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## **Emergency Relief Measures and Rehabilitation Policies in the Aftermath of the 921 Chi-Chi (Taiwan) Earthquake**

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### **1. Introduction**

On September 21, 1999, the most powerful earthquake felt on this island in one hundred years struck Central Taiwan. It has since been named the 921 Chi-Chi earthquake since its epicenter was near the town of Chi-Chi (Figure 1). With a magnitude of 7.3 on the Richter scale, the earthquake caused widespread damage. Taichung and Nantou counties were devastated, while areas of Taipei City, Taipei County, Miaoli County, Taichung City, Changhua County, Yunlin County, and other counties and cities also suffered severe property destruction and heavy human casualties. The tremendous force of the quake radically altered geographical features, while people's lives have been severely disrupted and infrastructure severely damaged. Table 1 provides some basic facts of the event.

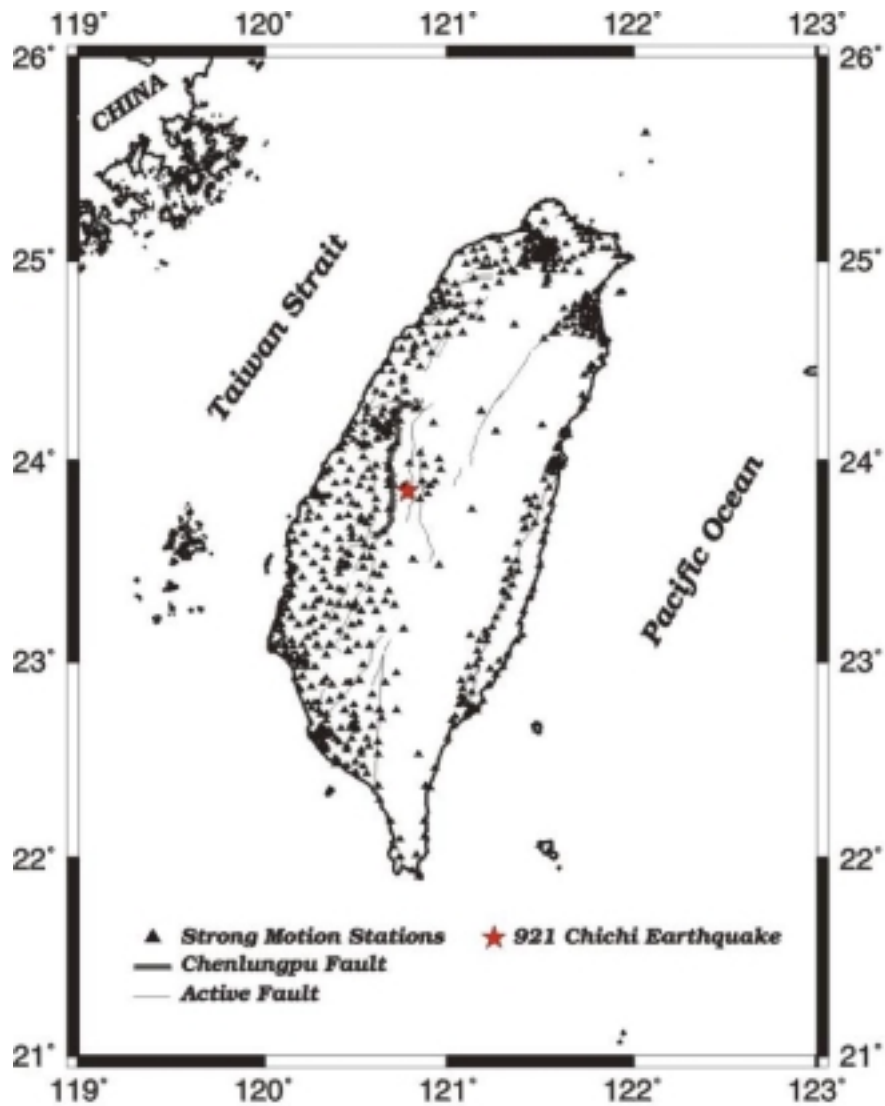
In the immediate aftermath of the disaster, both the central and local governments promptly mobilized all its resources for rescue and relief efforts. They were joined by private groups and individuals from all over the island as well as teams of experts from 21 foreign countries.

After attending to the emergency measures of rescuing trapped survivors, treating the injured, and providing care and shelter for the needy, the government focused its attention on the long-term task of reconstruction, rehabilitation, and enhancing the prevention and rescue mechanism.

This paper presents information and data of governmental emergency relief measures and the rehabilitation programs after the earthquake, and provides some lessons from the rare event.

### **2. Damage and Loss, and its Impacts**

The earthquake radically altered Taiwan's geographical feature and led to severe property damage and heavy human casualties.



圖一 本圖顯示集集大地震的位置（以星號表示）、車籠埔斷層（以粗線表示）和中央氣象局的地震站位置（以實心三角形表示）。

**Figure1. The Epicenter of the 921 Chi-Chi Earthquake, Chenlungpu Fault, and the network of Strong Motion Stations in Taiwan**

Source: Institute of Earth Sciences, Academia Sinica, <http://www.earth.sinica.edu.tw/NSCplan/Fig1.jpg>

**Table 1. Basic Data and Damages of the 921 Earthquake**

Basic Data	Time	21 Sep. 1999
	Epicenter	Chi-Chi, Nantou
	Depth	1.0Km
	Affected Area	Nantou County, Taichung County, Miaoli County, Taichung City, Changhua County, Yunlin County
	Magnitude (ML)	7.3
	Aftershocks	14,753 Times (Data ended 10AM Dec. 7, 1999)
	Population in the Affected Area	2,500,000
	No. of Victims	310,000
	The Chief of Command's Order for Rescue and Relief	Within 2 hours
The Last Survival rescued	130 hours	
Losses	No. of Deaths or Injured (person)*	13,799
	Deaths (Including missing)*	2,494
	Injured	11,305
	Severely injured*□	689
	Damaged Houses*	104,833 households
	Completely damaged *	51,392 households
	Half damaged*	53,441 households

Sources: Directorate General of Budget, Accounting and Statistics

Central Weather Bureau

\*: 921 Earthquake Post-Disaster Recovery Commission

Note: Data ended September 2000.

## 2.1. Geographical features

The earthquake took a heavy toll on Taiwan's landscape, causing soil and forests on mountain slopes to fall away and squeezing the island across its middle. The 921

Earthquake was manifested essentially by the Chelungpu thrust fault (Figure 1). The surface rupture length of more than 105 km was observed along the fault. The ground shaking during the earthquake was extremely strong, producing maximum horizontal shaking of more than 1g. Fault rupture and soil liquefaction caused more than 104,833 housing units to collapse or be severely damaged.

## 2.2. Property and infrastructure damages

According to a report by the Directorate General of Budget, Accounting and Statistics (DGBAS) on January 7, 2000, overall financial losses due to the earthquake was estimated at US\$11.5 billion (Table 2). This includes US\$8.4 billion in direct asset losses and US\$3.1 billion in indirect losses, with US\$5.0 billion in damages to residential buildings and durable goods accounting for almost half of the direct losses. Other major direct losses include damages to lifelines, transportation infrastructures, and school buildings. The majority of the indirect losses (US\$2.2 billion) were from manufacturing industries due to the two-week power outage. The total financial losses amounted to 3.5% of Taiwan's GDP in 1999. The percentage is higher than the 2% figure in the case of Japan's 1995 Kobe quake and the 0.7% of the 1994 U.S. Northridge quake. This indicates that its impacts on Taiwan's economy were much more severe.

Most damages to lifeline systems were severe, but tolerable. Lifelines include water and sewer systems, electricity power system, natural gas, liquid fuels, and telecommunications. Most of the damages were of pipes and joints (water and sewer systems, natural gas, etc.) as a result of damages to buildings and roads. Others were due to strong ground motions directly (water treatment plants, gas stations) and due to electrical power outage indirectly (telecommunication and cellular phones).

The damages to several 345kV transmission towers and a switching station, however, caused the worst blackout ever in northern Taiwan, and, consequently, huge business interruption losses. Among the estimated US\$2.2 billion in indirect losses, about US\$0.7 billion was from the semiconductor manufacturing and silicon processing firms at the Science Based Industrial Park at Hsinchu, about 110 km north of the epicenter of the quake. Since the industry provides a significant percentage of electronics products to the world, the two-week interruption created a shortage of computer chips (i.e., DRAM), resulting in an increase of their long-term contract price by 25% and 4 to 5 times higher spot prices for a brief period. The share prices of Dell Computer, a Just-In-Time personal computer producer and Direct-Sales company, went down by 7% in one day (Scawthorn, 2000; Papadakis, 2000).

**Table 2. Estimated Losses of the 921 Earthquake**

Items	Amount	
	NT\$ billion	US\$ billion
1. Sum of Nominal Financial Losses	364.65	11.47
1.1 Asset Losses (Direct Losses)	267.53	8.41
1.1.1 Buildings & Equipments	252.76	7.95
Housings, Residential Units	130.3	4.10
Durable goods of Households	27.53	0.87

Governmental Agencies	12.6	0.40
Industrial and Commercial Buildings	17.47	0.55
Electricity, Hydrological, Gas and Fuel Facilities	11.53	0.36
School Buildings	39.04	1.23
Facilities for Medical, Clinical & Social Welfare	4.41	0.14
Agricultural Facilities	7.01	0.22
Military Installations	2.88	0.09
1.1.2 Transportation Infrastructure	14.76	0.46
1.2 Losses of Potential Revenues (Indirect Losses)	97.12	3.05
1.1.1 Agriculture	2.36	0.07
1.1.2 Industries	72.96	2.29
Manufacturing	69.12	2.17
Electricity, Gas & Water	3.84	0.12
1.1.3 Services	21.8	0.69
2. Non-Nominal Losses	Human sufferings, lost orders and business credit, natural resource damages, lost cultural heritages,	

Source: Directorate General of Budget, Accounting and Statistics

Note: Data ended January 7, 2000.

The exchange rate used is NT\$31.8 per US\$.

### 2.3. Human sufferings

Among the 2,500,000 people living in the affected area, it is estimated that 310,000 people may have been displaced (Table 1). According to a September 2000 report to the Control Yuan by the 921 Earthquake Post-Disaster Recovery Commission, the tremor caused 2,440 deaths, 54 missing persons, and more than 11,000 injuries, of which 732 were severely injured.

### 2.4. Unemployment

The earthquake dealt a serious blow to the employment market in central Taiwan. The Council for Economic Planning and Development (CEPD) has estimated that around 194,000 people faced short-term unemployment after the quake. The unemployment rate in the disaster area was 5.01% right after the earthquake, and has fallen to 3.66% by July 2000, which is still higher than Taiwan average's of 2.73 %.

### 2.5. Impact on public finance

The loss of government revenues for the second half of 1999 and 2000 reached

NT\$36.8 billion (Table 3).<sup>1</sup> Major losses are from the exemptions of property tax, income tax and sales tax in the affected area.

## **2.6. Impacts on banks**

Major impacts on the banking system were losses of mortgage payments and savings. In order to reduce victim's financial burden, the repayment period for housing loans was extended five years, the interest rate was reduced by 1 percent, and a grace period of five years would be given on interest payments. The financial sector also offered six-month grace periods for payments on principal for commercial loans in the quake area (Table 4).

## **2.7. Impacts on economic growth and Consumer Price Index (CPI)**

DGBAS has estimated that because of the earthquake, GDP in 1999 fell by an amount of NT\$43.64 billion, shrinking the economic growth rate for 1999 to 5.42% (Table 5). The net growth rate reduction is 0.3%, which is the result of a 0.5% fall due to production reduction and 0.2% growth due to export growth and increased investment in reconstruction. At the same time, the annual consumer price index (CPI) dropped to 0.2% from 1.7% in the previous year.

According to CEPD, the post-quake reconstruction may push up economic growth rate for 2000 by 1 percentage point to well over 6%. However, the fact that private spending has shrunk significantly following the quake and some high-tech firms have decided to switch their production lines abroad as a result of the power shortage following the quake may offset the 1 percentage point growth.

## **3. Emergency Relief Measures**

In order to achieve greater coordination and efficiency of rescue and relief operations and post-quake reconstruction work, a six-month Emergency Decree was issued by President Lee on September 25. The Special Law for the 921 Chi-Chi Earthquake was passed by the Congress in February 2000 to replace the Decree. The Emergency Decree included actions to:

- ensure funding sources for reconstruction,
- build temporary shelter for victims,
- simplify relevant administrative procedures of reconstruction and exempt all fees,
- dispatch the armed forces to carry out relief efforts and reconstruction works,
- use public and private properties including land, buildings and equipment as necessary, and
- establish severe penalties for unwarranted price hikes.

In addition, the central government set up the 921 Earthquake Post-Disaster Recovery Commission (921REC) to ensure effective coordination and implementation of all related programs.

Major emergency relief measures include:

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<sup>1</sup> The exchange rate is approximately NT\$31.8 per US\$ in 1999-2000.

### **3.1. Relief and consolation payments**

The government has provided a special package of relief and consolation payments that is much more generous than the going standards of relief and consolation payments. A cash payment of NT\$ 1 million was given to the family of each deceased person. Each seriously injured person received NT\$0.2 million. However, the going standards are only NT\$100,000 for each deceased and NT\$ 50,000 for each severely injured in the event of natural disasters. Owners of houses that were totally demolished received NT\$0.2 million each. Those whose houses were partially destroyed received NT\$ 0.1 million each. The Central Government was responsible for providing such funds to counties and cities.

### **3.2. Temporary shelter for the victims**

Families of houses that were totally demolished may choose either to receive rental allowance of NT\$3,000 per month per person for one year, to stay in temporary housing for one year, or to purchase government-built housing units at a 30% discount.

**Table 3. Impacts on Public Finance**

Unit: NT\$ billion	
Items	Amounts
Loss of tax revenue	24.9
Loss of wine & tobacco monopoly revenue	11.3
Loss of income from public properties	0.6
<b>Total</b>	<b>36.8</b>

Source: Ministry of Finance

**Table 4. Financial Relief Measures in 1999**

Items	Applicants		Approved	
	No.	Amount (unit: NT\$ billion)	No.	Amount (unit: NT\$ billion)
Mortgage payments extended	11,836	23.92	8,259	16.33
Business loan extended	310	5.56	206	4.37
Take over mortgages	660	0.92	1	0.002

Source: Ministry of Finance

**Table 5. Impacts on Gross Domestic Product in 1999**

Items	Gross Domestic Production (value added) (unit: NT\$ billion)
Agriculture	-1.36
Industry	-26.32
Manufacture	-22.62
Water, Electricity, & Gas	-3.70
Business and service	-15.96
Commerce	-4.50
Banking	-6.96
<b>Total</b>	<b>-43.64</b>
<b>Economic Growth Rate</b>	<b>-0.5%</b>

Sources: Directorate General of Budget, Accounting and Statistics

### 3.3. Loans for purchasing new housing

In addition to the measures to reduce victim's financial burdens on existing housing

loans depicted in the last section on impacts, the Central Bank has made special appropriation for banks to offer long-term, low-interest, or interest-free emergency loans for earthquake victims to reconstruct their houses and firms.

A loan will be interest-free when the amount is less than US\$47,000. For loans ranging from US\$47,000-93,750, the annual interest rate is fixed at 3 percent for the amount higher than US\$47,000. The maximum period for repayment is 20 years.

### **3.4. Taxation**

Households that had filed damaged reports with the authorities could apply for deductions or exemptions on income, business, housing, land, and commodity taxes.

### **3.5. Setting up special bank accounts for humanitarian donations**

The Executive Yuan established a special account for accepting earthquake relief donations. A total of around NT\$ 13.4 billion has been received by the account. The local government also received NT\$7.6 billion in donations, while private organizations have received NT\$ 9.4 billion in donations.

### **3.6. Employment assistance**

A total of NT\$ 1 billion from the Employment Stability Fund was used to provide temporary jobs for people in the affected areas. In order to facilitate their re-employment, free vocational training programs were offered and living subsidies during the training period were provided.

In addition, the government has provided programs to:

- prevent and control epidemics,
- provide emergency medical treatments and mental health programs,
- inspect buildings' safety, and
- construct temporary schools and classrooms, and resettle students in the affected areas.

## **4. Rehabilitation Works**

After the stage of emergency relief, it follows the long-term rehabilitation works. In order to achieve greater efficiency in rehabilitation works, to maximize the benefits of limited rehabilitation resources, and to coordinate all efforts provided by both private and public organizations, CEPD drafted a Guideline for Rehabilitation right after the quake that was approved by the Executive Yuan on November 8, 1999. It defines the goals, policies, measures, and procedures for rehabilitation planning.

There are four elements in the five-year rehabilitation plan: the restoration and reconstruction of infrastructures, the rehabilitation of people's lives, the revival of industries, and the resettlement of communities.

### **4.1. Restoration and reconstruction of infrastructure**

The central government takes the responsibility for the restoration and reconstruction of infrastructures including school buildings, bridges, national and provincial highways, urban and rural roads, railroads, reservoirs, dikes, embankments, regional flood prevention systems, drainage structures, farming and livestock husbandry facilities, re-

forestation of slope ravaged by landslides, and central and local government buildings. The estimated budgetary allocation for restoration and reconstruction of infrastructure is NT\$55.2 billion.

Schools' repair and reconstruction takes the highest priority. The central government has the responsibility for 1,831 projects, while many private organizations and firms are voluntarily responsible for 123 schools. Seventeen school's reconstruction budgets are partially financed by private donations.

#### **4.2. Revival of industries**

The agricultural, manufacturing, and service industries in the affected area, especially tourism, were heavily impacted by the quake. Efforts that have been taken or will be taken to revive industries include financial assistance and preferential treatments, simplified administrative processes and regulations, and consultation and technical services.

#### **4.3. Rehabilitation of people's lives**

A detailed rehabilitation plan including psychological recovery, schooling and student counseling, social assistance and welfare, employment services, medical services and public health has been approved by the Executive Yuan in 2000. The planning principles are as follows:

- Identify those truly in need of assistance and provide for them according to their needs.
- Effectively utilize government resources, religious groups and other non-governmental organizations.
- Give priority to the employment of quake-area human resources in meeting the needs of reconstruction.
- Encourage disaster victims to rely on their own efforts and strengths, and to join forces in rebuilding their home communities.
- Strengthen medical services, public sanitation and environmental preservation in the quake areas in order to prevent the outbreak and spread of infectious diseases.
- Place emphasis on assisting the psychological recovery of students and others in disaster areas, as well as those who took part in rescue and relief efforts.
- Enhance educational and other efforts to make people better able to cope with disasters.

#### **4.4. Resettlement of communities**

There are four types of communities to be recovered based on their damages and locations. First, for individual housing reconstruction, the central government will provide preferential loans to rebuild or renovate. Second, for those communities that were damaged and need redevelopment, community revival plans were needed before reconstruction. Many professional teams from universities, private organizations and firms became involved in the community revival planning, with citizen participation in the planning process required by the Rehabilitation Guideline. The local government takes the responsibility for reviewing these plans. There are 95 community revival plans so far, but most of them still have not been approved yet.

Third, for rural housing, in addition to preferential loans, an NT\$200,000 grant will

be provided by the Council for Agriculture (CFA) if the reconstruction follows CFA rural housing prototype models and complies with the authority's landscaping requirements. Finally, for indigenous people's villages, the Council for Aboriginal Affairs also offers the same incentives as those in rural villages to assist village reconstruction.

The planning principles include:

- A bottom-top approach to encourage active participation by local residents.
- Preservation of local cultural features.
- Make use of new topographical and surface features created by the earthquake.
- Develop "green" building practices, promote recycling of resources, and strengthen environmental protection.
- Build a high-quality living environment, and provide all necessary public infrastructure, services and disaster-refuge facilities.

#### **4.5. Relief and rehabilitation expenditures and funding**

The government expenditure for emergency relief measures and rehabilitation works for the year 1999-2000 is only estimated to be NT\$106.1 billion. Table 6 depicts the itemized estimates of emergency relief expenditure of NT\$21 billion financed by the central government. These expenditures will be financed by issuing NT\$80 billion in public debits, and by diverting NT\$26.1 billion from other budget items. The expenditure for reconstruction works is estimated to be NT\$208 billion for next three years (2001-2003) (Table 7).

**Table 6. The Emergency Relief Expenditure of the Central Government**

(data ended Feb. 23, 2000; unit: NT\$ billion)

Items	Estimated
1.Disaster Relief (including the cost of temporary housing)	30.7
2.Condolence Payments	2.6
3.Emergency repair of roads and bridges	1.701
4.Emergency repair of water facilities	3.652
5.Emergency repair of school buildings	6.772
6.Repair of government offices	0.853
7.Employment of unemployed in the quake area	81.1
8.Medical cares	2.590
9.Demolition of damaged buildings and environmental hygiene	0.780
10.Truck rental for emergency relief works	1.047
11.Emergency repair of agricultural facilities	0.762
12.Reconstruction of aboriginal villages	0.245
13.Emergency relief for government employee-victims	0.220
14.Others	1.308
<b>Total</b>	<b>134.33</b>

Source: Council for Economic Planning and Development

**Table 7. Estimated Reconstruction Expenditure**

Unit: NT\$ billion	
Years	Estimated
2001	61.2
2002	54.9
2003	71.9
<b>Total</b>	<b>208</b>

Source: 921 Earthquake Post-Disaster Recovery Commission

The private sector also took an important part in funding rehabilitation. According

to the 921 Earthquake Post-Disaster Recovery Commission, total donations received so far are NT\$30.4 billion. In order to ensure that all donations received by the central government (NT\$ 13.4 billion) are put to the best possible uses and properly coordinated with the government's relief and reconstruction efforts, a 921 Earthquake Reconstruction Foundation was established.

## **5. Earthquake Prevention and Rescue Mechanisms**

Other than rehabilitation works, the central government has started to enhance long-term earthquake prevention and rescue mechanisms to minimize future earthquake damages. First, the Disaster Prevention and Rescue Law was enacted on June 30, 2000. It serves as the important legal base for setting up the emergency prevention and rescue mechanism. Second, the government will set up a high-tech satellite communications system for emergencies, and enhance the software, hardware, and functions of the emergency prevention and rescue system including rescue vehicles and equipment, transportation capability for the emergency medical service, helicopter rescue teams, and the National Search and Rescue Team. Finally, an earthquake insurance system for man-made capital is under study.

## **6. Earthquake Insurance Policy**

Taiwan's insurance industry has provided earthquake insurance policy since 1972. It is available by attaching the relevant endorsements and payment of additional premiums to fire insurance, engineering insurance, automobile insurance and life insurance. Fire insurance and engineering insurance are the two most important ones among them.

The demand for earthquake insurance policies is quite low. Among 660,000 fire insurance policies bought in 1991, only 3,107 (0.47%) purchased the attached earthquake insurance. The written premiums of earthquake insurance only account for 1.0% of that of fire insurance in 1991. After the earthquake, the demand increased slightly. A total of 10,314 private households have purchased the attached earthquake insurance by the end of 1999.

The total insured losses for the Nantou Earthquake was around NT\$25.8 billion. Most buyers are industries and businesses, with 80% of the insured losses come from the semiconductor manufacturing and silicon processing firms at the Hsinchu Science Based Industrial Park. Thus, the majority of earthquake damages has to be borne by the victims themselves and the government through subsidies, emergency relieves and reconstruction.

A three-level earthquake insurance system for man-made capital has been proposed and is under study by the Ministry of Finance. The earthquake risk will first be co-insured by insurance companies, and then re-insured by foreign re-insurance companies. The government will finance the remaining risks.

Another three-level earthquake insurance system has been proposed by the insurance industry. It will be compulsory to purchase primary earthquake insurance for all man-made capital. Re-insurance will not be needed for this compulsory insurance since its size will be big enough. Insurance companies will then sell insurance policies to cover the remaining risks and will seek further coverage from foreign re-insurance companies and/or by issuing CAT Bonds.

The Ministry of Finance and the insurance industry have commissioned EQECAT to conduct a detailed earthquake risk analysis in 2000. They will make a decision on any new earthquake insurance policies with the information provided by the analysis.

## **7. Lessons**

Although local victims living in the affected area do not seem to be satisfied with the performance of governmental emergency relief measures and the rehabilitation programs after the earthquake, several foreign reconnaissance teams have made favorable assessments (Golts and et al., 2000; Scawthorn, 2000; RMS, 2000). The factors that they believe are attributable to “the reasonably well-coordinated and effective response to the earthquake” include: (1) rapid information from the seismic network confirming the magnitude and likely severity of the earthquake (see Figure 1); (2) a very rapid mobilization at the national and local levels of government, and effective coordination between central and local government agencies; (3) rapid and effective utilization of the military, and a well-organized and integrated response by volunteer organizations; and (4) a healthy economy.

There are still several lessons that can be drawn from such a catastrophic event and governmental responses.

In the past, the government focused its attention on the science and technology aspects of earthquake risk management in Taiwan, for example investing heavily in building an advanced seismic network. However, human dimensions of earthquake risk management have mostly been ignored. Thus, people in Taiwan have seldom paid attention towards reducing their own risks via carrying out mitigation measures for their own buildings and buying earthquake insurance policies.

Individuals should be responsible for their own safety, such as retrofitting their own buildings. Although, in theory, people will reduce their own risk based on their private benefit and cost considerations as well as their risk preferences, those familiar reasons such as asymmetric information, principal-agent problem, low probability/ high consequence events, uncertainty, rent seeking, and public goods all contribute to reducing their incentives to minimize risks. In addition, the generous governmental relief and consolation payments, that are totally expected for such a catastrophe and the approaching presidential campaign, would reduce people’s incentive even more in the future (Shaw, et al., 2000).

The state should therefore only be responsible for providing earthquake risk mitigation services on all public assets. For man-made capital, the state should enforce compliance with building codes for buildings and infrastructures, enforce adherence to land use plans, and assess regional seismic risks. In addition, the state should invest in social capital and human capital by educating people about earthquake risks, making information easily accessible. Most importantly, state investment should aim at enhancing the efficiency of government and corporate worlds, and by cracking down on corruption among government employees and developers using various means such as the legal system, independent third parties, media, NGOs, etc.

Earthquake insurance is a good policy instrument to reduce financial losses of catastrophic risks. Kunreuther (2000) shows that earthquake insurance can also be designed to enhance people’s incentive to mitigate their own seismic risks by linking earthquake insurance to the safety/risk characteristics of buildings or infrastructures and

the potential of business interruption aspects that are the consequences of individual and governmental mitigation efforts with respect to the regional seismicity. Scawthorn (2000) spells out three important components of an “ideal” earthquake insurance scheme:

- (1) Earthquake insurance needs to be mandatory in selected high-risk regions.
- (2) Earthquake insurance needs to be strongly linked to mitigation.
- (3) Earthquake insurance needs to have a high credibility of payment.

Another lesson learned is that ensuring the continuity of lifelines and equipment for emergency and essential industrial facilities post-earthquake is very important. Thus, it is a good strategy to maintain redundant lifelines and equipment should they prove to be economically justifiable. It requires a systems analysis approach to guarantee the reliability of infrastructures. Joint efforts to develop technologies to mitigate earthquake risks for buildings and equipments should be encouraged.

Right after the earthquake, the central government paid enough attention to make sure the long-term rehabilitation works proceed orderly, provide safe public and private structures, and at the same time improve the urban and rural environment. Thus, the Executive Yuan approved the Guideline for Rehabilitation on November 8, 1999. It defines the goals, policies, measures, and procedures for rehabilitation planning. Since this procedure will slow down the speed of rehabilitation against the will of those affected people, it is important for governments to provide well-managed and quality temporary housing and other necessary facilities.

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