. It is an efficient policy framework of connectivity for the whole society on common interests. This poster showcases a series of activities and achievements focusing on global supply chain resilience under APEC.

3. Disaster Resilient Trade and Investment vs Business Continuity Management

Two case studies - Taiwan and Hi-tech industries in the science park expanded in this chapter verified the concept of public and private partnership in the previous chapter.

3.1 Disaster Governance Strategic Approaches

Globalization shows its vulnerability and complexity in business and manufacturing process as well as escalate the level of logistics support. Recall the economic impact of 2004 The South-East Asia earthquake and tsunami, 2011 the Great East Japan Earthquakes and tsunamis coupled with the INES level 7 Fukushima nuclear power plants accident and 2016 Kaohsiung earthquakes in Taiwan; these earthquakes caused significant economic losses and challenged the continuity of business operations across the continents.

The marketplace may highly sensitive to natural disasters such as extreme events or large-scale earthquakes or flooding in terms of global value chains (GVCs) or supply chain interruption. Failure to respond can lead to mass closures and bankruptcies. Followed the 2011 Great East Japan Earthquake and Tsunami and Thailand floods in 2011, the industries struggle for managing suppliers of information and communication technology (ICT) products ranging from hard-drives to component parts used in cars, cameras, electronics devices and etc. due to the supply chain interruption across the borders.

3.1.1 Public Private Partnership (PPP)

Engagement on Regional Business Continuity Planning / Management (BCP/BCM) Through Technology and Collaborations

Disaster Risk Reduction (DRR) is key toward national security, economic quality growth, environmental sustainability and people's livelihoods. For regional

consideration, a large-scale disaster could impact the GVCs/supply chain and hamper the regional economic growth and corporate profitability and even cease to exist. Hence, engaging regional join efforts on DRR becomes a global trend. After the 2011 Great East Japan Earthquakes and Tsunami, the Asia-Pacific Economic Cooperation (APEC) initiate an multi-year project[13] to promote business resilience and implementing BCP with capacity building training workshop to help the small and medium size enterprises (SMEs), the multinational or international corporations to minimize supply chain interruption and enhance resilient manufacturing, trade and investments in APEC region.

The APEC successful stories shared as best practice in promoting BCP and PPP drawn the attention of the global community. The Sendai Framework for Disaster Risk Reduction (SFDRR) [14] enforced during the Third UN World Conference on Disaster Risk Reduction (UN 3WCDRR) in 2015 promoted the value of resilience as well as encourage the PPP engagement and collaborations. SFDRR also encourages to adopt innovation, science and technology on DRR approaches such as big data and open data to facilitate the value-added information sharing on enhancing capacity building for multi-sectoral disaster resilience over higher public risk awareness and level of preparedness. In 2017, the 5th Global Platform for Disaster Risk Reduction in Cancun, Mexico further highlighted the importance of DRR agenda with four priorities to declare the momentum 'From Commitment to Action" and special focuses on ' International Cooperation Initiatives' to promote international collaboration, public private partnership (PPP), critical infrastructure resilience with stakeholders' participation to achieve the goals of improving preparedness and national coordination for disaster response supported by strengthened modalities of international cooperation [15].

3.1.2 Options for Tackle the Risks

The capacity of a supply chain in coping with disasters are varied. It depends on the corporate risk tolerance (a limitation), preference (a choice) or appetites (a policy) for formulating an appropriate strategy on DRR. (Fig. 2) The high-tech industries located in Hsinchu Science Park, known for semiconductor production, their product lines are vulnerable to ground shaking, water shortage or power interruption. In the case of 1999 Chi-Chi Earthquakes and 2016 February 6th Kaohsiung earthquakes, the expanding operational scale with the significant change in targeting their risk tolerance to "no" failures which challenge to engineering design if "Black Swan" exists. Most of the failures to losses to high-tech industrial risks were caused by products in progress, equipment damage, logistics/supply chain interruption due to power outage. Taking into

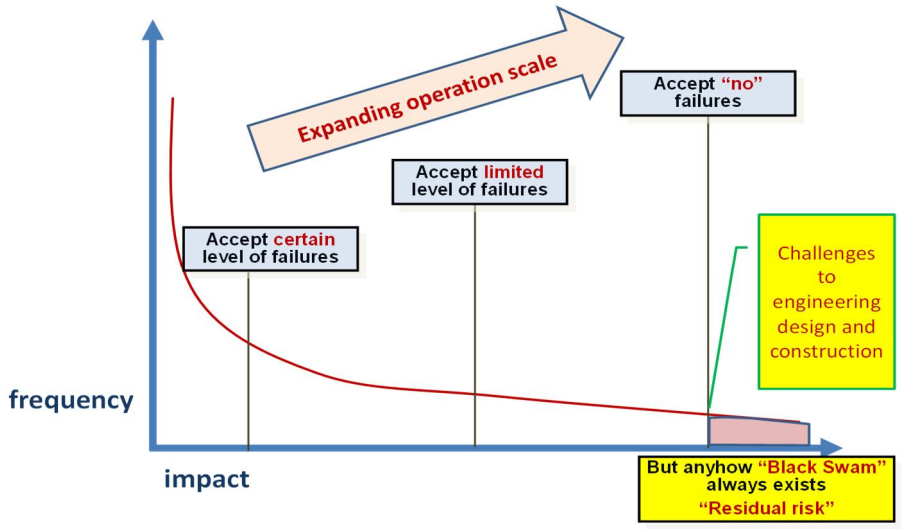


Fig. 2 Characteristics of Risks for Different Scale of Business – Tolerance of Failure and Interruption

account of highly vulnerability of the Hi-Tech Industry when tackle the risks, supply chain, disaster managers have difficult options on whether: 1) to lean an operation and secure cost efficiency; 2) to build redundancy and secure supply and keep the shipping and delivery on time; 3) to maintain remaining or residual capacity for operation and manage the shipment while supply chain interrupted if too big to build redundancy for the capital intensive investment.

In this context, DRR became the focal issue as well as the emergent needs for countermeasures availability for different risks scale in disasters. Many efforts and resources are allocated to sustain the end-to-end operation in APEC region (Fig. 3)[16] on public and private partnership. The supply chain of trade and investment benefit from the information sharing across the borders among developed and developing economies for DRR. For sustainable growth, disaster-resilient business promoted to facilitate the goods/services flow from small enterprises (SMEs/MSMEs) to big enterprises (Multinational corporations) in terms of manufacturing, shipping, financing and marketing.

Fig. 3 Supply Chain Across the Border

Each approach has its pros and cons and applicable case by case. Hence, it is important to improve disaster resilient capability through state-of-the-art technology and PPP collaboration on information sharing, resources allocations and risks communication across the borders via clear common picture of the situation for operation. It is made possible if we can recruit local knowledge, join scenario-based excises and drills based on the synergy of PPP in managing risks to mitigate the impact. With review of the global and regional lessons learn from the large-scale disasters, it is critical to formulate a strategic join operational framework for emergency preparedness via technology and collaborations on regional BCP/BCM to enhance GVCs and supply chain resilience. The risks involved can be divided into external and internal as stated below:

External – managing by the public sector

External (outside of the business complex or free trade zone):1) ensure the lifeline systems and utilities such as power, water, gas, telecommunications and transportation are available; 2) identify the targeted types of natural hazards and impacts (direct and indirect) such as earthquakes, typhoons, landslides and droughts; 3) facilitate supply chain resilience such as coordinate end-to-end connectivity from up-stream supplies to customers with common standards to follow such as ISO 22301; 4) encourage information sharing and exchange in different phases of planning, emergency response and recovery support by a systematic mechanism as an interface; 5) build up an inclusive platform to encourage dialogue.

Internal – managing by the private sector

Internal (inside of the business complex or free trade zone):1) Connecting with business continuity plan for contingency, constantly monitoring risks and update key players to take same step and having join exercise; 2) Hosting scenario-based table-top exercise and drill according to the realistic situations and demands for

better understanding of coping capability and capacity in extreme situations; 3) Facilitate internal information flow and decision making process by establishing "N" to "1" and "1" to "Many", identify key information helping key decision makers, ensure the responsible authority of executing BCP for sharing information with key stakeholders outside.

3.1.3 Taiwan Economy at Risk

Taiwan's ICT industry has played an important role in the global market. Taiwan established science parks (Fig. 4) [17] since 1980 for enhancing industry competitiveness, technology transfer to attract foreign direct investments and state-of-the-art technology to boost the economic growth.

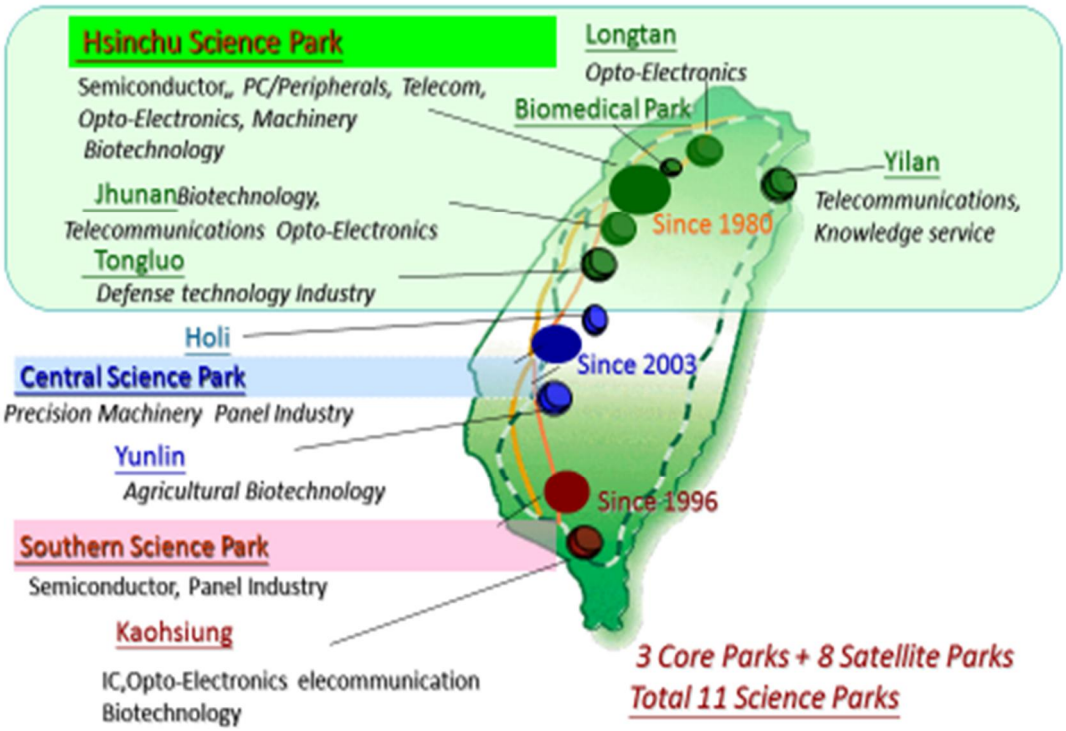


Fig. 4 Taiwan Science Park

Targeting to build the science parks in Taiwan as one of the research and development hubs in the Asia-Pacific, we clustering the upstream and downstream industries within the science park. Looking at the strategy and structure of the industry in Taiwan, it is similar to most of the APEC member economies. SMEs contribute more than 70% of industrial output in Taiwan. (Fig. 5) These SMEs usually produce products on an original equipment manufacturer (OEM) or original design manufacturer (ODM) basis[18].

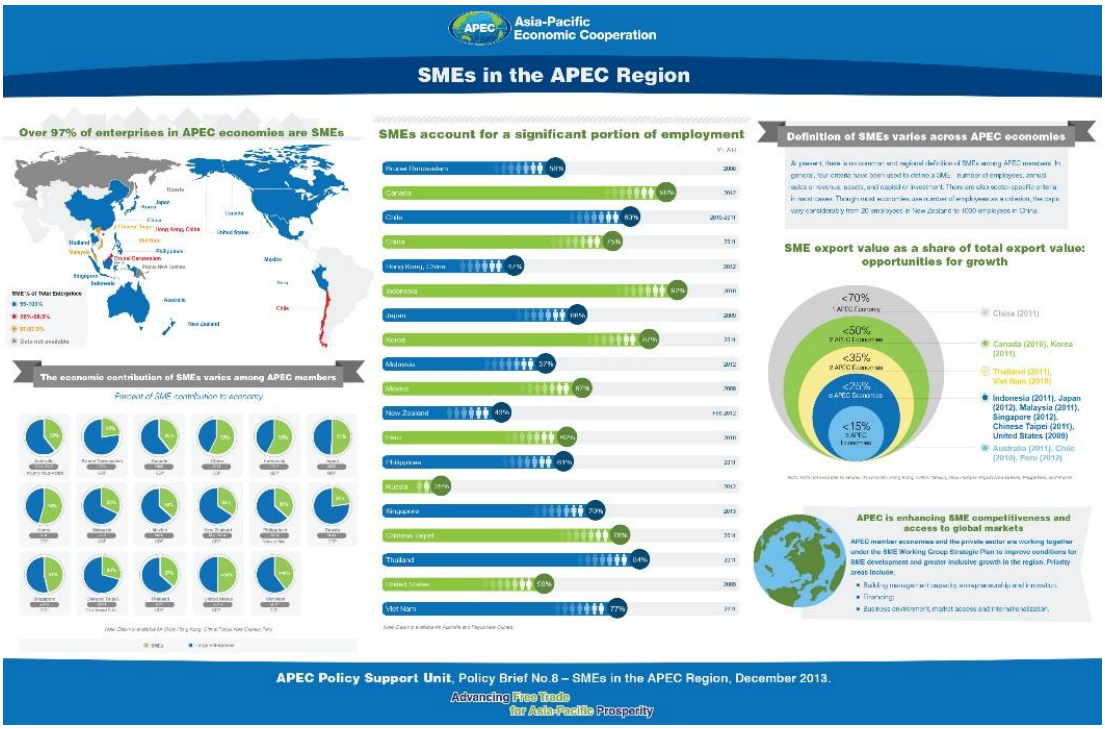


Fig. 5 SME in the APEC Region

The Science Park contribute 2.94% of economic growth and shoulder billions of trade and investment in Taiwan. ICT industry clustering in the science parks is the engine of Taiwan economic growth. In 2016, ICTs shoulder real rate of 3.2% GDP growth[19].. Major investments include the expansion of Taiwan Semiconductor Manufacturing. The total revenue exceeds US$89.5 billion in 2016, up 2.94 percent year on year to a record high. ICTs industry contributes to 14% of GDP[20.] (Fig. 6)

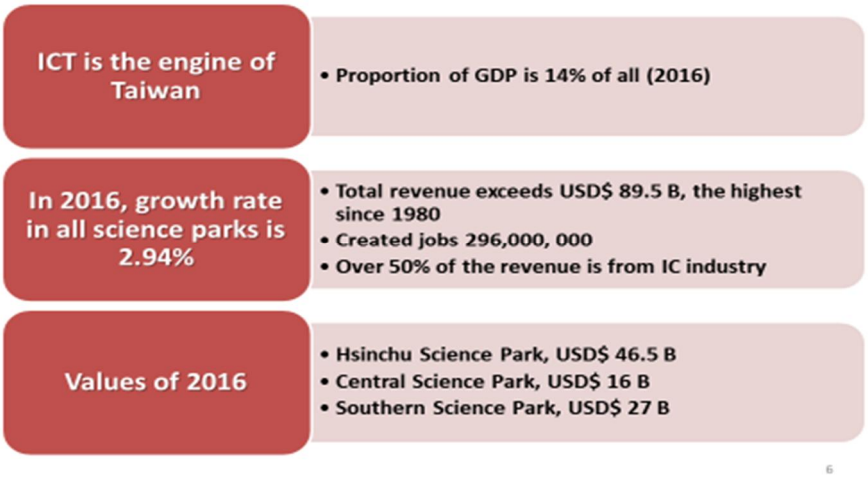


Fig. 6 Economic Contribution by Science Park in Taiwan

To sustain the economic growth, Taiwan government helps to bridge the information gap for emergency respond in the science parks and enhance the data process of the central emergency operation center (CEOC) operation while emergency. To interface with science park emergency operation, National Science and Technology Center for Disaster Reduction (NCDR) collaborated with Hsinchu Science Park Bureau to promote BCP/BCM from the viewpoint of public and private partnership collaborations.

3.1.4 TSMC Risk Management

Under the concept of business clustering, Taiwan Semiconductor Manufacturing Company (TSMC) and United Microelectronics Corporation (UMC), the world's largest and second largest semiconductor manufacturers were established in the science parks to synergy the integration of industrial resources and product management connect with major international suppliers. TSMC coach the future BCP implementation from the experience of 1999 Chi-Chi Earthquakes [21] to minimize the impact on the supply chain to uphold the ICT industry worldwide.

TSMC delivered a successful story after the 1999 Chi-Chi Earthquakes. Right after the quake, TSMC informed clients and set up hot-lines for Q&A. Within the first two days, 2 public announcements and 12 new releases. 5 days after, **100 interviews in 4 languages.** A guarantee, "**No delay to shipments**". TMSC received more news coverages, 57%, and **86% of them offered neutral or positive comments.** TSMC's emergency response to their staff and clients is to send out the clear message at the official level to protect their business and keep the shipment on time over implement disaster preemptive mechanisms at corporate level. A business owners challenges on the worst case and unexpected one to identify coping capacities and capability are key to survive the disaster. Thus, quick and decent responses, just-in-time information disclosure and team efforts are keys to succeed the corporate crisis management in this case. This case shared the value and importance of risk communication and proper information disclosure in time of disaster.

For long-term sustainability, TSMC established its Enterprise Risk Management (ERM) program based on both its corporate vision and its long-term sustainability and responsibility to both industry and society. Meanwhile, TSMC BCM is implemented for managing the safety of production lines, services and shipment if disasters. In the case of TSMC, the capital intensive industry, cannot afford to have redundancy and have to go for no failures approaches. Base on the targeted goal and risk strategic approaches, a proper BCP can be realistic for implementation to

achieve corporate disaster resiliency. Following the standards for the whole supply chain - ISO 22301, area BCM, TSMC exercised scenarios simulation to make plans and conduct drills for the worst or realistic worst case to test disaster resilient capacity and capability.

3.1.5 Kaohsiung Earthquake on February 6th, 2016

Taiwan, in the ring of fire, sits between the Eurasian plate (EP) and the Philippine Sea plate (PSP) is prone to earthquakes experiencing strong ground motions. On February 6, 2016 at 3:57 am local time, a magnitude-6.4 in-land and shallow earthquake hit the southern part of Taiwan and the casualties of 117 died and 546 wounded. More than 60 buildings totally or partially collapsed. The epicenter is located at Meinong, Kaohsiung City with a focal depth of 16.6 Kilometers. According to the shake records, the strongest intensity reached scale 6 (334.1 gal) Earthquake report of the main shock shown in Fig 7.

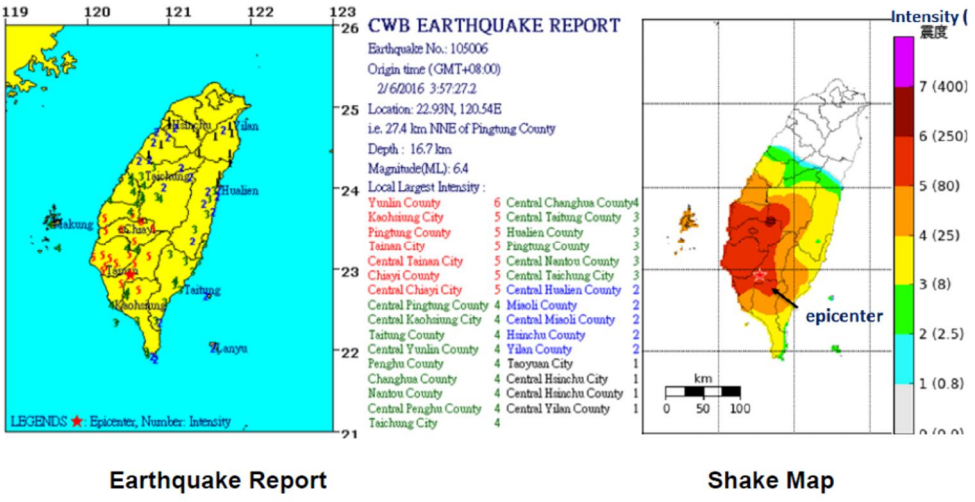


Fig. 7 Strong Ground Motion of Kaohsiung Earthquakes in Taiwan on Feb. 6, 2016[22]

For better emergency preparedness, response and recovery; we conduct the seismic risk and situation assessment to further support the CEOC operation while earthquakes. NCDR, as the think tank, provided the integrated multidisciplinary scientific suggestions on scenario-based GIS mapping for decision-making. The Earthquakes Impact Analysis Models were developed for urban areas to tackle large-scale earthquakes and further identify weak points of critical infrastructure, i.e., buildings, roads, and lifelines. (Fig. 8)

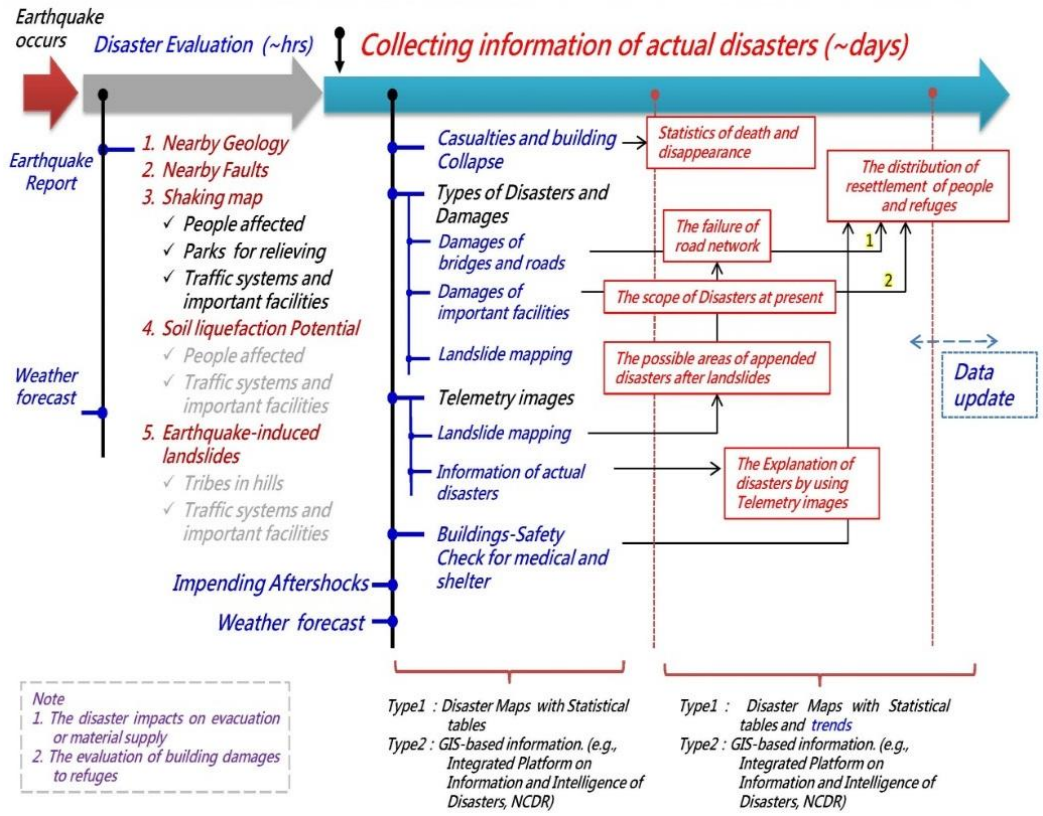


Fig. 8 Data Process Framework in the case of Earthquake in Taiwan CEOC Operation[23.]

Emergency Operations

Right after the strong quake, the Ministry of the Interior activated quick damage survey at an elevated level of emergency operation to level 1 at 4:15 am on Feb 6 to collect situations, and coordinate search and rescue efforts. The operation of search and rescue ended at 4:00 pm on Feb 14. In total, 29,000 of the urban search-and-rescue team, firefighters, police officers, volunteers and soldiers had ever joined the operation.

Taiwan is an indispensable partner in the Global Value Chains of Electronics Industry.[24] Most of the manufacturing lines of high tech industries are vulnerable to vibration. Regions most at risk when Kaohsiung Earthquake shook an electronics hub in Southern Taiwan (Fig. 9), where lies at the heart of Apple's supply chain[25.]a couple of days before Chinese New Year, a big day for family reunion. The water, electricity, transportation and communications services interrupted within 2 to 7 days. Major highways, highway bridges, railway. Taiwan High Speed Rail (THSR) system suspended south-bound service from Taichung for 2 days.

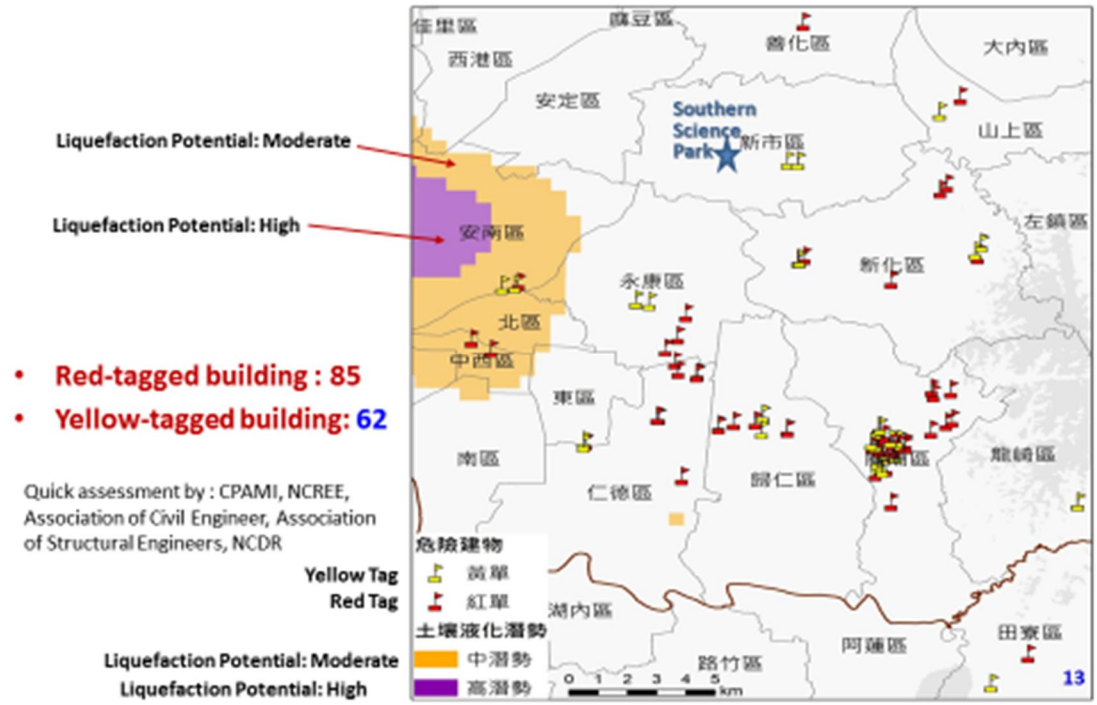


Fig. 9 Locations of Southern Science Park, Damaged Buildings and Liquefaction Zone

TSMC, APPLE's sole supplier and Qualcomm's supplier, operates its largest 12-inch wafer production facilities in the Southern Taiwan Science Park. As a leading company, TSMC incorporated BCP in its risk management with its suppliers. In the case of Kaohsiung Earthquake, TSMC minimized the losses at 'work in progress' no more than 1 percent of its first-quarter shipments[26]. It is inevitable to have the losses due to the automatic shutdown of the equipment by safety measures at a plant in Tainan. The situation soon be managed and resume to normal production. Fortunately, TSMC's maintain more than 95 percent of the tools fully function after restored in two to three days. Staff was safe and the firm's Tainan facilities were structurally intact.

In the past two decades, TSMC invested resources on BCP/BCM to strengthen the capability of its suppliers and endeavored to minimize the supply chain interruption in time of disasters. Nowadays, emerging technologies speed up the telecommunications development and shorten the lead time from data to deliverable messages in the digital age. Hence, the Taiwan government operated the emergency response to help business in responding to the disaster and provide big data and open data assessment and take preemptive measure to enhance disaster resiliency in the science park.

TSMC also learn to improve and restructure disaster management framework for emergency operation both after the Typhoon Morakot in 2009 which brought

record-breaking rainfalls with massive floods and large-scale landslides in southern Taiwan and the Great East Japan Earthquakes and Tsunami in 2011[27].

3.2 APEC Enhances Disaster-Resilient Trade and Investment

APEC active involvement with voluntary effort contribute to host the train the trainer workshop in the region and explore the future strategies to develop regional BCM approaches after the Great North Eastern Japan Earthquake and Tsunami. Promoting systematic project for capacity building to facilitate the regional collaborative efforts on improving business resilience since 2011, APEC BCP related deliverables as follows:

- Improving Natural Disaster Resilience of APEC SMEs to Facilitate Trade and Investment
- Developing Governments' Capacity to Promote and Facilitate the Effective Use of Business Continuity Planning for Disaster Resiliency (EPWG, Australia)
- APEC Seminar on Capacity Building for Disaster Recovery and Rehabilitation (EPWG)
- Policy Dialogue on Emergency Response Travel Facilitation (ERTF) (EPWG, BMG, SCCP)
- Business Continuity Planning: Policies, Practices and Programs (EPWG, Australia)
- Peer Group Review of BCP booklet/project effectiveness (EPWG, Australia)
- Workshop on Global Supply Chain Resilience (TPTWG, EPWG)
- Seminar on Enhancing Regional Supply Chain Resilience to Disasters in APEC (EPWG)
- Improving the Resilience of the Global Supply Chain (TPTWG, EPWG)
- High Level Policy Dialogue on Resilient SMEs for Better Global Supply Chains (SMEWG, EPWG)
- Sharing outcomes of BCP/PPP at The 6th Asia Ministerial Conference on Disaster Risk Reduction (UNISDR)
- Secure Infrastructure Workshop on Critical Infrastructure Security and Resilience (CTWG, EPWG)

Concerning the complexity to the regional business and emergency preparedness demands, APEC puts the efforts on improving business resilience since 2011, after the Great East Japan Earthquakes and Tsunami. APEC aimed at pursuing regional quality and sustainable growth on the concept of building the public and private partnership capacity to promote and facilitate the effectiveness of business continuity planning for disaster resiliency and deliver a number of train-the-trainer workshops. Take into account of critical infrastructure security and resilience, APEC continued to promote the BCP and BCM in a broader landscape from policy making to capacity build at regional level disaster-resilient trade & investment. For SMEs easy implementation, ten easy steps and guidelines of business continuity planning on strengthening supply chains. Forty one SME disaster resilient policies/programs from 12 APEC economies have been collected and organized to help economies design their own disaster resilience policies[28.]

BCP project has been recognized as the top 10 APEC milestones to chart 25 Years of APEC Progress in 2014. Since 2011, APEC Leaders emphasis on fostering business continuity, the application of science and technology in disaster preparedness and risk reduction to build sustainable and resilient communities and to secure global supply chains and facilitate trade and investment. The outputs and its impacts successfully draw the global attention and recognized by UNISDR. APEC continued to promote, share the achievement and supported BCP/PPP implementation in APEC region.

3.2.1 The Concept of Regional Collaborations

BCP/BCM capable is the key to maintain the country's comparative advantage[29.], the corporate competitive advantage[30.] And stabilize the industries while disasters, we have to safeguard the transboundary economic activities with end-to-end concept for join operation at regional level for GVC/supply chain resiliency. With sustainable buyers and suppliers, the quality growth of regional economic activities can be sustained if supply chain interrupted by natural disasters.

Engaging regional collaboration on capacity building for disaster risk reduction (DRR), emergency response, preparedness and recovery is the global trend. With the synergy of the PPP, the whole society can work more closely together and share the best practices on DRR for better management/business process and emergency preparedness. For DRR synergy on supply chain resiliency, the join efforts to develop international, regional, subregional and transboundary cooperation through innovative technology/tools is a must. The emergent BCP/BCM can help to enhance the GVCs/supply chain resilience if interruptions in terms of quick recovery. To

fulfill the goals, the global community shall work together to build networking on the regional BCP/BCM with PPP collaborations on DRR.

A disaster resilient supply chain network can coach its strategic process for operations to adapt to risk that affects its capacities. The upstream and downstream activities can be sustainable through collaboration across the network coping with the dynamic market place in terms of demand and supply with flexibility. Incorporating regional BCP/BCM into business operations leads to emergent competitiveness for sustainability in the global market. It is critical if enhancing the risk awareness of SMEs to uphold the economic growth in APEC region. We can benefit from sharing the natural disaster risks and the best practices while formulating BCP/BCM.

The increasing frequency and intensity of large scale disasters such as typhoon, extreme weather and volcano eruption can disrupt public services on transportation - flights, rail service for shipping where production networks depend on. To take references on NHK Special - disasters on big data[31] that illustrate the key to overlapping of hazard map and business operation on exposure to hot spot, identifying the problem of social development and the complexity of doing business in product delivery. It becomes the supply chain's major challenges for DRR in supply chain resilience. Using innovative Internet of Thing (IoT) tools, big data and open data for business vulnerability assessment at the regional level is convenient and widely accept by APEC economies to mitigate the supply chain interruption.

Continuing the effort in promoting supply chain resilience, it is critical to build a GIS-based information intelligence platform for information sharing. Through technology support and collaborations, the interoperability can be feasible to promote scenario-based exercises. From the historical events, we share the experience to improve in the future. The implement of BCP/BCM at the regional level can enhance regional disaster resilient trade and investment through:

3.2.2 End-To-End Scenario-based Information Sharing and Join Exercises

It is critical to incorporate the major large-scale disasters and historical data in the region for exercises. For example, the Great East Japan Earthquake or the floods in Thailand[32], which hamper the cross-border supply chain resilience. APEC EPCC will continue the effort to promote BCP/BCM and build up an operational framework at the regional level to build the information intelligence platform for

DRR and emergency preparedness. It will be the hub of the APEC region to share the common picture for emergency preparedness via regional digital preparedness[33] initiatives.

3.2.3 Concept of Regional Operational Framework for Emergency Preparedness

For encouraging wider, more effective business continuity planning in APEC economies to mitigate risks, APEC Emergency Preparedness Capacity Building Center (EPCC)[34] and NiTech co-hosted 'the 2017 APEC Summit on Resilience and Capacity Building Training Workshop on Promoting Business Connectivity in Nagoya' [35] to explore the challenges with actions on BCM. Connecting the 'Business Clusters' cross-border toward supply chain resiliency, we conclude the preliminary approaches for regional BCM are to collaborate on : 1) information and risk sharing; 2) BCM-based operation; 3) possible damage assessment to critical infrastructure protection (CIP) impact on business operation for recovery; 4) join operations networking; 5) common operating picture for join operation.

To sum up, a user friendly GIS-based cross-border evidence-based emergency operation for join operation is key to secede the end-to-end scenario-based exercise and shoulder the knowledge-based experience transfer for the regional BCM. The cross-border join operation required newly innovative IoT tools, ICTs, big-data and open data for cross-border situation assessment with joint efforts to facilitate business resumption. With common operating picture on real-time monitoring data integration, the GIS-Web-based platform can synergize support through the join discussion for cross-border collaboration on public private partnership.

3.3 Moving Forward

– Enhancing Cross-Border Collaboration in Promoting Regional BCP/BCM

The ever-changing environment triggered the frequency and intensity of natural disasters which scaling up the risks level and impact of the economic activities. APEC pursue the GVCs and supply resilience to host the APEC Summit on Resilience and Capacity Building Training[36] in Japan to invite the stakeholders' participation to brainstorming the future perspectives on developing regional BCP/BCM in two dimensions including:

3.3.1 Synergize work on regional BCP/BCM – cross-sectorial collaborations

- **Managing risks and impacts of natural disasters to business in the Asia-Pacific region with Public-Private Partnership**
  - To offer feasible solution packages to enhance regional resilience
  - To initiate a pilot study on BCM-based supply chain

- **Seeking leadership and coordination for cross-sectorial coordination**
  - To engage key stakeholders through Public Private Partnership
  - To keep flexibility among Private Sector, NGOs, NPOs and government to take the leading role
  - To manage the risk of critical infrastructures

3.3.2 Accumulation of Knowledge, Experience and Know-how of BCP and BCM

• Information-intelligence knowledge Platform

–To build up Integrated systems and database adopt Open Data Approach

–To design scenario-based joint drill in the APEC region

–To involve the disaster risk management with financing sectors

–To keep BCM rating transparent

–To discuss Disaster sign standard for risk communication

• knowledge transfer and the best Practices sharing of BCM

–To share information

–To share experiences of formulating BCPs

–To provide solution package on challenges while implementing BCPs

To work as a team, ensure no business know-how will be disclosed for disaster management, adopt innovative user-friendly technology for collaboration, provide common picture on situation and clearly define the role, level of response and involvement for both public and private sectors are key to success. As a whole, the regional strategies through technology and collaboration for large-scale disasters must be: 1) smart and convenient using common picture of situation for operation instead of language communication; 2) on scenario-based; 3) cost-effective for response and preparedness

4. Regional Digital Preparedness on Natural Hazards

To further moving forward to enhancing cross-border collaborations in promoting regional BCP/BCM and resolved the challenges, enhancing digital preparedness on natural hazards is the cornerstone for PPP through science, technology and collaboration. Therefore, the public private partnership concept discussed in chapter 2 verified the case study of Taiwan emergency operations on the common operating picture for emergency preparedness and operations. It also introduced the cross-border collaborations information sharing through global social media to achieve the goal of public private partnership through Technology and Collaborations discussed in chapter 3.

The Cornerstone for PPP through Science, Technology and Collaboration

In March, 2015, the Sendai Framework for Disaster Risk Reduction (SFDRR) enforced during the Third UN World Conference on Disaster Risk Reduction. The SFDRR does not just succeed spirits and values of the Hyogo Framework for Action, but also leads the world entering a new phase of disaster risk reduction through stakeholders at national, regional and global levels. Among all regions around the world, the Asia-Pacific is the most vulnerable to natural hazards and climate changes. Disaster risk reduction (DRR) is critical concerned in terms of national security, economic quality growth, environmental sustainability and people's livelihoods. For regional consideration, a large-scale disaster could direct and indirect impact more than one countries due to the damaged or interrupted supply chain. Therefore, regional efforts on DRR have been a focal issue. After the 2011 Great East Japan Earthquakes and Tsunami, an emergent global trend of developing strategy to strengthen global value chain or supply chain resilience via business continuity planning (BCP) approach engages the small and medium enterprises (SMEs) and the multinational or international corps to limit interruption and enhance cross border manufacturing, trade and investments. Base on the practical DRR project implementations and experiences over the years, the Asia-Pacific

Economic Cooperation (APEC) identifies several key factors to promote disaster resilience in business sectors. The SFDRR also encourages innovation, science and technology DRR approaches i.e. big data and open day can help sharing the value-added information on enhancing capacity building of SMEs' disaster resilient capacity via decent risk communication tools for raising the risk awareness and level of digital preparedness. This paper describes to what extent the business sectors involved in and how to safeguard the cross-border trade and investments with safer and smarter regional strategies in the digital age with large-scale disasters.

4.1 High Vulnerabilities of Natural Hazards in Asia

Asia is one of the most competitive marketplaces in the world. Within the region, the struggle on compromising profits on supply chain interruption while disasters. Thus, the fruitful profits come from the significant economic growth via highly supply chain integrated operations in the region of high vulnerabilities and exposures to natural hazards of Asia. From 2003-2013, the annual economic loss reach up to some US$68 billion in the Asia-Pacific Region[37.] The critical issues drawn by the average loses call upon the action plans for enhancing disaster resilience at the regional level. Disasters not just adversely impact people's livelihoods, but also could interrupt regional or even global business operations, due to the direct impact on commodity shortage. In today's highly globalized and regionalized integration on production activities, more and more business units take advantages to governing global value chains for pursuing ultimate profitability, i.e. to navigate cross-border business networks of public and private sectors to coordinate the manufacturing, operations, financing, marketing and logistics on multiple product line suppliers and subcontractors in order to outreach the end consumers in various parts of the world.

Asia-Pacific Economic Cooperation (APEC) is one of a kind Asia-Pacific economic forum target to uphold the regional economic growth and prosperity. Twenty-one APEC member economies occupied 44 percent of global trade ($16.8 trillion) and 53 percent of world real GDP in purchasing power parity (PPP) terms ($35.8 trillion) created by 40 percent of world population (2.7 billion people)[38.]

Fig. 10 APEC Twenty-one Member Economies

4.2 Regional and Global Efforts on Promoting Business Continuity

Business Continuity Plan (BCP) is not an emergent idea in business management. A conventional BCP usually copes with threats of financial crisis, information interruptions and manufacturing accidents, instead of natural hazards. Learning experiences from the 2011 Great East Japan Earthquakes and Tsunami, and the Floods in Thailand that clearly identify high vulnerabilities in business sectors and reminds business owners to develop traditional business continuity plan and include adverse impacts caused by natural disasters. Though interruptions, originated from business operations, cash flows or inconsistency of information, have been taken into serious consideration, but those setbacks are listed as daily-basis check-up items and most business units has plans to respond to the emergency by Standard Operation Procedures (SOPs). However, after a major disaster, chain effects of business interruptions would probably affect the whole supply chain domestically or even internationally. For example, the severe floods in Thailand caused ripple effects of business interruptions to automobile production line and PC manufacture activities in the Asia-Pacific. Likewise, the 2011 earthquakes and tsunami in Japan also brought down ICT industry and auto parts. Counting casualties and losses aftermath, economic loss exceeded 1.7 Billion Yen (equal to 3.4 % GDP of Japan), death toll number (or missing) around twenty thousand, direct loss (including damaged households, manufacturing utilities, highways and bridges).

Besides the tangible damage and losses in Japan, it strongly impact the global markets of the supply chain interruption, especially from global supply chain viewpoint. In the 2011 earthquakes, the semiconductor manufacturing and

automobile industries were severely affected and interrupted in the Tohoku read in Japan. The consequences shown on the declining production in car industry. Comparing the number of car manufactured from February of 2011 (800,000), March (400,000) and April (290,000), the supply chain interruption shows the impact of the large-scale disaster toward Japan's global strategy on highly integrated operations. It may attributes to the declining of car productivity in Thailand (19.7 %), in the Philippines (24.0%), and in Indonesia (6.1%). Likewise, manufacturers involved in the global value chain such as computer, smartphone and ICT device faced shortage of essential chips produced or supplied by Japan.

Therefore, a trend of enhancing preparedness for private sector by adding new elements to BCP has become an essential issue of disaster management. In 2012, International Organization for Standardization has introduced the ISO 22301 as a new standard to regulate disaster management activities for business operations. An APEC survey conducted by the Asia Disaster Reduction Center shows that over 79% of companies including large corporations and SMEs that these companies neither didn't have nor know business continuity plans (BCPs), Fig. 11[39]. From observation of the trend, obviously, the business owners think that the governments ought to take a major proportion of disaster management and responsible for helping them to reduce losses and overlook certain obligations shouldered by the business owners themselves. To better enhance the whole society disaster resilience, how to motivate active participation and border engage the involvement from private sectors are the essential backbone supporting to succeed the public-private partnerships. BCP with factors of natural hazards is an ideal vehicle to transport concepts of disaster risk reduction, capacity building and emergency preparedness to business operations via robust preparation.

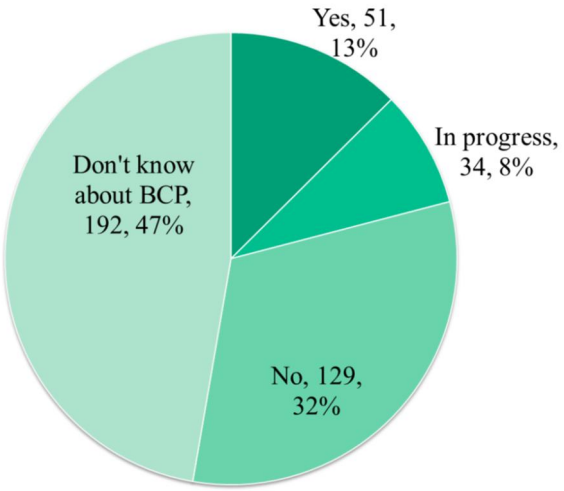


Fig. 10 Survey of Adoption and Awareness of BCP by the ADRC

These main purposes to introduce BCP to business are: 1) Raise businesses' awareness and knowledge to develop disaster reduction/disaster preemptive mechanisms and responding teams; 2)Establish a process to help business develop tailor-made plan for solving foreseen challenges; 3) Help individual company in quickly resuming operation to strengthen business competitiveness and keep promises to clients and employees.

More and more industries and corporations taking it seriously of the impacts brought by natural disasters as risks and threats to their employees, suppliers and customers after the 2011 earthquakes and tsunami in Japan. Hence, both public and private sectors recognize the importance of BCP which can help formulating plans on the potential risks and scenario to further identifying internal and external vulnerabilities with disaster risk awareness while disasters to ensure the business continuity, industry development and economies sustainability.

4.3 Primary Targets for Introducing Business Continuity Plan

Australia and Thailand co-host the 2010 "APEC Workshop on Public Private Partnerships and Disaster Resilience" address the need to develop a whole society approach on enhancing disaster resilience and outline the common objectives with scope of collaborative partnerships.

After the Great East Japan Earthquakes and Tsunami in 2011, the Asia Disaster Reduction Centre (ADRC) survey on 267 large and small-medium enterprises within 17 APEC member economies shows the averaged statistic of 67% - "Don't know about BCP" or "Don't have BCP". Exclude the large enterprises, the percentage for SMEs' jumps high to 83%[40]. With limited BCPs availability, the high disaster risk ranking of the economic activities, business operations and product manufacturing in the disaster-prone areas show the vulnerability of global supply chain while natural hazards. Without proper BCPs in position to go through risk identification, preparedness, emergency response and business resumption phases, disaster can lead the situations toward business and supply chain interruptions and even cease to exist. Compare with those enterprises with BCPs, the quicker recovery from the disaster can quick resume the business operations which contribute to the regional supply chain connectivity to uphold the regional economic sustainability. However, with limited risk awareness, local knowledge and disaster risk reduction capacity building or training program, business units tend not to prepare in advance. In views of business continuity after disasters, this research depict how to define the information source and utilize the communications tools (ICTs) to better raising the general risk awareness and enhancing disaster resilience as well as encouraging the public and private sectors to develop BCPs for managing risk or impact.

SMEs make great contributions to the national, regional and global economy and trade. Nevertheless, the SMEs are fragile in nature that hampered global supply chains and business operations while natural disasters especially large-scale ones. From coverage of news media, the repeating reports of SMEs' losses occupied headlines year after year. It highlights to some extent the natural disasters impact SMEs in great deal and induce severe supply chain interruption and aftermath economic losses.

A few tangible existing facts confirm the importance of disaster resilience to the SMEs' operations. Firstly, direct impacts of disasters can stop the whole or partial production lines' operations due to the facilities damages, raw materials contaminated or even workforce casualties. Secondly, accompany by the inconvenient situations for SMEs to recover while interruption on water/ electricity supply and transportations/logistics occurred. Thirdly, indirect impacts on slow economic and livelihood recovery to some extent cripple business operations especially SMEs'.

Without doubts, flexibility is the key strength of SME to rapidly adapt to the changes of competitive marketplace. SMEs, compared to the large corporations, have relatively little and limited finical support, knowledge and human resource to cope with the risk and exposure to natural hazards. In global economic lifecycle, SME is the fundamental unit to contribute to the local community incomes and regional business economic growth. By reviewing other issues related to disaster management on public private partnership (PPP), disaster resilience and emergency preparedness; it is shown a common trend and demands of SME on mitigating potential disaster risk. As consequence, BCP is an ideal approach to linkage among business people, key stakeholders and disaster managers jointly to work on improving disaster resilience.

The ten easy steps for building up SME's BCP, developed base on ISO22301 Business Continuity Management Standard System, have been introduced to the Asia-Pacific region since 2012 by training workshops and document circulation. The ten steps are composed[41:]

1. Determine BCP purpose, scope and team.
2. Prioritized activities and Recovery Time Objective
3. What do you need to resume key activities?
4. Risk assessment – know your tragic scenarios
5. Do not forget pre-disaster protection and mitigation
6. Emergency response to disaster

7. BC Strategies to early resumption
8. Be financially prepared
9. Exercise makes your plan functional
10. Ongoing review and improvement

4.4 Integrated Big Datasets

- Coordinating Digital Preparedness for Natural Hazards

Case studies from the recent large-scale disaster in the Asia Pacific clearly identify the emerging demands on big data and open data application in time of disasters for emergency preparedness. As a whole society from public services, private industries and general publics, a verified reliable information through the revolutionary concept of big data and open data is critical for formulating the dynamic DRR strategies and BCPs, deploying emergency relief missions, ensuring global supply chain resilience and maintaining quality growth and livelihoods security. Asia is one of the disaster-prone region, cross-border capacity building and training program, scenario-based drills and exercises on big data and open data on enhancing disaster-resilient manufacturing, trade and investment can direct benefit both of the regional economic sustainability and human security.

Recent projects of business resilience and global chain resilience, conducted by APEC Small and Medium Enterprises Working Group (SMEWG) and APEC Transportation Working Group (TPTWG) respectively, emphasize importance of applying data and information for achieving smarter investments and building up safer trade environment. For twenty-one member economies of APEC to share the synergies of economic prosperity, regional capacity building and public-private partnership, it is vital to broadly adopt the big data and open data information sharing on emergency preparedness approach to concrete solid and sound foundation for global value/supply chain resilience to artery connect and support business and economic activities in the Asia-Pacific region.

Digital preparedness is a cornerstone of evidence-based DRR approach which offers value-added knowledge for emergent response while decision-making, process from big data and open data to information intelligence. However, there are technical and policy barriers for developing countries to utilized crowdsourcing, ICTs or Internet of Things (IoT) technology to build up an analytical database and integrated systems with proper telecommunication tools for cross-border BCPs or regional emergency preparedness from data collection to applications, especially

for a cross-border or large-scale disasters. Taking into account of the diverse social-economic datasets of demographic characteristics, economic activities, educational background, gender, level of public awareness and etc., it is essential to carefully interpret and identify the social vulnerability with gaps for enhancing regional capacity building as a whole society. These parameters from social science perspectives help capacity building at community level and reshaping actionable information from "big data and open data" approach for sustainable economic and business activities.

4.5 Best Practices

- On Digital Preparedness in Taiwan through Public-Private Partnership

Taiwan is a highly disaster-prone country and how to mitigate disaster risk is an essential issue catching attention from both government and the public. However, due to extreme weather events and potential large-scale earthquakes, risk exposures to land and population increase and become more diverse than ever. In past two decades, the Ministry of Science and Technology has been investing resources on fundamental scientific and technological researches related to characteristics of natural hazards and knowledge for disaster management that helps to pave the basis developing disaster risk reduction and emergency preparedness. Nowadays, emerging technologies speed up the telecommunications development and shorten the lead time from data to deliverable messages in the digital age. In information age, big data and open data not just facilitate trades and business, but also benefit disaster management as a whole.

In case of the lessons learnt from the 2011 Great East Japan Earthquakes and Tsunami, specific big datasets can provide a dynamic view on human behaviors and reactions to the shakings and warnings as well as the traffic flow in different phases. From Pre-disaster to post disaster phase, from data to reliable information or message is critical for raising public awareness. An updated information with better risk communication approaches can mitigate the disturbance while emergency respond and level up the quality DRR assessments with higher public awareness of emergency situations. Applying open data principles to big data, it will enhance social preparedness and resilience. Since 2013, Taiwan has introduced the Common Alerting Protocol (CAP) to standardize disaster information for dissemination through multiple channels. Google Crisis Map is one of the platforms in building up the last mile to connect people living in Taiwan and one of the easy access tools to adopt in sending the demanding information in times of disasters. Later, in 2016, five system operators of the fourth-generation (4G)

telecommunications officially join to provide the Cell Broadcasting Service (CBS) to mobile phone users. It is an innovative approach to facilitate raising public awareness and ensure wide coverage of the dissemination of information during emergency within time collaborations among public and private sectors.

In 2009, Typhoon Morakot brought record-breaking rainfalls which caused massive floods and large-scale landslides in the southern Taiwan. The tremendous casualties and losses pushed forward a restructure of disaster management framework and the full commitment of improving emergency operation via information integration. The improvement on meeting the quality information demands for decision-making required to tackle of what we have been exposed to when Typhoon Morakot strike - no adequate collaborations and synergies among respective governmental agencies and authorities at all level to disseminate and interpret the just-in-time effective integrated information for proactive emergency preparedness and response.

One of the key reasons for formulating an integrated information framework on decision-making support is that too many existing individual systems operated independently by each government authority and provided only fragment of information in different time span. Hence, an efficient coordinated emergency preparedness and response countermeasure cannot be deployed in time without the holistic views and pictures of the real situations and the impact assessments on Typhoon Morakot prior to the disasters hit. To cope with the incompatibility of datasets, file structures and value-added information via the social media related to typhoons, floods and precipitation-triggered landslides, the remedial countermeasures request decisive decisions to acquired and incorporated science and technology efforts for integration - ‘one Taiwan one respond’. The evidence-based emergency operation needs the implementation of applying improved numerical ensemble models to forecast trajectories and rain of typhoons, producing potential risk maps of inundation for scenario simulation, integrating real-time monitoring data for further decision making. All the outcomes and collective verified information are displayed on GIS-Web-based platform for discussion and decision-making at all level of the government authorities and Emergency Operation Centers (EOCs). Without doubts, big data is the core behind the scene to support the emergency preparedness and operations.

In recent years, the scope of information sharing has extended from central to local governments and NGOs to help enhancing information preparedness at grassroots levels. For local governments, delayed or inadequate information hampers and slows down the process of decision making. Information dissemination and sharing from central to local governments fill in the gap of miss-

links information and provides a common operating picture to bring meaningful discussions-speak on the same page. Collaborations with NGOs on helping them to allocate resources in advance, governments can benefit from receiving the NOGs feedbacks as the reliable on-site data source for information and data collection. The mechanism of big data integration is shown in Fig.12. [42.]

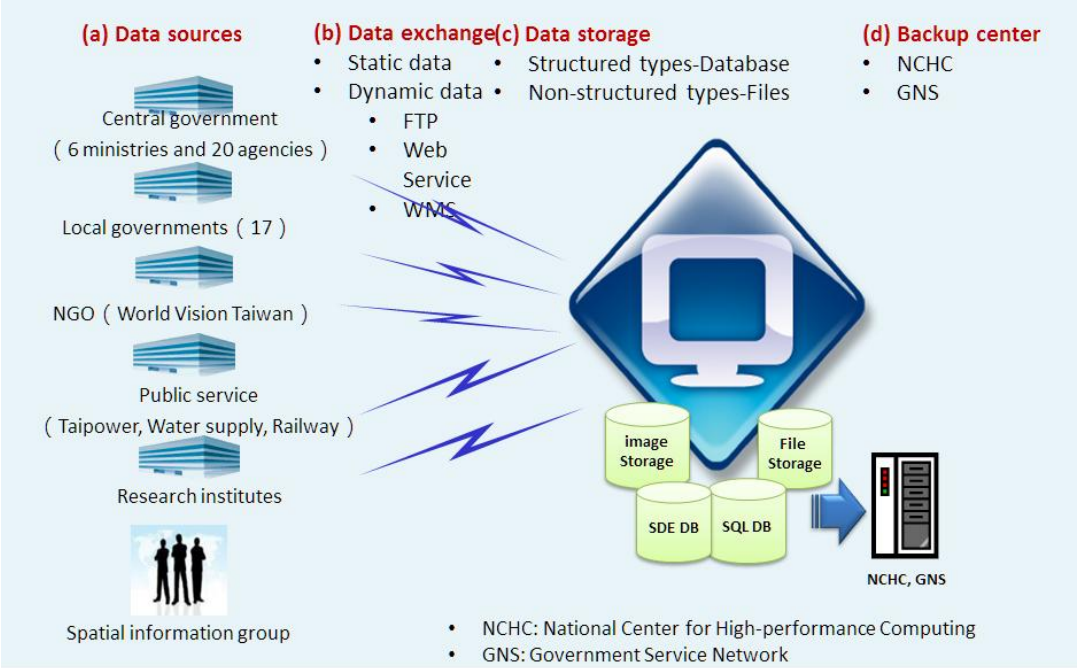
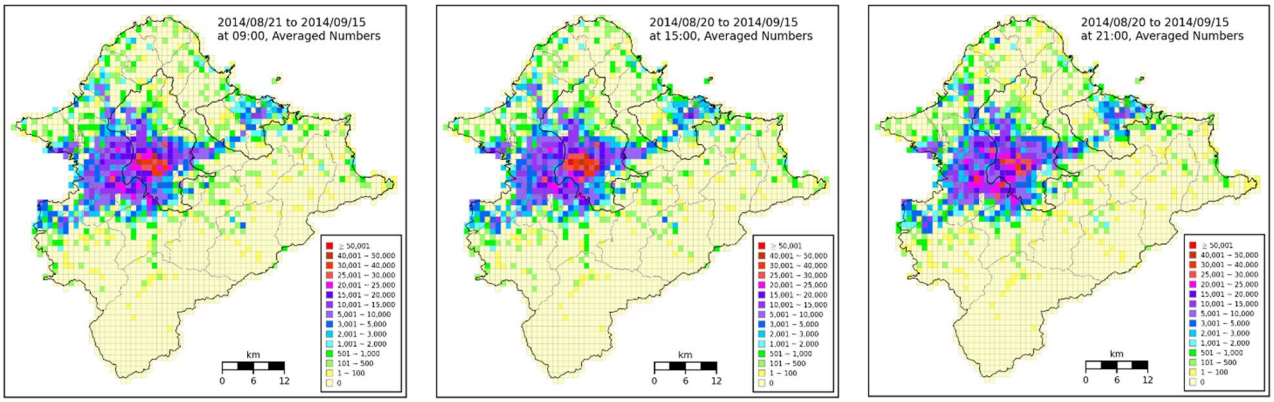


Fig. 11 Integration Mechanism of Big Data

It is always a challenging question to answer - how many and where are people staying - or - when will the next destructive earthquakes hit? For the number of the affected people, through an averaged estimation of population distribution, it could be calculated by allocating population proportional to floor areas based on census statistics and taxation data. However, it presents a static status of population distribution but real-time facts which doesn't fully reflect people's dynamic movements in urban districts or nationwide around the clock while disasters. As scenario analysis for seismic risk reduction in urban areas, locations, population density and distribution are the key factors which shape the strategic approaches on how to mitigate possible casualties claimed by a large-scale earthquake.

To resolve the situation, National Science and Technology Center for Disaster Reduction (NCDR) collaborated with the Chunghwa Telecom (CHT), a major telecom service provider occupies 37.90% of the mobile service in Taiwan[43.], to tracing mobile signals for collecting numbers of mobile users at specific grids to estimate population distribution pattern. The scope of the pilot project covers three

major metropolitan areas in north Taiwan, Taipei City, New Taipei City and Keelung City with numbers of population at 2,695,007, 3,959,855 and 373,721 respectively. The CHT provides data updates three times; at 9 am, at 3 pm and 9 pm; every day that roughly reflects dynamic characteristics of urban population flow and allocation pattern in the urban area as illustrated in the Fig.13.



(a) Averaged data at 9 am (b) Averaged data at 3 pm (c) Averaged data at 9 pm

Fig. 12 Population Distribution Based on the CHT Data

4.6 Channels of Disaster Information Dissemination

- 7-ELEVEN, Convenience Chain Stores

The Office of Disaster Management launched a project since late 2011 to recruit convenience chain stores for undertaking the roles of situation reporting and information dissemination if disasters. The aim is to provide easy access to the up-to-date information if emergencies and to facilitate the efficiency and effectiveness of emergency response at township level. The Uni-President Corporation, the holding company of 7-ELEVEN in Taiwan, is the first one of the partners to join the above-mentioned project. Uni-President, one of the largest consumer product manufacturers, runs 7-ELEVEN chain stores numbering over 4,800 retail outlets with comparably wide coverage of in-land logistics networking in Taiwan.

To facilitate the efficient and effective information dissemination, each 7-ELEVEN is well equipped with a LCD panel at cashier displayed possible risks or threats with relevant emergency information on site at local level as illustrated in the Fig. 14. During the 2012 typhoon season (usually from May to October), 7-ELEVEN has piloted a successful story on public private partnership. Their customers including drop-by tourists are well informed and benefit from the real-time typhoon and weather related information via these LCD panels to avoid the

possible impact on floods in the immediate areas. In the case of floods, the person in charge of the disaster reporting at 7-ELEVENs will direct report their observations on water levels on real-time basis to the Water Resource Agency(WRA), the government authority of floods. The WRA will relay the confirmed flood cases to the emergency operation center at central or local level for further emergency response i.e. road closure or search and rescue (SAR) deployment.

Fig. 13 Updates on Typhoon on 7-ELEVEN LCD Panel Maintained by Water Resource Agency, Taiwan

4.7 Open Data on the Common Alerting Protocol (CAP)

For further expand coverage on information dissemination during typhoon season, Google starts to offer its services on displaying and disseminating the real-time warning messages by Google Crisis Map, Google Alerts and Google Now. The data sources of warning messages, follow the CAP - an international standard, are come from nine government authorities and public transportation servicing sectors. Messages in CAP format are open to the internet service providers, APP developers, research institutes and industries as open data for them further develop disaster related researches/systems or the innovative DRR APPs and etc. from the free-of-charge information.

Smartphone is another ideal handy device to catch warning messages in the sense of point to point and end to end services, direct to the end users concept. With introducing the 4G mobile technique, a cell broadcasting system (CBS) project is ongoing to send alerts and warnings by the Public Warning System (PWS), which put through the sound of the sirens or alarms as top priority emergency messages from Mobile Network Operator(MNO) to the smartphone users, if earthquakes or any immediate emergency.

4.8 Moving Forward

– Enhancing Digital Preparedness on Natural Disasters for Safer and Smarter Investments

The cross-border movements of goods, services and workforce grow rapidly and rather dynamically in the Asia-Pacific. The natural disaster warnings and alerts from big data and open data approach can provide the best and holistic common pictures to effectively integrate the information flow with partnership between public and private sectors to mitigate the impacts. For particularly note, the newly emerging technology accelerate the development of telecommunications technology and shortens the lead time of data processing and information dissemination. Wide coverage of disaster related information dissemination contributes by social media, 7-Eleven chain store, smartphone, MNO and etc. In the digital age, big data and open data approach plays the key role in saving lives, securing livelihood, facilitating trade and investments, enhancing business resiliency in operations, raising disaster risk awareness for better emergency preparedness, formulating business continuity plan, maintaining resilient global supply chain, protecting critical infrastructure and safeguarding tourism industries.

In the case of the 2011 Great East Japan Earthquakes and Tsunami, Using proper big datasets can facilitate interpret human behaviors and reactions to provide more comprehensive pictures and views to the shakings, warnings efficiencies and the traffic flow situation in different phases of disasters. From Pre-disaster to post-disaster phases, big data and open data approach can deliver just in time message to maintain the effective and efficient risk communication with higher level of public awareness through public private partnership to deploy emergency response effort and to deliver quality DRR assessments if situations.

APEC for a studies conclude the emergent needs to adopt big data and open data approach on large scale disaster with cross-border view of digital preparedness while emergency. To include whole society from public sectors to private industries

and general publics, a comprehensive picture for emergency response using real-time big data and open data is vital to succeed the collaborative interoperability operations from adopting DRR strategies, BCPs, deploying emergency relief missions and mitigating losses for sustainable economic growth and human security. A disaster-prone region, regional capacity building programs and training on BCPs and promoting big data and open data approach can ensure safer and smarter cross-border trades and investments in the booming economies of Asia.

The core value of the key objectives on enhancing digital preparedness against natural disasters is the real-time information-sharing and interoperability with cross-border capacity building on cross-cutting demands with synergies. The objectives are shown as below:

1. To picture the capacity building among APEC member economies in adopting big data and open data approach to build up a foundation for information sharing mechanism;
2. To interpret on-demand big data and open data through a region-wide survey to further identify shortfalls, challenges and opportunities that public and private sectors concerned the most;
3. To promote big data and open data approach to provide safer marketplace and enhance global supply chain resilience through quality BCPs, transparent real-time risk information disclosure and resilient critical infrastructure protection plan in position;
4. To formulate a collaborative real-time focal point network and mechanism on sharing cross-border big data and open data on better emergency preparedness to facilitate integrated actions and capacity building on DRR at the regional level as a whole society.

Introducing science-and-technology based sharing mechanism through ICTs to enhance BCPs and digital preparedness on DRR is a global trend as the SFDRR highlighted in the third WCDRR. Without doubts, a solid backbone support via ICTs can benefit the stakeholders with synergy in all phases of disaster management from mitigation, preparedness, response to recovery in the Asia-Pacific region.

5. Public Private Partnership Operational Model

Based on the concept discuss in chapter 2 and the case studies expanded in chapter 3 and 4 from corporate, national and regional level, the Public Private Partnership Operational Model developed in this chapter conclude the role and relationship of public and private sector for collaboration through science and technology base on the digital resilience concept discussed in the previous chapter.

The 2004 South-East Asia earthquake and tsunami as well as the 2011 Great East Japan Earthquakes and tsunamis caused the greatest economic losses and challenged the continuity of business operations across the continents. Thereafter, regions most at risk when the 2016 Kaohsiung earthquake shook an electronics hub in Southern Taiwan, where lies at the heart of Apple's supply chain. The large-scale disasters demonstrate the fragility of supply chains and the importance of enhancing disaster resilience through innovative technology and keen collaboration on information sharing/dissemination, resources allocations and risks communication/awareness across the borders.

With review of the global and regional lessons learn from the large-scale disasters, the increasing threats from devastating earthquakes and extreme weather call for the actions to enhance economic security. Base on the practical experience of DRR project implementations in decades, APEC identifies several key factors to promote disaster resilience in business sectors while the Sendai Framework for Disaster Risk Reduction (SFDRR) declared to promote the disaster risk governance and encourages innovation, science and technology DRR approaches on raising the risk awareness and level of preparedness. At the regional level of disaster risk management, empowering the cross-cutting collaborations on science and technology as well as enabling the inter-disciplinary information intelligence platform for communications are keys to resilient society and human wellbeing.

This paper aims to identify a conceptual model for enhancing regional resilience and connectivity through public-private partnership. The country-level case studies

and comprehensive regional reviews for promoting inclusive and disaster resilient development will be cover.

5.1 The Disaster Governance Strategic Approaches at the Regional Level

Concerning the complexity to the regional business and emergency preparedness demands, APEC puts the efforts on improving business resilience. After the 2011 Great East Japan Earthquakes and Tsunami, APEC aimed at enhancing disaster-resilient trade & investment on the concept of the public and private partnership (PPP) to further facilitate the effectiveness business continuity planning (BCP) and business continuity management (BCM) from policy making to capacity building at the regional level. For Small and Medium Enterprises (SMEs), ten easy steps and guidelines of BCP on strengthening supply chains for implementation are available online in 7 languages free for download. In brief, 40% of global population can read and use the APEC BCP booklet online to improve disaster resilience of 60% of global SMEs [44]. Forty one SME disaster resilient policies/programs from 12 APEC economies have been collected and organized to help economies design their own disaster resilience policies. Furthermore, APEC recognized the importance of BCP project and highlighted it as one of the APEC top 10 milestones to chart 25 Years of APEC Progress in 2014.

APEC not only emphasis on fostering BCP/BCM but also highlighted the importance of cross-fora collaboration, cross-cutting application on science and technology in disaster preparedness and disaster risk reduction (DRR) to build resilient communities and Global Value Chains (GVCs)/ supply chains at the regional level. In 2013, APEC economies agreed on "Seven Principles of Supply Chain Resilience" [45], which provides an overarching framework to support APEC economies to manage and mitigate risks to the supply chain while natural disasters, deliver train-the-trainer workshops and evaluate the performance of supply chains in the APEC region[46].

In another hand, APEC promoted a cooperative regional approach to critical infrastructure security and resilience (CISR) to facilitate trade and travel across the APEC region in 2014. An integrated approach benefited APEC economies by reducing gaps or vulnerabilities by facilitating future cooperation on CISR for enhancing regional disaster resilience[47]. The outputs of the above-mention projects successfully draw the global attention. In March 2015, the Sendai Framework for Disaster Risk Reduction (SFDRR) enforced during the Third UN World Conference on Disaster Risk Reduction (UN WCDRR) promoted the value of BCP as well as encourage the PPP engagement and collaborations of stakeholders for DRR at the regional level. The SFDRR also encourages innovation, science and technology

DRR approaches such as big data and open data to facilitate the value-added information sharing on enhancing capacity building for multi-sectoral disaster resilience to raise higher public risk awareness and level of preparedness. UNISDR recognized the important role of BCP/ PPP and embedded business continuity concept into "The Sendai Framework for Disaster Risk Reduction 2015-2030"(SFDRR) to further promote and support BCP/PPP implementation at the regional level[48.49.].

APEC continued to shares the regional effort on disaster resilience of business continuity management and successful stories of the team efforts with inspiring outcomes, future perspectives and challenges for enhancing disaster resilient trade and investment[50]. In this context, engaging regional collaborations on capacity building for DRR on BCP/BCM for, emergency response, preparedness and recovery became common goal in the global community.

The sustainable growth relied on social security, economic stability and environmental sustainability. For regional consideration, a large-scale disaster could impact the GVCs//supply chain and hamper the regional economic growth and corporate profitability. Hence, engaging regional collaborative efforts on DRR have been a global challenge. This paper focused on discussing how to tackle the inconsistency and differentially of capacity, information and resources of developed/developing countries, public/private sector or big/small enterprises in response to disasters at the regional level. "Work as a team" in the global society to face the disasters on real-time basis is the motivation of developing the PPP strategic process and operational model. Through science, technology and collaborations, this paper provides the key references/components for facilitating disaster resilience.

5.1.1 Strategic Planning for Regional Emergency Preparedness

Globalization shows its vulnerability and complexity in business and manufacturing process as well as escalate the level of logistics support. The market place may highly sensitive to natural disaster such as extreme events or large-scale earthquakes or flooding in terms of GVCs or supply chain interruption. Followed the 2011 Great East Japan Earthquake and Tsunami and Thailand floods in 2011, the industries struggle for managing suppliers of information and communication technology (ICT) products ranging from hard-drives to component parts used in cars, cameras, electronics devices and etc. due to the supply chain interruption across the borders. The above mentioned large-scale disaster such as earthquakes and flood caused the significant economic losses and challenged the continuity of business operations across the continents.

Take the example of Taiwan, it is strategically critical in the Global Value Chains of Electronics Industry [51]. Taiwan Semiconductor Manufacturing Company (TSMC), the world's largest dedicated semiconductor foundry and APPLE's sole supplier as well as Qualcomm's supplier, operates its largest 12-inch wafer production facilities in the Southern Taiwan Science Park. When 2016 Kaohsiung Earthquake shook the electronics hub in Southern Taiwan, major highways, highway bridges, railway. Taiwan High Speed Rail (THSR) system suspended south-bound service from Taichung for 2 days. The public services such as water and electricity supply, transportation and communications services interrupted from 2 to 7 days. As a leading company, TSMC incorporate BCP in its risk management vertical integrated with its suppliers. In the case of Kaohsiung Earthquake, TSMC minimized the losses at "work in progress" of its first-quarter shipments [52] [53]. Fortunately, TSMC's maintain more than 95 percent of the tools fully function after restored in two to three days. In addition, staff was safe and the TSMC Tainan facilities were structurally intact.

TSMC's strategy is to enhance the seismic resistance of facilities along with emergency response skills in line with ISO22301. With the above-mentioned ant seismic methodologies, the public sector provided the emergency response information of critical infrastructure situation (such as power or water, roads or logistics) according to its timelines stated in Fig. 15. TSMC's emergency team will respond to disasters on business continuity through a common operating picture provided by click the webpage of http://eocdss.ncdr.nat.gov.tw/web/. The webpage provided real-time monitoring data integrated including evacuation information for emergency response. In addition, Fig. 9 provided TSMC the possible impact on

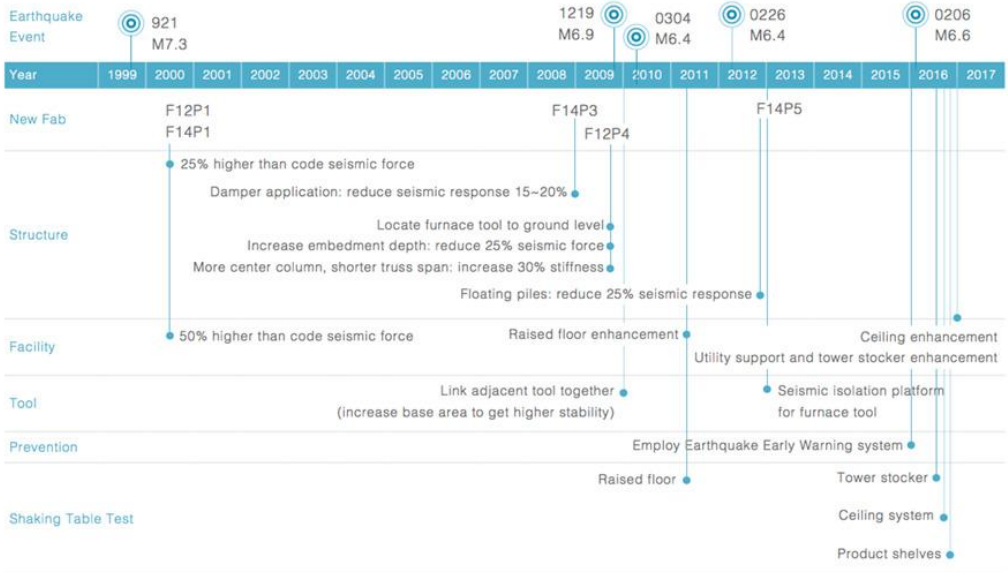


Fig. 14 TSMC Anti-seismic Methodologies Timeline

future building/Fab structure damage might induce by the liquefaction after earthquakes if liquefaction.

In another hand, TSMC, Science Park and the general publics can receive early warning message sent by the public sectors through smart devices. Ever since the South-East Asia Earthquake and Tsunami in 2004, Taiwan put its effort in developing a proactive early warning for earthquakes. From detecting earthquake, measuring tidal pressure change, relaying signals, to issuing warnings, the end-to-end early warning connect TSMC, science park and the general public on real-time basis since 2013 in Taiwan. A public warning system in operation is designed to send earthquake and typhoon alert to 4G cellular phones by using Cell Broadcast Service (CBS) in responding to disasters for PPP connectivity.

Base on the findings of PPP collaboration with hi-tech industry, in the case of emergency response for TSMC and Science Park, strategic planning across the borders are critical for BCP in term of critical infrastructure safety and supply chain resilience. Thus, for encouraging wider, more effective business continuity planning in APEC economies to mitigate risks, APEC Emergency Preparedness Capacity Building Center (EPCC)[54] and Nagoya Institute of Technology (NiTech), Japan co-hosted 'The 2017 APEC Summit on Resilience and Capacity Building Training Workshop on Promoting Business Connectivity in Nagoya" [55] to explore the challenges with actions on regional BCP/BCM. For further connecting the 'Business Clusters' cross-border toward supply chain resiliency, it is a must to have a common operating picture of information and risk or situation assessment for join operations, drills and exercises on emergency response and preparedness. In this context, the Strategic Planning for Regional Connectivity (Fig. 16) was formulated according to the fruitful results of the APEC summit. From APEC best practices and capacity building process, the Strategic Planning for Regional Connectivity identified key components for the strategic planning process. The findings can be divided into 6 dimensions on the core value - leadership, vision, goals, mission and backbone support with action plans to succeed and guide business connectivity countermeasures for GVCs/Supply Chain connectivity.

Through implementing the APEC multi-year project, we have key findings and lessons learned from SME's capacity building on BCP after the 2011 Great East

Fig. 15 Strategic Planning for Regional Connectivity

Japan Earthquakes. As indicated, in Fig. 16, in support of the efficient join operation for emergency response and preparedness base on PPP end-to-end scenario-based exercise or emergency operations across the borders indicated in Fig. 3, we have to enable an effective real-time digital resilient communication through ICT application on information dissemination networking indicated in Fig 17 and Fig. 18. Adopting user-friendly GIS-evidence-based platform, stakeholders can speak on the same page with common operating picture to facilitate the effective and efficient emergency operation. For the public sector, GIS-evidence-based information sharing through website and social media is important to provide information for formulating realistic BCPs, exercises or drills. In addition, clear and reliable information to some extent supported the leader to coordinate disaster team efforts. Meanwhile, strong leadership to coordinate the cross-sectorial efforts through PPP is the key to accomplishing the mission of implementing operational model of scientific-based BCP/BCM through PPP collaborations. As strategic objectives, GVCs and supply chain connectivity synergized regional collaborations for human well-being. With common operating picture on real-time monitoring data integration, the GIS-Web-based platform can facilitate the join discussion for cross-

border collaboration on PPP. With join efforts, we can facilitate business resumption and knowledge transfer for the regional BCM while large-scale disasters. In the long run, adopting the newly emerged technology such as internet of things (IoTs) tools as backbone support for cross-borders situation assessment in terms of time/cost efficiency and convenience.

5.2 Public Private Partnership through Technology and Collaborations

For regional connectivity, a common picture of situation upheld team efforts. In the digital era, Digital preparedness is a cornerstone of evidence-based DRR approach. It offers value-added knowledge for emergent response while decision-making, process from big data and open data to information intelligence in a timely manner. However, there are technical and policy barriers for developing countries to utilized crowdsourcing, ICTs or IoT technology to build up an analytical database and integrated systems with proper telecommunication tools for cross-border BCPs or regional emergency preparedness from data collection to applications, especially for a cross-border or large-scale disasters. Taking into account of the diverse social-economic datasets of demographic characteristics, economic activities, educational background, gender, level of public awareness and etc., it is essential to carefully interpret and identify the social vulnerability with gaps for enhancing regional capacity building as a whole society. These parameters from social science perspectives help capacity building at community level and reshaping actionable information from “big data and open data” approach for sustainable economic and business activities.

Digital preparedness for join emergency operation is a fundamental of evidence-based disaster management with value-added knowledge to support decision-making over quality data and information. Case studies from the recent large-scale disaster in the Asia Pacific clearly identify the emerging needs of applying big data and open data for emergency preparedness. Located in a highly disaster-prone area, Asia Pacific regional capacity building on big data and open data is critical to human security, trade and investment.

In case of the lessons learnt from the 2011 Great East Japan Earthquakes and Tsunami, the analysis using big data can provide the in-depth view on human behaviors and reactions to the shakings and warnings as well as the traffic flow in different phases. In 2013, Taiwan has introduced the Common Alerting Protocol (CAP) to standardize disaster information for dissemination though multiple channels. Google Crisis Map is one of the platforms to outreach the general public in Taiwan for sending the alert on demand in times of disasters. In 2016, five system operators of the fourth-generation (4G) telecommunications officially join to

provide the Cell Broadcasting Service **(CBS)** to mobile phone users. While enjoying economic prosperity, regional capacity building and public-private synergy in APEC, Taiwan adopted an innovative approach to raise public awareness and ensure wide coverage of information dissemination for emergency preparedness through technology and collaborations on PPP.

5.2.1 Digital Preparedness for Natural Hazards in Taiwan

After 2009 Typhoon Morakot, every outcome and collective verified information are displayed on GIS-Web-based platform for situation assessment and join operation for decision-making at all level public sector in Emergency Operation Centers (EOCs) operations in Taiwan. In order to prevent delayed or inadequate information as well as provides a common operating picture for effective and efficient discussions, the scope of information sharing expended from central to local governments and even NGOs to empower the information preparedness and knowledge transfer at grassroots levels. A quality collaboration with NGOs on proactive resources allocation, governments can direct benefit from obtaining the first-hand reliable on-site data to take further action with NGOs[56.]

To further enhance risk communication and awareness through push strategy[57.]and maximize coverage on information dissemination for typhoon season, Taiwan adopted strategies on managing disaster communication and information flow through distribution channel[58.]approaches to collaborate with private sectors. Thus, Taiwan promoted corporate social responsibility and collaborate with private sectors to develop channels for disaster Information Dissemination.

Taiwan ranked the second highest ratio of convenience stores per population density in the world. In March 2017[59], there were 10,662 different convenience stores in Taiwan, with an average of one convenience store for every 2,211 people nationwide[60.] Convenience stores in Taiwan, with their wide variety of services and products, along with their widespread distribution and convenient access make them a very important part of Taiwanese society.

Since late 2011, the 7-ELEVEN convenience chain stores undertook the roles of situation feedback and information dissemination while disasters for easy access to the up-to-date information at township level. In 2012, 7-ELEVEN has piloted a successful story on public private partnership to outreach the drop-by customers and tourists. With 7-ELEVENs direct report of the on-site real-time information such as water levels for the emergency operation center at central or local level to take proactive countermeasure in response such as road closure or search and rescue (SAR) deployment.

5.2.2 Public Private Partnership on Enhancing Information Coverage

Sending the decent and clear information just in time to the targeted audience is very challenging in the digital age in terms of time efficiency and coverage. The Collaborate with Google to launch public alerts and crisis map in Taiwan, Through Google Public Alerts system, Taiwan launched a dedicated crisis map since 2013. Such alerts will also appear on Google Search, Google Maps and Google Now in the case of Typhoon. In another hand, earthquakes and full spectrum of natural disasters alert and information are also available on Line since 2017. (Fig.17)

Fig. 16 Disseminate Information, Alert and Early Warning by NCDR

5.2.3 Enhancing Disaster Information Flow through Open Data Platform

The data sources of warning messages in CAP format came from government authorities and public servicing sectors (Fig. 18). Messages in CAP format are open to the internet service providers, APP developers, research institutes and industries as open data free-of-charge for further add-on development such as DRR APPs. For Smartphone users, the end-to-end warning messages dissemination approaches are the most efficient just in time delivery. With introducing the 4G mobile technique, the on-going cell broadcasting system (CBS) project aimed at sending alerts and warnings by the Public Warning System (PWS) with sirens or alarms as top priority messages from Mobile Network Operator(MNO) to the smartphone users if earthquakes or immediate threats or emergency.

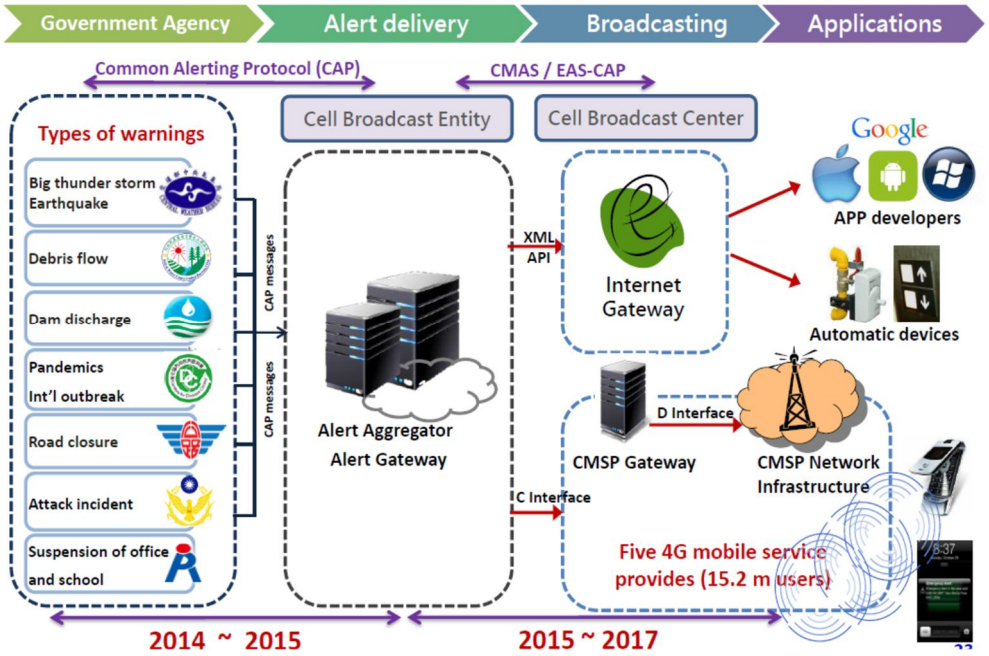


Fig. 17 ICT Applications for Disaster Risk Reduction in Taiwan Picture by NCDR

5.2.4 Challenge

– The Dynamics of the Whole Society, Real-Time Situation and Disaster Management vs. Big data/Open data Application and Data Crawling

'Dynamic 'of people, goods and services movement as well as 'Real-Time' situation and environment while natural disasters always headache decision support officials in providing situation assessment for proactive action. In the case of large-scale earthquake, the scenario analysis for seismic risk in urban areas, locations, population density and distribution are the key factors to shape the strategic approaches on how to mitigate possible casualties by taking proactive countermeasures. The circle of collecting real-time situation from media and social media using data crawling (Fig. 18) can to some extent maintain the data dynamics for situation assessment.

Fig. 19 Proactive Collaborate with Media and Social Media for Collecting Situation/Event and Outreach the Potential Affected People by NCDR

To resolve the situation, National Science and Technology Center for Disaster Reduction (NCDR) collaborated with the Chunghwa Telecom (CHT)[61], the leading telecom service provider with 80% of the broadband market and 35% of the wireless market in Taiwan[62].. We collect the real-time population density and distribution by tracing mobile signals at specific grids to simulate the population distribution pattern. In the case of earthquakes, the CHT provides data updates (Fig. 19) to support data integration of clear common operating picture for CEOC operations in Taiwan through the integrated scientific and social economic data.

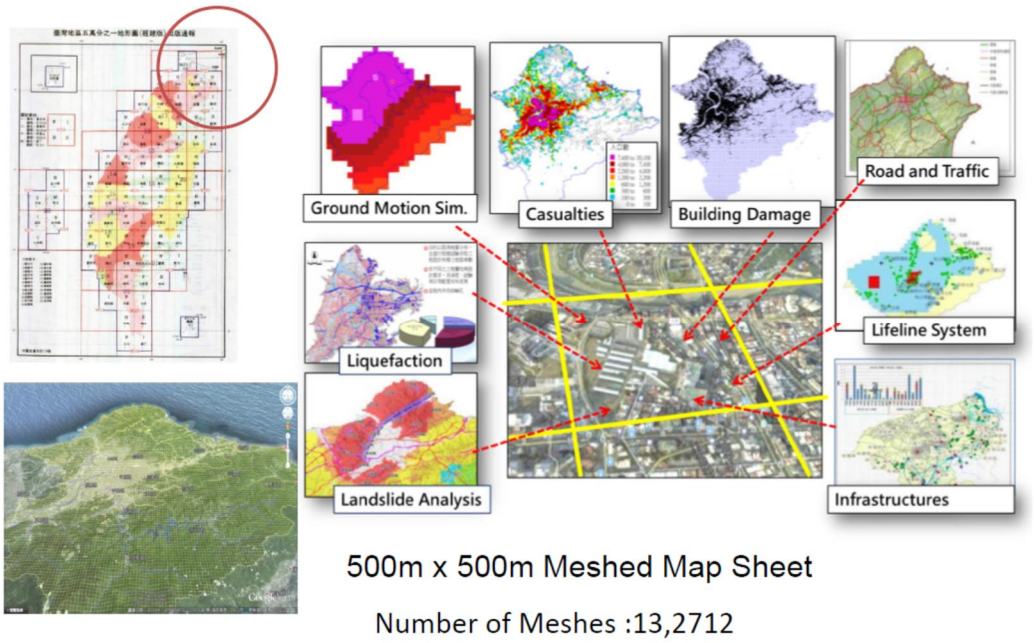


Fig. 18 Apply Big Data for Earthquake - by Adopting Geospatial Meshed Data

5.2.5 ICTs

- The Backbone Support of Emergency Preparedness

Government and business operations increasingly depend on the reliable telecommunication infrastructure across the globe on daily operations. As a pillar of regional connectivity, the ICTs infrastructure is recognized as the enabler to facilitate the flow of goods, people, money, services and knowledge within and across the borders[63]. Meanwhile, ICT plays an important role to enable timely disaster response, management and preparedness in promoting DRR and risk awareness. Nowadays, ICTs have been widely adopted in DRR solutions at the national and regional levels, the development of sustainable and resilient infrastructure and the role played by ICT in last mile information dissemination and community empowerment particularly for marginalized communities[64].

Taiwan located in a disaster-prone area where received typhoons annually for water supply along with wind damages, floods, landslides and debris flows. Due to extreme weather events and potential large-scale earthquakes, risk exposure of natural hazards to land and population increases and becomes major threat to national security. The 2005 World Bank Report[65] highlighted Taiwan's exposure to natural hazards is extremely high and vulnerable to natural hazards on Earth. Discussing hazards, vulnerability, marginalized communities and disasters in Taiwan along with case studies of 1999 Chi-Chi Earthquake and 2009 Typhoon Morakot and 2016 Kaohsiung Earthquakes, rapid urbanization, high population density[66], aging society are also contribute to its social vulnerability and escalate the risk level to multiple natural hazards in terms of significant economic and life losses. Hence, it is a demanding priority to develop an integrated platform with ICTs backbone support for emergency management and operations to engage the whole society's participation. With Technology and Collaborations, the unique operational model for emergency management in Taiwan functioned to facilitate the emergency preparedness and risk communication.

5.2.6 A Scientific-Evidence-Based Decision Making Operational Model

- for PPP on Disaster Risk Management in Taiwan

The ideas for developing A Common Operating Picture on GIS platform aimed at keeping information clean and neat on one page to facilitate cross-cutting issues discussion and inter-departmental coordination while emergency operation. A Common Operating Picture on GIS platform functioned to bridge information gap from central, local and community level of emergency preparedness and response in Taiwan. Thus, the National Science and Technology Center for Disaster

Reduction (NCDR) provided a GIS platform for decision-making support and share the integrated data provide by public sector on real-time basis. The platform is recognized as user-friendly, clear and easy to understand as well as flexible to meet emergency operation demands.

5.3 The Concept of Regional Collaborations

How Resilience can be Encouraged

In order to strengthen resilience through managing future risk, reducing current risk and build back better for maintaining positive cycle of reinforcing structural and non-structural mitigation, it is critical to conduct join integrated risk assessment on multi-hazards, socio-economic dynamics and take advantage of the innovative science and technology in the digital age[67]. Following the "Strategic Planning for Regional Connectivity", the conceptual operational model for enhancing disaster resilience and connectivity through PPP, the conceptual operational model (Fig. 21) elaborated the synergy among stakeholders on PPP through strong leadership.

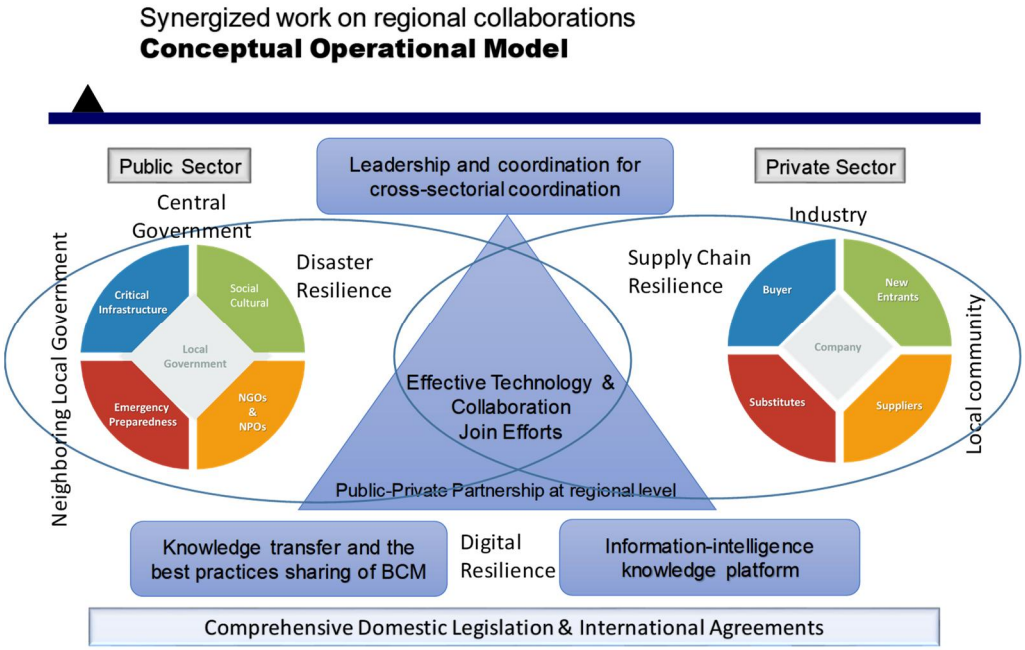


Fig. 20 The Public, Private Partnership Conceptual Operational Model

Data collection for information-intelligence knowledge platform

For connectivity among stakeholders, effective technology such as smart devices are user-friend tools for data collection and information dissemination through

social media for emergency response. To deal with the response dilemma in corporate and dynamics of situation while disasters, big data and open data jump up to be the major data input for DRR, emergency preparedness and operations. Thus, using of big data to generate quality data for information transmission, exchange, storage, display and dissemination in disasters to improve knowledge transfer for raising the risk awareness is the key missions to succeed the public private partnership. Moreover, DRR required flexibility in problem-solving and strong leadership in coordinating the cross-sectorial to integrate scientific and social economic datasets based on GIS and evidence to tackle the case by case situation. For example, to conduct early evacuation prior to typhoon triggered landslide, we need to coordinate the data for situation assessment including typographic/demographic structure, weather forecasting, real-time rainfall monitoring, threshold values for flood or landslide and CCTV availability. Avoid responding in the dark, we need to collect as much as possible of good data for a successful typhoon emergency operations in perspective. In this context, to better prepare for disasters, efforts on digital preparedness help to picture comprehensive coordination in advance.

Knowledge Transfer and the Best Practices Sharing of BCM

From industry viewpoint, they can work as a team with public sector to obtain common operating picture for internal emergency respond internally and independently. For example, government sent real-time warning and alert through smart device as well as shared common operating picture (real-time situation assessment and integrated data) as open data posted on the webpage of its disaster decision making support platform. Corporate can receive real-time warning or alert and activate their BCP/BCM process by further utilizing the common operating picture to tailor-make their own by click to overlay mapping. As a result, corporate can seek new entry (new business partner), substitutes, supply and buyers base on their individual BCP for corporate decision and strategy on supply chain resilience and kept the business secrets within the internal process use only. In other words, the public sectors share the data or knowledge or situation base on the private sector's demand. Governments, NGOs and NPOs work as a team to collect big data for situation assessment and using open data to provide clear common operating picture with consideration of social economic issues and critical infrastructure safety online to guide disaster resilience effort with private sector to encourage a whole society participation. With the transparent information shared by the public sector, the joint efforts on PPP at all levels can facilitate business continuity, supply chain resilience and travel safety. Sharing information, knowledge and best practices through the information platform and smart device will direct benefit stakeholders from efficient and effective information flow in a timely manner at the regional landscape.

Effective Technology and Collaboration Join Efforts

To further benefit from data integrated, clear picture of risk or vulnerability help raising public awareness and decision making in public sector. Open data help to disseminate the information with limited cost to outreach the people in large. It is efficient to keep the general publics well-informed of the situation. Over time, Change of the mindset can be in progress for the general public to take action in disaster. Introducing big data and open data in disasters, Taiwan enabled the public private partnership to promote the team efforts among original datasets producers/aggregator, app/system developers, social media/intermediates as well as end users for better solutions. A developing example of Taiwan to adopt ICT application for disaster risk reduction from data collection to information dissemination in Fig 16 and Fig 17. The current PPP for operations turn out to be efficient and applicable to applying big data and open data for annual typhoons, floods, landslides and earthquakes operations.

With corporate/business secrecy concerns, a better model for public and private partnership is to keep each other's secrets within the internal process. Thus, the public sectors take proactive countermeasures through big data/open data approach, ICTs for information dissemination in real-time GIS basis for emergency preparedness at natural/regional level to monitor the critical infrastructure security, maintain social/cultural diversity and to coordinate NGOs/NPOs emergency relief efforts with synergy. Benefit from knowledge transfer from the public sector, the big and small enterprises benefit can activate their BCPs/BCM from clear picture of situation received to take further action in minimizing the business supply chain interruptions. For example, with these data received from public sector, the corporate can themselves make a business strategic planning to identify the availability of specific substitutes, possible suppliers, or options for secure shipment according to their BCPs/BCM. Both public and private sectors can maintain its independent operations through the big data/open data and ICTs approaches. In general, the public sector shouldered the disaster resilience responsibility and the private sector carried out the supply chain resilience mission. Central government with helping hand from local and its neighboring government can acquire synergy of team effort in delivering disaster resilience efforts. With the assistance of the nearby local community, the industry can be sustainable with manpower and resources allocation.

Leadership and Coordination for Cross-sectorial Coordination

Base on the successful story, best practices of APEC and case studies in Taiwan and hi-tech industry, the above-mention conceptual model on PPP in disaster management for collaborations are feasible to secure business activities, sustain

economic growth and human. However, in this model, the key concern leads to a successful PPP synergy is the strong leadership to coordinate the collaborations among public and private sector as well as stakeholders to achieve disaster resilience, digital resilience and supply chain resilience in sharing real-time situation and knowledge on a GIS-based information intelligence platform.

With the synergy of the PPP, the whole society can work more closely together and share the best practices on DRR for better management/business process and emergency preparedness to some extent it does enhance the BCP/BCM capability which is the key to maintain the country's comparative advantage[68], the corporate competitive advantage[69] and stabilize the industries and the society while disasters. The joint efforts on developing international, regional, subregional and transboundary cooperation through innovative technology/tools is a must to further safeguarding the transboundary economic activities with end-to-end concept for synergy. With sustainable buyers and suppliers, the quality growth of regional economic activities can be sustained if supply chain interrupted by natural disasters.

Furthermore, to maximize the synergy of R&D in developing state-of-the-art technology worldwide, regional-wide and national-wide, adopting PPP technology transfer to private sector/small enterprises for DRR through information-intelligence platform[70] will direct benefit the public sector/big enterprises from acquired experience, in-time situation and reliable feedback. Transform science and technology findings or assessment into understandable knowledge to fit into people's mindset with risk perception to trigger the actions is the work of art in disaster management. Moving from data/information toward intelligence, technology can help to deliver timely, accurate and actionable situation assessment for decision-making. Big data and open data can be of better efficiency to acquire quick information to facilitate the situation assessment.

Using big data and open data through PPP operational model to manage the dynamics and reliability on real-time basis is the key to structure the information intelligence GIS-based operations. Document GIS base situation and action was taken in each event from private/small enterprises can foster learning organization at community level in each experience-based operation. In order to maintain an efficient cycle of feedback among stakeholders, we can learn from experience. Through interpret and digest the situation via scientific findings, the information disseminated can be easy to understand for raising the general public's risk awareness. In this context, moving forward to "work as a team" and change people's mindset can be achieved as well as the goal of PPP at the regional level.

Based on the above-mentioned concept, the PPP conceptual operational model through technology and collaborations can be promoted through: 1) enhancing

digital preparedness on natural hazards for sound and smarter Investments, 2) enhancing disaster resilience through “business sectors helping business sectors” approaches, 3) developing private sectors by supportive public sectors, 4) resourcing “big enterprises to small enterprises” for resources allocation and experience sharing on GVS/supply chain resilience, 5) empowering “small enterprises to sustain big enterprises” on business continuity.

5.4 Synergized Regional Collaborations for Human Well-being

The increasing threats from devastating earthquakes and extreme weather call for the actions to enhance economic security in the world’s most natural disaster-affected region - the Asia-Pacific Economic Cooperation (APEC) region. Base on the practical experience of DRR project implementations in decades while the Sendai Framework for Disaster Risk Reduction (SFDRR) declared to promote the disaster risk governance and encourages innovation, science and technology DRR approach on raising the risk awareness and level of preparedness. It is important to build resilience in different sectors, discuss challenges to resilience and highlight the importance of multi-stakeholder engagement.

The objectives of safer and smarter regional strategy are to encourage the long term collaborations through technology, support the business sectors and enhance the cross-border trade and investments while large-scale disasters. With review of the lessons learn from the large-scale disasters in decades, the strategic approaches via technology and collaboration at the regional level can be now focused to tackle the challenges of the large-scale disaster. By using Information and communication technology (ICT) for effective information management in practices, we need a common clear picture of situation for emergency preparedness, response and recovery in managing disaster risk and secure sustainable growth at the regional level. The local knowledge, scenario-based excises and integrated drills based information platform can help synergized the PPP in managing risks to mitigate the impact of disasters. Base on the PPP, using dynamic science and technology approaches to support the emergency preparedness and operations at the national and regional levels become possible.

In addition, we have to take into account of natural disaster risks as well as facilitating disaster risk awareness and communication, the involvement of stakeholders is critical concerning the effective information dissemination if disaster. Further Focusing on strengthening end-to-end communication on enhancing connectivity through joint efforts is an effective outreach to the whole society’s participation for pursuing the human wellbeing in the future.

Using innovative IoT tools, big data and open data for business vulnerability assessment at the regional level is convenient and widely accepted at country and regional level to mitigate the supply chain interruption. It is critical to build a GIS-based information intelligence platform for information sharing and continuing the effort in promoting supply chain resilience. With common operating picture on real-time monitoring data integration, the GIS-Web-based platform can synergized support though the join discussion for cross-border collaboration on PPP. Through technology support and collaborations, the interoperability cross-border can be feasible to promote scenario-based exercises and drills as well as share the historical events, experience and lesson learned.

The synergy of collaboration for PPP operational model can facilitate technology transfer from the public sector to the private sector, from big enterprises to small enterprises for profitability and sustainable growth. Both the public sector/big enterprises and private/small enterprises can benefit from the resilient GVCs/supply chain through BCP/BCM capacity building activities to work as a team on common picture for DRR.

6. Appropriate Public Private Partnership Approach for Collaborations

How Worst or Resilient We Are in Disaster

ICT strategy is efficient and critical into human's daily operations. From end-to-end connectivity; scientists, engineers and practitioners benefit from efficient and effective information and communication technology in all phases of disaster risk management from reduction, preparedness, response to recovery. Enhancing disaster resilience in the digital age, IoT as one of the powerful tools provide both macro- and micro- viewpoints through supply chain as well as scientific findings and social economic impact for decision-making of disaster risk reduction or emergency response.

In order to interpret and massage informative/multiple inputs for demands among stakeholders, it is critical to identify efficient use of ICT for action. Team builder benefits from real-time information sharing for disaster management to coordinate actions through variety of channels including smart device upon public-private partnership. Partner with social media in years, emergency responders and scientists in Taiwan has developed a PPP approach to integrating scientific outputs into emergency operation while typhoons and earthquakes. The results do prove well-organized information shared by ICT enhance both emergency operation and public awareness in a timely manner.

However, the capacity of community from central to local government, from public to private sector as well as from developed countries to developing countries are different. This chapter discussed the synergy of collaborations among stakeholders and concluded with the "Appropriate public private partnership approach" with future perspectives.

the conceptual operational model for safer and smarter regional strategies through technology and collaborations between public private partnership for enhancing disaster resilience through global supply chain connectivity should be promoted through: 1) Enhancing Digital Preparedness on Natural Hazards for

Sound and Smarter Investments, 2) Business sector helping business sector to enhance disaster resilience, 3) Public sector help uphold private sector, 4) Big leads small for resources allocation plus Small sustain big on business continuity

Evaluate risks on investment decisions need not avoid disaster-prone area but transparent risk disclosure of the national and local strategies for disaster risk reduction such as BCP/BCM in place for recovery. The risk and scenario-based approaches for public private partnership can help each counterparty to have drills and exercises base on the feasible/dynamic scenario. Through the process from identifying situations, risk and cascading impact, the proactive countermeasure can be deployed to activate BCPs/BCM, SAR and early evacuation according to the vulnerability / GIS-Based Common Operating Picture for join operations. (Fig. 22) Constantly review the risk and scenario-based approach for public private partnership joint operations can help to evolve the approach to better support experience-based operation against “New Normal”.

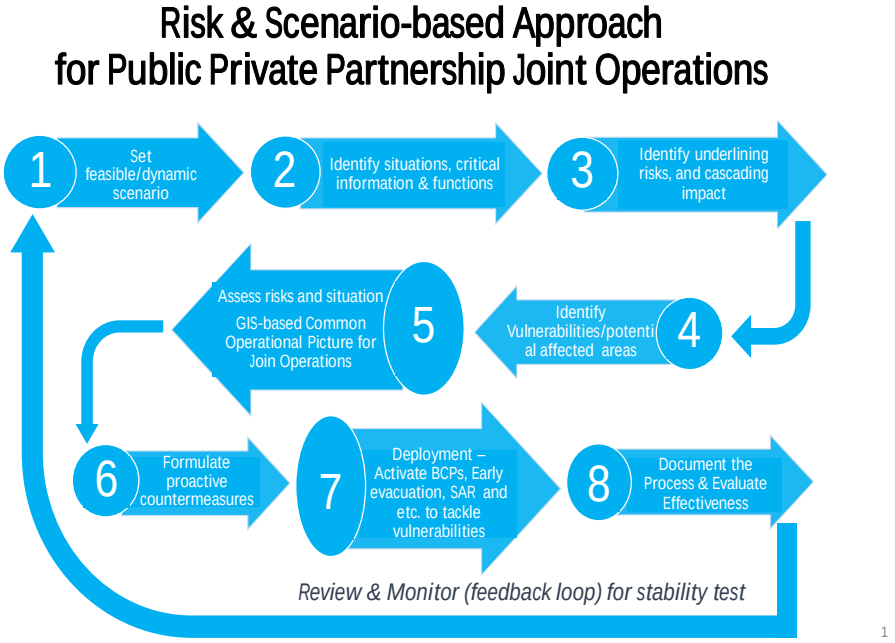


Fig. 21 Risk & Monitor Process

6.1 Appropriate Public Private Partnership Approach

A new people-centered approach of enabling innovation on Public Private Partnership collaboration for sustainable development

The concept of Appropriate PPP approach is based on the fundamental of people-centered oriented model aim at user-friendly, minimal entry barrier/training pre-

requisite, small-scale, decentralized, energy-efficient, easy to maintain, environmentally sound, locally autonomous, open source enabling and cost-effective. In this context, appropriate built on the fundamental element of availability and people's need. In the case of information dissemination, knowing the web/social media user's behavior is important to outreach the general public in large. For instance, sending messages through Facebook, Apple, Amazon, Google (FAAG) and Twitter in the United States can be an efficient appropriate PPP approach for sharing information. While sending messages, it is efficient to engage PPP approach for collaboration with Google, Line and Facebook in Taiwan, WhatsApp in Indonesia, WeChat and QQ in China and Facebook and Messengers in Japan, Thailand and the Philippines. Collaborate with the popular social media is the fundamental element to succeed the appropriate PPP approach in targeting the general public in large. Putting appropriate PPP approach into perspective, thing-made-easy is the way to connect people day in and day out. Then, DRR can become an attitude or a lifestyle for better emergency preparedness and response. To sum up, "appropriate" built and based upon people's need and human behavior. It is the theme we adopt in public private partnership approach targeted in long term development perspective.

In general, the synergy of collaboration for Appropriate Public Private Partnership Approach (Appropriate PPP Approach) will facilitate the technology transfer from the public sector to the private sector. The easy access people-centered approach can encompass technological choice and application at community level in small-scale, decentralized, energy-efficient, environmentally sound, locally autonomous and open source base (can be freely accessed on the Internet). Fig. 23. State-of-the-art technology can be found at the lab, national, regional or global level of R&D activities with available funding scheme for economic, science and technology strategy. However, markets, industries, corporate or households concern more on the profitability and cost of living while making decisions to allocate resource or funding/money spending. The Public sector can be efficient to acquire the real-time data/situation/feedback from communities for CEOC operation or DRR decision support cross boundary. Technology made-easy at community/local level is the key to empower the public private partnership for DRR on a real-time clear common picture of the situation while disasters.

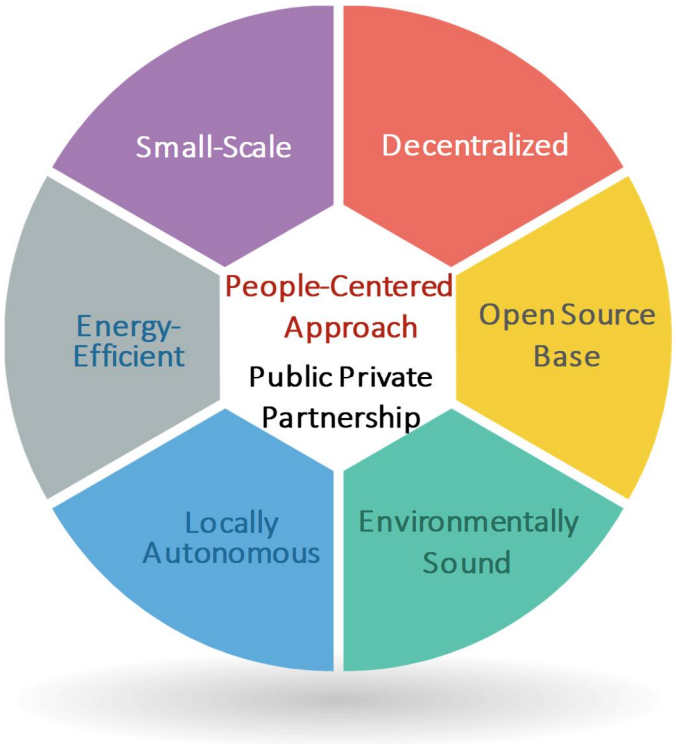


Fig. 22 Concept of Appropriate Public-Private Partnership Approach

6.1.1 Taiwan Adopting the Appropriate PPP Approach in Natural Disaster

Introducing the concept of GIS-base open source data to facilitate risk communication on a common picture for operation in Taiwan, the CEOC benefit from minimal language barrier to "talk on the same page" with clear and comprehensive picture in coordinating the appropriate PPP approach for operation. Map is easy to understand. Accompany with critical information of impact or situation to some extent help the stakeholders to synchronize the actions in disaster.

Appropriate information sent to or broadcasting in the appropriate location. For instance, airport open or close or delay are critical to tourists or business travelers. For traveler facilitating perspectives, the appropriate PPP approach is to collaboration with airport authorities at the regional level to provide clear common picture for travelers/tourists to take further action. Thus, easy to understand is key to invited private sector's participation. Information made-easy in GIS-based can minimize the lead time of digesting the information and provide a holistic view of what's happening in the affected area, the neighboring economies and communities.

Messages to the general public must be single, clear, actionable and real-time. In another hand, messages to emergency responders must be real-time and clear to support deployment and actions; information to commanding officials must be real-time, integrated and comprehensive situation assessment for decision-making on resources allocation and evacuation. Not only message/information sharing but

also coverage, the end-to-end connectivity must connect the whole society among stakeholders to facilitate the supply chain resilience.

For people connectivity, Taiwan adopted appropriate PPP approach to engage the possible channels for information dissemination through convenience stores, the Internet, Public Warning System, Cell Broadcast Service, TV and smart devices. In order to empower PPP for promoting disaster resilience, better display of the disaster warning with variety of channels to inform end users. Basic standards or protocols are required to formulate business conduct to follow. Through the above-mentioned process, the big data can be turned into open data for better efficiency and effectiveness for sharing. For examples, Taiwan introduced Common Alerting Protocol (CAP) application for exchanging warming messages and connecting smart devices to broadband Internet or Wi-Fi to acquire better risk communication in disasters.

In the case of Taiwan, the appropriate PPP approaches for people to people connectivity are partner with: 1) government agencies for data integration, 2) convenience store for information dissemination and on-site situation feedback, 3) community for big-data and open data information sharing, 4) NGO and NPO in Science Park for enhancing business resilience through BCP/BCM and critical infrastructure safety and resilience mechanism, 5) Social Media such as Google, Line and Facebook for enhancing information coverage.

To facilitate the end-to-end connectivity of the appropriate PPP approach, in the case of Taiwan, we sum up several key elements for maintaining a sound environment for decision support. First of all, the fundamental data collection and real-time monitoring information with clear and actionable message to raise risk awareness in both public and private sector. Secondly, engaging broad-band wireless telecommunications through social media (such as Google, Line or Facebook) for data collection and information dissemination. Thirdly, protocols and standards facilitated cross-platform application of information. Fourthly, GIS-based platform made easy to deliver risk communication mission. Finally, further acquired artificial intelligence (AI) to analyze structured- and non-structured big data will enhance the quality of better open data in the future process. With the five key elements, ICT will continue to play an important role in DRR and emergency preparedness in Taiwan practices.

6.1.2 Taiwan's Practice in Natural Disaster Emergency Preparedness and Response

For emergency response, a sensor networking monitored environmental changes and provided baselines for situation assessment before, during and after a disaster. For example, a sensor networking to identify threshold values of floods in a river basin usually includes several rain gauges for rainfalls, water levels of the river, soil moisture and operating pumping stations availability. For remote rural area, well-structured broad-band wireless telecommunications will facilitate data transmission for situation assessment. The lesson learned from recent large-scale disaster events in Taiwan, broad-band wireless telecommunication enhanced coordinated operations in the affected area from search and rescue, emergency relief, evacuation and shelter management.

An effective message for end user to take actions for disaster in progress, a real-time clear GIS-based time-dependent description with suggested actions is critical. Take the example for decision-making based on information intelligence for road closures in Taiwan. GIS platform provided integrated rainfall information (both hourly intensity and accumulation) and closed circuit television cameras (CCTV) real-time images to facilitate a proactive countermeasure for road closures.

For a successful appropriate PPP approach, coordination and communication are critically important. Especially for the end to end connectivity, early warning systems deliver messages to assist decision-making with clear common operating picture for better inter- and intra- agencies coordination. An appropriate PPP approach for risk communication among stakeholders provided a realistic scenario-based impact assessment for emergency preparedness, especially, when a large-scale disaster or cascading impacts occurred.

Web-GIS-based system is efficient for information sharing with emergency responders in scattering disaster affected sites. However, we suffered from no common platform in Taiwan while typhoon Morakot strike in 2009. The overwhelming result from checking too many individual systems operating independently to produce comprehensive integrate information for emergency response. It is not efficient and effective in a timely manner for real-time information sharing.

For bridging the gaps for communications between central and local government, a decision-making support platform designed by the National Science and Technology Center for Disaster Reduction integrated existing data shared by government agencies. In Fig. 24, the webpage displayed GIS information with real-time situation notes. The ideas are to keep information nice, clean and neat on one page. End user can freely overlap GIS layers by click on the webpage icons to have tailor-made picture on real-time situation at local level (government or community).

Fig. 23 A Typical Layout of "Common Operating Picture" Designed by NCDR

The appropriate PPP approach highlighted the engagement of the stakeholders on team efforts. To avoid government system break-down from sudden increasing volume of searching on the internet for situation of large-scale disaster, Taiwan engaged Google, Line and Facebook to send messages and leverage their bandwidth to tackle the excessive web surges. A pilot project with Google in 2013 and with Line in 2017 is welcomed by the general publics as best practices of appropriate PPP approach in sharing disaster alerts and geo-spatial information on Google's (Google Alert and Google Crisis Map) and Line's platforms. That is an effective and creative innovation approach in Taiwan, the public sector sharing open data with private sector.

6.1.3 Earthquakes Disaster Resilience Through Public Private Partnership: From Collaborations Integration to Practices for Business Continuity at Taiwan Science Park

Taiwan suffered from frequent disaster, under the "National Science and Technology Development Plan (2017-2020)", The Ministry of Science and Technology call for a project on "Enhance Disaster-Prevention Technologies to Mitigate Disaster Impact'. [71] The objectives are utilizing R& D capacity to improve warning systems and decision making mechanism in response to extreme weather, climate change, through smart technology on enhancing disaster resilience. Emphasizing on strengthening the R&D capacity in earthquake engineering, MOST aimed at promoting collaboration between academia and industry to build earthquake-resistant core infrastructures for boosting the capability of risk management. Applying big data and open data to improve information sharing. Through engaging R&D efforts on smart technology and ICTs, NCDR shoulder the responsibility to provide real-time common operating picture for emergency operation in the future. In another hand, located in Taiwan Science Parks, TSMC acknowledged the urgent need to enhance disaster resilience after the 2011 Great East Japan Earthquakes to minimize the supply chain interruption. With the same objectives and goals, a public private partnership project launched in 2018 on creating a win-win synergy for public safety and sustainable business operations. TSMC, The Allied Association for Science Park Industry, The Authority of Science Parks of MOST, Taipower Company, Hsinchu City Government (Public Health Bureau), and NCDR.

In 2017, Taiwan Semiconductor Industry Association (TSIA) host "International High Technology Environment, Safety and Health) Conference" (IHTESH) [72] in Hsinchu. TSMC held a technical program "Earthquake Protection" to promote the importance of enhancing disaster resilience through PPP networking. After frequent discussions and seminars for exchanging ideas, coordinating common interests and integrating capacity, a PPP networking synergy aimed at the Earthquake Emergency Management of Hsinchu Science Park Project launched in 2018 for sustainable growth and business continuity summarized in Fig 25. With consensus, two priorities for risk management are: 1) Strengthening Emergency Medical Services (EMS), 2) Mitigating the impact on power outage with quick recovery program.

An Earthquakes Crisis Management Project on enhancing earthquake risk management in the Science Parks for sustainable development and resilient supply chain launched to deal with disasters on PPP based on the conceptual operational Model illustrated in Fig 21. In four phases implementation of 2018, the objectives are:

Mission in Progress	Phase 1 Facilitate Cross-cutting Knowledge and Experience Sharing	Phase 2 Enhance Earthquake Risk Perception, Recognition, and Awareness	Phase 3 1 Integrate Situation and Communication for Emergency Operation	Phase 4 Strengthening Capacity for Robust Emergency Management
Risk Management	How to raise risk perception and improving risk management, and practices in the science park?	In the case of large scale earthquakes, conduct scenario simulation on the potential impact for the science parks Think of how to prioritized the resources allocation on minimizing supply chain interruption.	How to integrate the situation and data from each commanding center of business units for decision making? Formulating a process for information flow among public and private sectors. Establishing the communication protocol to facilitate the real-time communication on GIS common operating picture.	How to set a goal for PPP scenario simulation and conducting drills, exercises and emergency response in the science parks in the long run for improvement?
Deliverables on PPP	Establish an earthquake oriented platform for PPP dialogues on science and technology, risk management, experience and best practices sharing in a timely manner for effective communication and collaboration.	Raising risk awareness and strengthening preemptive countermeasure for emergency operation on: 1. Strengthening Emergency Medical Services (EMS), 2. Mitigating the impact on power outage with quick recovery program.	Ensuring the efficiency of information intelligence for communication in the case of earthquakes emergency operation. For future join scenario simulation, drills and exercises among stakeholders, TSMC, Allied Association for Science Park Industry, the Authority of Science Parks of MOST, Taipower Company, Hsinchu City Government (Public Health Bureau), and NCDR to improve the reporting efficiency from hour to minutes.	Scenario simulation on power outage and mass injuries, conducting the join drill and exercises for large-scale earthquakes to NCDR collaborated with Taipower Company to provide realistic scenario for join operation, drills and exercises among business units, medical system and infrastructure in the science parks.

Fig. 24 Earthquake Disaster Resilience Project in Taiwan Science Parks

For implementation of the above-mentioned project, NCDR established “Earthquake Emergency Management Model for Science Park”. The platform provided mitigation countermeasure, monitoring, Real-time GIS common operating picture and statistics for facilitating the collaboration through data integration. By adopting the concept of appropriate public-private partnership approach, in Fig. 26, big data and open data integration facilitated the transparency of situation while disasters. The fundamental elements for disclosure by public sectors are the availability of lifeline systems and real-time monitoring for emergency response, drills and exercises. Transparency helped to mitigate the panic in the marketplace. The comprehensive situation assessment based on the real-time information, impact and recovery in progress is the cornerstone for the collaboration and team work in times of disaster. Thus, based on the earthquake disaster resilience project in Taiwan science parks, NCDR designed earthquake disaster emergency management module for science parks to provide mitigation countermeasure, monitoring and common operating picture for enhancing supply chain resilience and business continuity indicated in Fig. 26. In this context, infrastructure of transportation, power and water supply are critical to business units. Benefit from easy understand and assessable common operating picture, business unites can take action to activate their BCPs/BCM respectively without external intervention. Thus, the response dilemma can be minimized to a certain extent. To be transparent, public sector took the lead on information disclosure through big data and open data to minimize supply chain interruption for collaboration and integration.

Fig. 25 Mitigation Countermeasure and Monitoring Function Designed by NCDR

The integration of the capacity among business units in the science parks is very challenging. With frequent communications, discussions, information sharing and dialogues, synergy from team efforts to integrate the resources and information benefit the economic activities among stakeholders in the science parks. In this context, the outcomes of science park project demonstrate the team work convergence of synergy on appropriate PPP approaches for enhancing disaster resilience from collaboration, integration to practices for business continuity. In another hand, the clustering effect of science parks contributed directly to raise the risk awareness and perception of the local community and neighboring government, upstream and downstream buyers and suppliers. In addition, by promoting BCPs/BCM, the public and private partnership enhanced team efforts on problem solving and emergency response through discussion, drills and exercise with synergy. On demand, strengthening the decision-making process and countermeasure through the public and private partnership can be expected through frequent join scenario-based exercises and drills. To further enhance disaster resilience in the science parks, we have to migrate from experience based operation to information based for business continuity.

6.1.4 Appropriate Pubic Private Partnership Approach in Science, Technology and Collaborations Perspective

Through broadly applying digital resilience countermeasures in Taiwan for disaster risk management, the direct benefits come from data quality improvement to support dynamic and location-based information display. With direct communications with the end users, scientists and emergency responders can have clear picture to bridge the gaps to deliver timely decision making and emergency

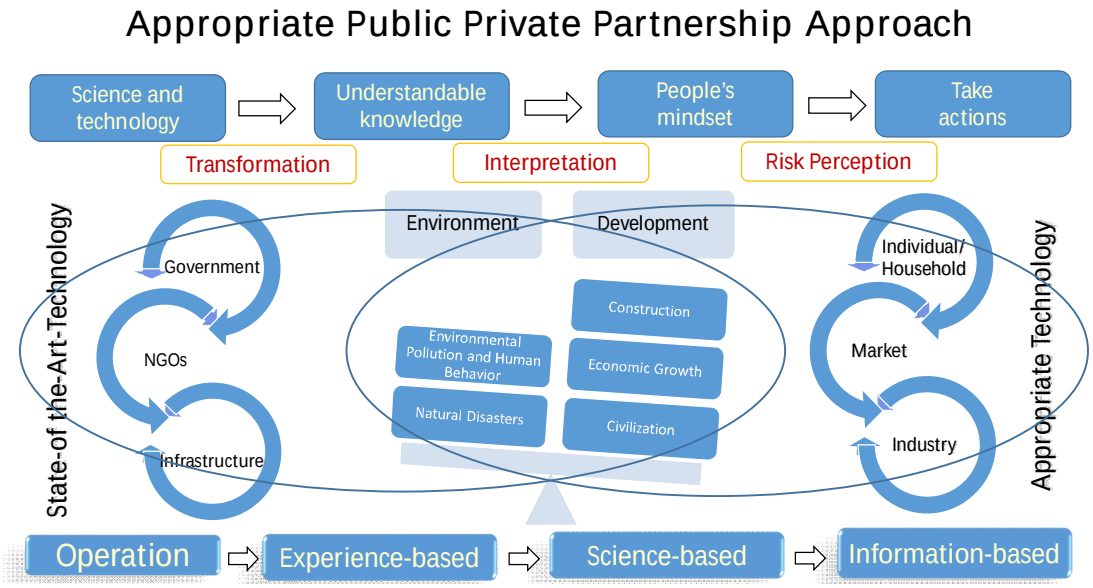


Fig. 26 Appropriate PPP Approach from Science, Technology and Collaborations Perspective

respond on a holistic and comprehensive picture. Nevertheless, the evolving process of an appropriate PPP approach to future challenges, stakeholders need to be flexible and open-minded to embrace future technology for PPP team efforts.

Appropriate PPP Approach incorporated concept of adopting the fundamental/basic level of technology. Open-Source Appropriate Technology (OSAT) and any of cost effective and energy efficient devices and mechanism can help to achieve the intended purpose on disaster risk management in different social condition for capacity building, robust and sustainable living. Thus, adopting the same logic extended from appropriate technology[73,] appropriate PPP Approach (Fig. 25) illustrated the collaboration, integration and relationship of economic development. One of the alternatives to technology transfer available from: 1) public sector to private sector, 2) more capital-intensive technology/industrialized nations to relatively labor intensive/developing countries.

In the case of 2016 Kaohsiung Earthquakes on Feb. 6, integrating disaster information is challenging due to the dynamic of situation and cascading effect of the afterquakes. Blackouts also increased the difficulty in sending information from the disaster affected area. In Fig. 28, using big data and open data, the practice to collect real-time information and situation from social media is a successful story of adopting Appropriate PPP Approach. The real-time information cycled from public and private sector available on-online facilitated the effective data integration process for better emergency response on synergy of team efforts.

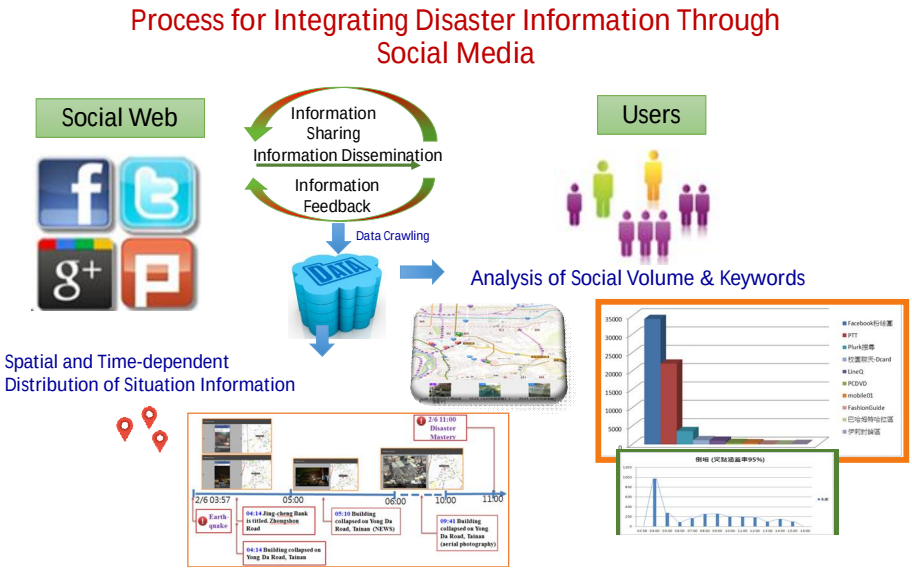


Fig. 27 Integrating Disaster Information form social media via Adopting Appropriate PPP Approaches

6.1.5 Big Data and Open Data Facilitated Disaster Risk Management

Adopting big data and open data in disaster risk management, a resilience digital preparedness definitely required vertical and horizontal integration through coordination among stakeholders from data collection, situation assessment to decision-making. The data or information flow among stakeholders must build on consensus over time for sustainable quality operation.

The big data obtain from governments or research institutes are fundamental. Outputs provided by the scientific community could include numerical simulations and data analysis with historical, statistical and spatial data. Those data inputs are critical for DRR planning with quantitative and qualitative risk exposure assessment using BIA in responding timeline.

Practical Improvements on Disaster Risk Reduction in Taiwan

Natural disasters brought huge uncertainties to strike the area in target. Typhoon forecasting challenged decision maker on “to do” or “not to do” as well as “where” and “when” in formulating proactive countermeasures. From the practical experience and collaboration in decades, scientists and emergency responders in Taiwan now work out an innovative approach for efficient and effective emergency operation and response.

Focusing on impact assessment, the scientific outputs both from numerical models, dynamic models and historical data are transformed into understandable operation-oriented charts, GIS maps and suggestions for actions. It is a huge engineering revaluation during the transformation process. Under “Learning-by-doing”, scientists and engineers work as a team to guide emergency responders to collect the information on-site for further risk assessment in support of decisions-making on evacuation and response. In the case of typhoon emergency operation, in the operation of CEOC, commending officials need to be fully aware of the possible impacts brought by strong winds or torrential rains in timeline with clear picture of “when?”, “where?”, “Scale of impact?” and “Scope of impact?” By conducting impact assessment, scientists open the eyes of commending officials to provide information intelligence support for early evacuation and resource allocation. The information intelligence for emergency responders and commending officials are not models or equations but clear GIS maps. All information are clear and operational from practical or historical experiences as well as knowledge learned by extensive dialogues and discussion. Multi-disciplinary approach adopted in risk or situation assessment is critical to have a holistic view for better emergency operations. The lesson-learn from disaster, Taiwan enhanced its disaster resilience from collaboration, integration to practices for business continuity and developed its unique PPP approaches.

2018 Hualien Earthquake, Taiwan

A magnitude of 6.2 earthquake hit Taiwan in Hualien area on February 6, 2018 at mid-night of 23:50:42(Taipei time) with the focal depth of 10km and maximum intensity of 7 at the strongest level. Four buildings collapsed with dead toll at 17 and 295 injured. Thereafter, 18 buildings tagged red flag (structure severely damage – no access) and 14 yellow flag (damage - restricted access). Forty thousands of households suffer water shortage and 1,794 suffered from power outage after the earthquakes. Four bridges closure due to structure damages. The direct economic loss reached up to USD 68 million.

Emergency Response Operation and Information Collection

After the earthquake hit, NCDR conducted the situation assessment through Earthquake Risk Assessment Program for Decision Making (EDM). From the real-time earthquake parameters received through PPP approach from the Central Weather Bureau, EDM automatically produced a report on passible impacts and identify disaster hotspots. For loss assessment, NCDR developed Taiwan Earthquake Impact Research and Information Application Platform (TERIA) to conduct scenario-based seismic disaster risk reduction efforts. The big data approach provide data input for EDM and TERIA operations. The big datasets consist of lifeline systems, demographic data, household information, fragility curves of bridges and buildings, geological data and etc. Ever since an earthquake hits Taiwan, a test run on EDM parallel the traditional earthquakes emergency operation process at CEOC. For example, 10 minutes after the Hualien earthquake, EDM produced a report of clear comprehensive situation picture for commanding officials in CEOC for decision making.

Typhoon Morakot Strike Taiwan on August 6-9, 1999

Typhoon Morakot brought record-breaking rainfalls trigger flooding, landslide and debris flows in Taiwan. From the lesson learned, a disaster management organization reshuffled and a decision-making support information platform initiated to provide information intelligence in GIS-Web-Based for emergency response.

Thus, Taiwan introduced the PPP approach through information sharing to local governments, NGOs/NPOs, business sector and communities for better preparedness at grassroots level. In local government perspective, delayed or insufficient information can’t proper support the decision making process. Improving information efficiency and effectiveness by adopting big data and open data approach, stakeholders both from public and private sector can discuss and respond the emergency on a common GIS platform.

For maximizing the synergy of R&D in developing state-of-the-art technology world-wide, regional-wide and national-wide, adopting appropriate PPP technology of disaster risk management in private sector will direct benefit the public sector on tax revenue from private sector, the private sector on minimized supply chain interruption again environmental disasters for sustainable growth.

By using big data and open data, it does offer new approaches to understand multi-faceted characteristics of natural disasters. More than traditional measurements on environmental changes, inputs from real-time and social-dynamic data expend the scope of emergency responders, researchers and decision makers to explore disaster impacts. To make better use of two different cetology data, special attention will help to produce useful information. Individual user groups, researchers, decision makers, disaster managers, emergency responders and citizens should build up constant dialogues to make better preparation through multi-lateral understanding.

6.2 Future Prospective

A New Approach towards Global Collaboration

– Engaging Stakeholders with PPP Strategy - Science-based/Knowledge-based Decision Making Support

From Big-Data to Open Data Towards IoT

The future generation enjoys well-developed technological, scientific and economic resources, which we should use to picture a more sustainable, equitable and inclusive future. In another hand, adopting emerging digital tools for deepening the collaboration to deliver change for quick recover the global supply chain, the minimum losses and cascading impact can be expected. By providing a global platform and common operating picture for public-private collaboration and operation, we can seek to advance the goal by working with governments, businesses and civil society organizations to find new ways of tackling the risks and challenges that affect us all. “Work as a Team” is the key to build up “One Global Resilient Society” for future generations. As global risks are increasingly complex, interactive and cascading, our responses must be highly interconnected across the borders and numerous global systems. Easy access, easy understandable GIS-based information with multi-stakeholder dialogue remains the roots of the strategies that will enable us to leverage a keen collaboration at everyone’s best convenience.

Top-down Approach

Transform science and technology findings or assessment into understandable

knowledge to fit in people's mindset with risk perception and trigger the actions is the work of art in disaster management. Using big data and open data in disaster management to manage the dynamics on real-time basis is the key to structure the information intelligence based operations. Document GIS base situation and action taken in each events to foster learning organization at community level with experience-based operation. To maintain an efficient cycle of feedback from private sector can learn from experience acquire, interpret and digest the situation scientific finding and disseminate the information with risk perception to change people's mindset and for transform science risk profiling and experience, bridge the gap from experience-based to scientific base operations to maintain real-time and reliable information efficiency, synchronize the proactive emergency preparedness, response and recovery as "one community".

Button-up Approach

Using Big data and open data to better understand customer behavior are critical while doing business or managing disasters risk. Disaster related datasets are critical for business continuity, emergency preparedness, response, mitigation and recovery. Private sectors' inputs, feedback and their active participations are critically important in public private partnership approaches to acquire reliable information and current situation on real-time basis.

Dynamic Approach

Moving from data/information toward intelligence, technology can help to deliver timely, accurate and actionable situation assessment for decision-making. Big data and open data can be of better efficiency to acquire quick information for situation assessment. After the Typhoon Morakot, "web information collection" emerge as new-assignment under New and Media Division of Taiwan CEOC operation. Following the complexity of internet environment, the team work efforts are focused on obtaining the reliable big data and open data for situation assessment, maintaining a knowledge-based information intelligence databank, identifying the fake news in time of disasters. In the case of Taiwan, take advantage of super/grid computing technology, the situation assessment team can process massive data in a timely manner.

Multi-Social media Approach for Coverage – Information Dissemination

None of the single media can cover world-wide. To promote risk awareness, it is critical to take advantage of user-friendly and easy-access approach by sending warning messages at user preference through popular social media such as Google, Line, Facebook, Twitter, WhatsApp and etc., to ensure the best coverage just in time in on real-time basis for better emergency management. The priory will be

building the cornerstone, the GIS-Based Decision Making Support Systems, to support the dynamic global services of providing a common picture on real-time basis for situation assessment, decision-making, information dissemination disaster risk management and recovery.

Key Considerations for Future Disaster Risk Management on Appropriate PPP approach

In decades, scientific community promoted inter-disciplinary approach to tackle natural hazards with vulnerabilities. The impacts of natural disaster on infrastructure, livelihoods, economy and sustainable development interacted with human behavior are the tough mission for researchers and disaster managers to achieve. Moreover, scientific model in every kind has its limits and assumption. The total solution for every situation does not exist in the reality. Coping with future challenges of natural hazards, disaster manager must be fully aware of the risk of misleading information or interpretation of scientific outputs which may possibly incur case by case.

Appropriate PPP approach depended on efficient and effective risk communication through information intelligence. How to present the data or information on GIS map is critical. In Taiwan, GIS is broadly applied to situation assessment and emergency operation. An illustrative GIS map consisted of spatial and time factor facilitated decision making (by commending officials) and risk communication (with the general publics) on clear picture. Pure text reports are not easy to attract attention of stakeholders and need more time to digest. How to make all the data in clear picture will be a challenging work toward an ever-changing disaster in larger-scale and scope.

Data and information exchange and sharing are always the most challenging issue to engage cross-cutting inter- or intra governmental dialogue for collaboration on PPP approach. However, through introducing well-defined and well-structure protocols, it may facilitate the information flow and applications among stakeholders. Cyber security is another developing challenge. Big datasets can be of intelligence sensitive, any leak of big data or fundamental data may higher privacy issues and national security crisis. Hackers and fake news can jeopardize emergency response and operation to certain extent. A future “anti-hacker” and “fake-news-filter” countermeasure need to be further developed to tackle the cyber security issue.

It is critically challenging to conduct impact assessment for emergency operation based on future extreme events, realistic scenarios or real historical situations for emergency operations, response, drill and exercises. Science has its limit and assumption but natural disasters. We need future research to prioritize possibly

impact through appropriate PPP approach to build data bank of scenario for training and emergency operations.

Smart devices not only help bring daily convenience, but also form new channel to collect situations while disaster. Pictures, texts or videos are effective ways for the general publics to report the situation on-site with GPS tags for CEOC to flag on GIS maps. However, huge volume of data process required to verify smart devices inputs including duplications, rumors and fake news. Future development is expected from the scientific community to formulate a better mechanism or methodology of "facts only inputs" via artificial intelligence or future technology.

As the world becomes more and more complex and interconnected, in this regards, enhancing disaster resilience through PPP from collaborations, integration to practices for business resilience becomes the top priority mission for the sustainable growth and inclusive development. The sustainable public and private sector based on a close collaboration to deliver team effort in respond to a common operating picture and synchronize the proactive emergency preparedness countermeasure, SAR deployment and recovery as "one community". Private Sectors need to look at those global risks with cascading direct or indirect impact on their business, to define a holistic approach in managing those risks. Public sector can facilitate the business resilience by 1) utilized big data and open data for situation assessment, 2) providing science-based emergency preparedness countermeasure and decision support, 3) facilitating the critical infrastructure safety and resilience 4) adopting ICTs on information dissemination for action. A PPP collaboration network needed to be built and having drills and exercises on scenario-basis. Obtain the reliable situation feedback from private sector, a knowledge-based information intelligence databank can help to put out "digital wildfires" of "fake news" in time of disasters on real-time basis. Thus, it is important to have reasonable scenarios to prepare for the possible impact. A scenario-based drills or exercises for join operations are critical to facilitate and maintain keen collaborations for public and private partnership to tackle the emergent threats.

Key directions to enable an environment for future research to explore IoT in natural disaster are: 1) To investigate current status of application and demands of data through a region-wide survey; 2) To develop a roadmap of capacity building on assisting neighboring economies in establishing big data; 3) To promote open data for a Safer trade environment; 4) To formulate a mechanism of information sharing on open data for strengthening emergency preparedness with actionable roadmap.

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Yanling Lee

RESEARCH ACCOMPLISHMENTS

(1) Peer-reviewed research paper

Ch. No.	Author	Title	Publication	Vol.	No.	Pages	Date
1	陳可慧、李燕玲、張芝苓、李維森、陳宏宇	「仙台減災綱領」相對於科技發展之檢視與建議	土木水利雙月刊 (Journal)	43	3	92 - 98	June 2016
2	Yanling Lee, Kenji Watanabe, and Wei-Sen Li	Exploring the Strategic Approaches in Support to Disaster Risk Governance for Public and Private Partnership	Proceedings of The 23rd Pacific Science Congress (PSC-23) 2016 - (Book and presentation) (Conference speaker)			323	June 13-17, 2016
3	Yanling Lee, Kenji Watanabe, and Wei-Sen Li	Enhancing Regional Disaster Resilient Trade and Investment – Business Continuity Management (to be published in April 2019 by Springer International Publishing	Proceedings of the 2nd IFIP Conference on Information Technology in Disaster Risk Reduction (ITDRR 2017), Publisher: Springer International Publishing (Book and presentation) (Conference speaker)				Oct 25-27, 2017
4	Yanling Lee, Kenji Watanabe, and Wei-Sen Li	Enhancing Regional Digital Preparedness on Natural Hazards to Safeguard Business Resilience in the Asia-Pacific	Proceedings of the 1st IFIP Conference on Information Technology in Disaster Risk Reduction (ITDRR 2017), Publisher: Springer International Publishing (Book and presentation) (Conference speaker)			Ch.14 pp 170 - 182	Nov 18-20 2016
5 & 6	Yanling Lee, Kenji Watanabe, and Wei-Sen Li	Public Private Partnership Operational Model- A conceptual study on implementing scientific-evidence-based integrated risk management at regional level	Journal of Disaster Research (Scheduled to appear in Vol.14 No.4.) (Journal)	14	4		

(2) Published research paper by chapters

Ch No.	Author	Title	Publication	Vol.	No.	Pages	Date
1	陳可慧、李燕玲、張芝苓、李維森、陳宏宇	「仙台減災綱領」相對於科技發展之檢視與建議	土木水利雙月刊 (Journal)	43	3	92 - 98	June 2016
	Wei-Sen Li, Yanling Lee	Global Forum on Science and Technology for Disaster Resilience. Nov. 23-25 2017 Tokyo, Japan	Global Forum on Science and Technology for Disaster Resilience. Nov. 23-25 2017 Tokyo, Japan (Conference)				2017
	Wei-Sen Li, Yanling Lee	Emergency Preparedness Capacity Building Center (EPCC) (New Initiatives)	The 7th APEC EPWG Working Group Meeting, Subic, the Philippines, Jan. 28-29, 2015 (Conference)				2015
	Wei-Sen Li, Yanling Lee	Moving toward to a safer and resilient business environment in the Asia-Pacific region	The 3rd UN World Conference on Disaster Risk Reduction (3WCDRR) Efforts to promote disaster resilience of private sector in the Asia-Pacific region, March 16, 2015 (Conference)				2015
2	Yanling Lee, Kenji Watanabe, and Wei-Sen Li	Exploring the Strategic Approaches in Support to Disaster Risk Governance for Public and Private Partnership	Proceedings of The 23rd Pacific Science Congress (PSC-23) 2016 (Book and presentation) (Conference speaker)			323	June 13-17, 2016
3	Yanling Lee, Kenji Watanabe, and Wei-Sen Li	Enhancing Regional Disaster Resilient Trade and Investment – Business Continuity Management (to be published in April 2019 by Springer International Publishing	Proceedings of the 2nd IFIP Conference on Information Technology in Disaster Risk Reduction (ITDRR 2017), Publisher: Springer International Publishing (Book and presentation) (Conference speaker) To be published in April 2019				Oct 25-27, 2017
	Wei-Sen Li, Sheu-Yien Liu, Huei-Ru Hsieh, Ke-Hui Chen, Chi-Ling Chang, Yanling Lee, Ming-Wey Huang	Observations and learned lessons from 2018 Hualien Earthquake, Taiwan	The Magazine 2018 Korea Society of Hazard Mitigation. (Journal)	18	5	39 - 50	Sep. 2018
	Yanling Lee(presenter), Kenji Watanabe, Wei-Sen Li	APEC O2O Initiative : Enhancing SME Digital Competitiveness & Resilience towards Quality Growth	12th APEC EPWG Meeting 2017 (Conference and Presentation)				2017

	Wei-Sen Li, Chi-Ling Chang, Yanling Lee, Ke-Hui Chen	Risk-communication-based information designed for decision making at times of disasters	4th Asian Conference on Urban Disaster Reduction, November 26~28, 2017, Sendai, Japan (Conference)				2017
	Li, Wei-Sen; Huei-Ru Hsieh; Chang, Chi-Ling; Chen, Ke-Hui, Lee; Yanling	Disaster Management for Earthquake in Taiwan	2016 International Conference on Landslide and Debris Flow Disasters, Nov. 16-17 2016 (Conference)				2016
	Wei-Sen Li, Yanling Lee, Huei-Ru Hsieh,	Summary of "APEC Policy Dialogue for SME BCP Forum and Workshop" Sustainable knowledge and capacity building on MSMEs for business resilience	APEC Policy Dialogue for SME BCP Forum and Workshop held in Clark Bay, Jan. 30, 2015 (Conference)				2015
4	Yanling Lee, Kenji Watanabe, and Wei-Sen Li	Enhancing Regional Digital Preparedness on Natural Hazards to Safeguard Business Resilience in the Asia-Pacific	Proceedings of the 1st IFIP Conference on Information Technology in Disaster Risk Reduction (ITDRR 2017), Publisher: Springer International Publishing (Book and presentation) (Conference speaker)			Ch.14 170 - 182	Nov. 18-20 2016
	Wei-Sen Li, Yanling Lee	Enhancing regional digital preparedness on natural hazards to safeguard communities and business in the Asia-Pacific	APEC Official Website (2015/SOM1/006) (Others-articles On-line publication)				2015
	Wei-Sen Li, Yanling Lee	Application of Big Data and Open Data to Emergency Preparedness	The 7th APEC EPWG Working Group Meeting, Subic, the Philippines, Jan. 28-29, 2015				2015
	Wei-Sen Li, Ke-Hui Chen, Chi-Ling Chang and Yanling Lee	Lesson-learned investments on evidence-based disaster risk management through series of national programs in Taiwan	Science and Technology in Disaster Risk Reduction in Asia. 2018 Elsevier Inc. (Book)			Ch. 15 239 - 252	2018
5	Yanling Lee, Kenji Watanabe, and Wei-Sen Li	Public Private Partnership Operational Model-A conceptual study on implementing scientific-evidence-based integrated risk management at regional level	Journal of Disaster Research (Scheduled to appear in Vol.14 No.4.) (Journal)	14	4		

	Wei-Sen Li, Yanling Lee, Ke-Hui Chen and Chi-Ling Chang	An Institutional Mechanism to Implement Science-based and Co-designed Disaster Risk Management in Taiwan	Co-designing Disaster Risk Reduction Solutions: Towards participatory action and communication in science, technology and academia (Book)				2017
6	Li, Wei-Sen; Lee, Yanling(Corresponding Author); Lin, Ming-Chieh; Chen, Ke-Hui	Science-and-Information-based Disaster Risk Management	3nd Asia Conference on Urban Disaster Reduction, 28 November 2015 (Conference and presentation)				2015
	Wei-Sen Li, Ke-Hui Chen, Chi-Ling Chang and Yanling Lee	Lesson-learned investments on evidence-based disaster risk management through series of national programs in Taiwan	Science and Technology in Disaster Risk Reduction in Asia. 2018 Elsevier Inc. (Book)			Ch. 15 239 - 252	2018

(3) 2015 - 2018 publication

	Year	Book/Title	Author	Presentation / Conference	Type
1	**2018**	Observations and learned lessons from 2018 Hualien Earthquake, Taiwan	Wei-Sen Li, Sheu-Yien Liu, Huei-Ru Hsieh, Ke-Hui Chen, Chi-Ling Chang, Yanling Lee, Ming-Wey Huang	The Magazine 2018 Korea Society of Hazard Mitigation. Vol.18 No.5, Sep, 2018.	Journal
2	**2018**	Public Private Partnership Operational Model- A conceptual study on implementing scientific-evidence-based integrated risk management at regional level	Yanling Lee, Kenji Watanabe, and Wei-Sen Li	Journal of Disaster Research Vol.14 No.4	Journal
3	**2016**	「仙台減災綱領」相對於科技發展之檢視與建議	陳可慧、李燕玲、張芝苓、李維森、陳宏宇	土木水利雙月刊，第43卷，第3期，92-98頁	Journal
4	**2018**	The 13th APEC EPWG Meeting in Papua New Guinea	Ke-Hui Chen, Wei-Sen Li, Yanling Lee, Chi-Ling Chang	2018 NCDR NEWSLETTER, 1	Online publication
5	**2018**	The 9th International Workshop on Natural Disaster Reduction and Management among Japan-Korea-Taiwan	Ke-Hui Chen, Wei-Sen Li, Yanling Lee, Chi-Ling Chang	2018 NCDR NEWSLETTER, 2	Online publication
6	**2018**	Typhoon Maria and torrential rain hit Taiwan	Ke-Hui Chen, Wei-Sen Li, Yanling Lee, Chi-Ling Chang	2018 NCDR NEWSLETTER, 3	Online publication
7	**2018**	The 7th DPRI-NCDR International Workshop	Ke-Hui Chen, Wei-Sen Li, Yanling Lee, Chi-Ling Chang	2018 NCDR NEWSLETTER, 4	Online publication
8	**2017**	Overview of 2016 NCDR International Events	Ke-Hui Chen, Wei-Sen Li, Yanling Lee, Chi-Ling Chang	2017 NCDR NEWSLETTER, 1	Online publication
9	**2017**	The 8th International Workshop on Natural Disaster Reduction and Management among Japan-Korea-Taiwan	Ke-Hui Chen, Wei-Sen Li, Yanling Lee, Chi-Ling Chang	2017 NCDR NEWSLETTER, 2	Online publication
10	**2017**	2017 International Training Workshop for Natural Disaster Reduction	Ke-Hui Chen, Wei-Sen Li, Yanling Lee, Chi-Ling Chang	2017 NCDR NEWSLETTER, 3	Online publication
11	**2017**	The 6th DPRI-NCDR International Workshop	Ke-Hui Chen, Wei-Sen Li, Yanling Lee, Chi-Ling Chang	2016 NCDR NEWSLETTER, 4	Online publication
12	**2016**	9th APEC Emergency Preparedness Working Group Meeting Held in Lima	Ke Hui Chen, Yanling Lee, Chi-Ling Chang, Wei-Sen Li	2016 EPWG NEWSLETTER, 1	Online publication

	Year	Book/Title	Author	Presentation / Conference	Type
1	**2018**	Lesson-learned investments on evidence-based disaster risk management through series of national programs in Taiwan	Wei-Sen Li, Ke-Hui Chen, Chi-Ling Chang and Yanling Lee	Science and Technology in Disaster Risk Reduction in Asia. 2018 Elsevier Inc. Ch15, P239-252	Book
2	**2018**	Initial Use of Big Data and Open Data on Disaster Risk Management	Wei-Sen Li, Ke-Hui Chen1, Chi-Ling Chang and Yanling Lee	2nd IFIP Conference on Information Technology in Disaster Risk Reduction (ITDRR 2017), UNWE Sofia, Bulgaria. Oct. 25 - 27th, 2017 (To be Published)	Book
3	**2018**	How ICT Changes the Landscape of Disaster Risk Management	Wei-Sen Li, Chi-Ling Chang, Ke-Hui Chen, and Yanling Lee	2nd IFIP Conference on Information Technology in Disaster Risk Reduction (ITDRR 2017), UNWE Sofia, Bulgaria. Oct. 25 - 27th, 2017 (To be Published)	Book
4	**2018**	Enhancing Regional Disaster Resilient Trade and Investment-Business Continuity Management (BCM)	Yanling Lee, Kenji Watanabe, and Wei-Sen Li	2nd IFIP Conference on Information Technology in Disaster Risk Reduction (ITDRR 2017), UNWE Sofia, Bulgaria. Oct. 25 - 27th, 2017 (To be Published)	Book
5	**2017**	An Institutional Mechanism to Implement Science-based and Co-designed Disaster Risk Management in Taiwan	Wei-Sen Li, Yanling Lee, Ke-Hui Chen and Chi-Ling Chang	Co-designing Disaster Risk Reduction Solutions: Towards participatory action and communication in science, technology and academia	Book
6	**2017**	Lesson-learned investments on evidence-based disaster risk management through series of national programs in Taiwan	Wei-Sen Li, Ke-Hui Chen, Chi-Ling Chang and Yanling Lee	Science and Technology in Disaster Risk Reduction in Asia. Ch15, P239-252	Book
7	**2017**	Enhancing Regional Digital Preparedness on Natural Hazards to Safeguard Business Resilience in the Asia-Pacific	Yanling Lee, Kenji Watanabe, and Wei-Sen Li	Information Technology in Disaster Risk Reduction. ITDRR 2016, Sofia, Bulgaria	Book
8	**2015**	台灣在國際安全中被邊緣化的角色 Taiwan's Marginalized Role in International Security	參與訪談人：李維森、李燕玲	公開發行 2015年2月27日出版	Book ISBN 978-1-4422-4059-9

	Year	Book/Title	Author	Presentation / Conference	Type
1	**2017**	APEC Summit on Resilience and Capacity Building Training Workshop on Promoting Business Connectivity	Wei-Sen Li, Yanling Lee	12th APEC Emergency Preparedness Working Group Meeting. 21-22 Aug, 2017	Conference
2	**2017**	Policy Dialogue on Science, Technology, Innovation, Food Security, Climate Change and Gender Empowerment by "Plant Back Better" initiatives	Wei-Sen Li, Sophia Yanling Lee	12th APEC Emergency Preparedness Working Group Meeting. 21-22 Aug, 2017	Conference
3	**2017**	APEC O2O Initiative : Enhancing SME Digital Competitiveness & Resilience towards Quality Growth	Yanling Lee, Wei-Sen Li	12th APEC Emergency Preparedness Working Group Meeting. 21-22 Aug, 2017	Conference
4	**2017**	Enhancing Regional Disaster Resilient Trade and Investment-Business Continuity Management (BCM)	Yanling Lee, Kenji Watanabe, and Wei-Sen Li	2nd IFIP Conference on Information Technology in Disaster Risk Reduction (ITDRR 2017), UNWE Sofia, Bulgaria. Oct. 25 - 27th, 2017	Conference
5	**2017**	Enhancing disaster resilience through global supply chain connectivity	Wei-Sen Li, Yanling Lee	Global Forum on Science and Technology for Disaster Resilience. Nov. 23-25 2017 Tokyo, Japan	Conference
6	**2017**	Risk-communication-based information designed for decision making at times of disasters	Wei-Sen Li, Chi-Ling Chang, Yanling Lee, Ke-Hui Chen	4th Asian Conference on Urban Disaster Reduction, November 26~28, 2017, Sendai, Japan	Conference
7	**2017**	Enhancing Regional Digital Preparedness on Natural Hazards to Safeguard Business Resilience in the Asia-Pacific	Yanling Lee, Kenji Watanabe, and Wei-Sen Li	Information Technology in Disaster Risk Reduction. ITDRR 2016, Sofia, Bulgaria	Conference
8	**2016**	Exploring the Strategic Approaches in Support to Disaster Risk Governance for Public and Private Partnership	Yanling Lee, Kenji Watanabe, and Wei-Sen Li	The 23rd Pacific Science Congress. 13-17 Jun 2016	Conference
9	**2016**	Disaster Management for Earthquake in Taiwan	Li, Wei-Sen; Huei-Ru Hsieh; Chang, Chi-Ling; Chen, Ke-Hui, Lee; Yanling	2016 International Conference on Landslide and Debris Flow Disasters, Nov. 16-17 2016	Conference
10	**2016**	Reviews and Reflections on 2016 Typhoon Season in Taiwan	Li, Wei-Sen; Chang, Chi-Ling; Chen, Ke-Hui2; Lee, Yanling	2016 International Conference on Landslide and Debris Flow Disasters, Nov. 16-17 2016	Conference
11	**2015**	Attend the 6th Asia Ministerial Conference for Disaster Risk Reduction (AMCDRR)	Wei-Sen Li, Yanling Lee	The 7th APEC EPWG Working Group Meeting, Subic, the Philippines, Jan. 28-29, 2015	Conference
12	**2015**	Application of Big Data and Open Data to Emergency Preparedness	Wei-Sen Li, Yanling Lee	The 7th APEC EPWG Working Group Meeting, Subic, the Philippines, Jan. 28-29, 2015	Conference

13	**2015**	Enhancing Regional Digital Preparedness on Natural Hazards to Safeguard Communities and Business in The Asia-Pacific (New Initiatives)	Wei-Sen Li, Yanling Lee	The 7th APEC EPWG Working Group Meeting, Subic, the Philippines, Jan. 28-29, 2015	Conference
14	**2015**	Emergency Preparedness Capacity Building Center (EPCC) (New Initiatives)	Wei-Sen Li, Yanling Lee	The 7th APEC EPWG Working Group Meeting, Subic, the Philippines, Jan. 28-29, 2015	Conference
15	**2015**	Moving toward to a safer and resilient business environment in the Asia-Pacific region	Wei-Sen Li (Co-Chair), Yanling Lee (Secretary General) APEC Emergency Preparedness Working	The 3rd UN World Conference on Disaster Risk Reduction (3WCDRR) Efforts to promote disaster resilience of private sector in the Asia-Pacific region, March 16, 2015	Conference
16	**2015**	The Application of Science and Technology in DRR Decision-Making	Hongey Chen, Wei-Sen Li, Yanling Lee, Ke-Hui Chen	亞太經合會第九屆資深災害管理官員論壇 APEC 9th Senior Disaster Management Officials Forum, Iloilo city, the Philippines, Sept 22-23, 2015	Conference
17	**2015**	Science-and-Information-based Disaster Risk Management	Li, Wei-Sen; Lee, Yanling(Corresponding Author); Lin, Ming-Chieh; Chen, Ke-Hui	3nd Asia Conference on Urban Disaster Reduction, 28 November 2015	Conference
18	**2015**	Update APEC-funded project of "Application of Big Data and Open Data to Emergency Preparedness"	Wei-Sen Li, Yanling Lee	The 8th APEC EPWG Working Group Meeting, Boracay Island, Aklan, the Philippines, May 13-14, 2015	Conference
19	**2015**	Report a self-funded project of "Scientific decision support for natural disaster emergency operations" (EPWG-PPSTI project to be held in Chinese Taipei)	Wei-Sen Li, Yanling Lee	The 8th APEC EPWG Working Group Meeting, Boracay Island, Aklan, the Philippines, May 13-14, 2015	Conference
20	**2015**	The updated EPWG Satellite website	Wei-Sen Li, Yanling Lee	The 8th APEC EPWG Working Group Meeting, Boracay Island, Aklan, the Philippines, May 13-14, 2015	Conference
21	**2015**	Brief on Emergency Preparedness Capacity Building Center (EPCC)	Wei-Sen Li, Yanling Lee	The 8th APEC EPWG Working Group Meeting, Boracay Island, Aklan, the Philippines, May 13-14, 2015	Conference
22	**2015**	Propose sub-group, "Business Continuity Plan"	Wei-Sen Li, Yanling Lee	The 8th APEC EPWG Working Group Meeting, Boracay Island, Aklan, the Philippines, May 13-14, 2015	Conference

	Year	Book/Title	Author	Presentation / Conference	Type
1	**2017**	APEC Emergency Preparedness Capacity Building Center	李燕玲	2017年亞太經濟合作(APEC)業務研習營	Tainer at Workshop
2	**2015**	Summary of “APEC Policy Dialogue for SME BCP Forum and Workshop” Sustainable knowledge and capacity building on MSMEs for business resilience	Wei-Sen Li, Yanling Lee, Huei-Ru Hsieh,	APEC Policy Dialogue for SME BCP Forum and Workshop held in Clark Bay, Jan. 30, 2015	APEC BCP Training Workshop
	Year	Book/Title	Author	Presentation / Conference	Type
1	**2018**	EPWG 03 2017A - Capacity Building and Emergency Preparedness for Sustainable Development at Agricultural Communities through "Plant Back Better" (PBB) Initiatives	Project Overseer: Wei-Sen Li and Yanling Lee	APEC Project	APEC Support Fund
2	**2016**	Application of Big Data and Open Data to Emergency Preparedness Phase 1” Project.	Ke Hui Chen, Yanling Lee, Chi-Ling Chang, Wei-Sen Li	9th APEC Emergency Preparedness Working Group Meeting. 20-21 Feb, 2016	Others-Project complete report
3	**2015**	強化區域防災數位能力建構保障亞太亞社區及企業案全倡議 Enhancing regional digital preparedness on natural hazards to safeguard communities and business in the Asia-Pacific	李維森、李燕玲	APEC Website (2015/SOM1/006)	Articles On-line publication
4	**2015**	2015-2030仙台減災綱領中譯	總校閱：李維森、李燕玲、陳可慧	Taiwan government publication on-line	On-line Publication
5	**2015**	成立「亞太防災能力建構中心」APEC Established Emergency Preparedness Capacity Building Center (EPCC) (2015/SOM2/006)	李維森、李燕玲	APEC Website (2015/SOM2/006)	Articles Online publication

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