Chapter 6

STRATEGIES TO REDUCE IMPACT OF FUTURE EARTHQUAKES

6.1 Seismic Risk Assessment for Mitigation Planning

During the foreseeable future, there will be a rapid growth of industrial development of seismic prone regions of the Philippines accompanied by urban expansion and increased population, many of which are regularly afflicted by natural disasters. Experience has already demonstrated that natural disasters, and earthquakes in particular, have tended to become increasingly destructive since they ever affect a larger concentration of national property and population. Depending on the site, such instantaneous disasters may very well lead to increased economic, political, and social instability, the adverse effects of which will further erode the capacity of the region stricken, or even the entire country, to cope with the consequences of natural and, as a chain effect, man-made disasters.

Specialized or comprehensive assessment of natural (and technological) hazards, including a rigorous scientific, technological and intellectual approach will be required to solve this truly global problem of protecting the orderly industrial development and accompanied urbanization patterns such as investments in regional and local infrastructure, life-lines, housing, urban furniture and other public and social activities against losses at all stages of their development.

Even though two disasters (seismic events and associated afflicted areas) are not alike, the problems created are basically of the same nature, thus, quite foreseeable. The common profile of earthquake related disasters enable planning of pre-disaster measures and activities for effective risk management through experience and technology transfer, performance of pre-disaster demonstration projects, elaboration of programmes for technical assistance, education and training, etc., as well as the evaluation of the effectiveness and organization of pre-disaster measures and activities planned to be undertaken.

Although disastrous natural phenomena cannot be prevented, their effects are often reduced through better construction standards, improved land-use policies and other measures. Identifying sources of vulnerability and taking steps to mitigate the consequences of future disasters are the most essential elements of any disaster preparedness, mitigation and reconstruction programme. With a proper pre-disaster policy, it often seems that many measures could have been adopted before catastrophic consequences exact a very high price.

Recent research and field surveys have shed a new light on the effects of natural disasters that are pertinent to the technologically organized society, indicating thus better approaches for providing the appropriate response of national and local policy planners.

For planning of new development or appropriate post-earthquake reconstruction, for earthquake preparedness and disaster relief organization, for insurance, decision making, as well as many other related purposes, quantitative seismic risk assessment tools are needed for various elements at risk in various locations.

The methods, procedures and models for assessment of seismic risk should be developed providing a basis, essential data and assistance for the following needs:

- Assessment of the accuracy of existing methods for evaluating seismic hazard, seismic zoning and microzoning and their practical application in earthquake engineering, land-use planning, development planning and public information and training, as well as performance of the sensitivity analysis of the final results on factors controlling most influentially the aforestated outputs;

- Control of the industrial and residential development in regions of expected, or already prone seismic activity in order to reduce both human and property losses;

- Control of the certain kinds of hazardous activities in industrial plants carried out in regions of expected seismicity - environmental management and development of effective strategies for countering the threat of increased susceptibility to secondary effects caused by a natural disaster;

- Planning of the most rational and effective access to the region stricken by a natural disaster, provision of accesses for emergency, disaster relief and other technical and expert services, and the location of the disaster relief and emergency service facilities;

- Development of improved (i.e., less biased) survey sampling methods for estimating physical, functional and economic losses and damages due to large-scale earthquakes;

- Improvement of data collection systems to increase their utility in estimating the size of physical, functional and economic losses for the expected seismic events;

- Analysis, for casting and planning disaster preparedness and relief;

- Reviewing of various approaches for earthquake risk mitigation under different socio-economic conditions with an emphasis on post-earthquake period of rapid revitalization and reconstruction;

- Estimation of vulnerable regions, areas and points, processes and/or activities and planning of disaster preparedness and prevention of many primary and secondary phenomena accompanying the major natural disaster. The greater preparedness for the expected seismic event is, the more effective and timely organized relief operation, reconstruction and revitalization will be;

- Development of rigorous organizational research on the factor that facilitate or hinder the effectiveness of the pre-disaster preparedness and/or emergency response as well as disaster relief efforts in the very post- earthquake conditions.

Only on these grounds it might be possible to:

- Devise new mechanisms and strategies for continuous application and updating of the existing knowledge taking into account the cultural, socio and economic diversities within the region;

- Foster scientific and engineering endeavors aimed at bridging critical gaps in knowledge that exist on the way of reducing the earthquake induced losses;

- Disseminate the existing and new information related to the measures for assessment, prediction and mitigation of the seismic hazard; and,

- Implement these measures for better scientific and technical understanding of earthquake-induced hazards and mitigation of specific and composite risk components.

Care should be taken, however, that planning is unfortunately a long range activity highly vulnerable to conflicting priorities and demands, especially if these are of economic nature. Urbanization, as a complex social process, represents a predominant characteristic of the development of regions, towns and human settlements. Spatial distribution and density of material property (industry, enterprises, the system of human settlements, etc.), life-line systems, population density, etc., are usually controlled by the level of socio-economic development regardless of the degree of seismic hazard they are exposed to. Ultimately, a society should, therefore, accept a compromise between exposure to seismic hazard and long-run economic and social necessities.

Only recently have efforts been made in the development of quantitative loss prediction procedures. Two decades ago, there existed almost no predictive estimates of damage that might result from earthquakes. The development of various procedures for estimation of earthquake losses has been prompted by the increased loss potential due to rapid development and concentration of material property in seismically active regions. However, the development of a single damage prediction methodology is presently not feasible because of the complexity of the problem and the strong lack of a uniform data base.

Loss evaluation is presently made with varying degrees of rigor. However, all models (theoretically or empirically based) proposed for predicting seismic losses of an urban area share the common necessity of performing a series of complex procedures requiring extensive computations and proper data acquisition and handling. A systematic approach, is therefore necessary and the problem of an integrated prediction and estimation of seismic risk should be performed through the following five basic sequences:

- **Inventory and classification** of the existing elements at risk with their zonation within each zone of the considered area.

- **Prediction of the site-dependent seismic hazard** with evaluation and presentation of ground motion parameters for each zone including the effects of local site-soil conditions in modifying the characteristics of the earthquake ground motion at the considered zones.

- **Assessment of vulnerability** and development of vulnerability functions based on experimental and theoretical studies, and empirical data banks from the past earthquakes.

- **Loss prediction** with cumulative presentation of losses for all elements at risk including density distribution with mapping for each zone and considered seismic hazard levels.

- **Seismic risk analysis and optimization** with consideration of the existing and improved scenarios of land use and urbanization. Through the functional improvement of the existing conditions in the development plans, physical improvements will be incorporated for each element at risk and presented for each zone and urban area/region for the considered levels of seismic hazard, representing alternatives of improved scenarios. Seismic risk analyses for the improved scenarios and comparative analyses in respect to the existing conditions will lead to an optimized land use scenario causing minimum losses for a given level of seismic hazard. The optimized land use scenarios could be presented with the **optimized level of physical losses** as a percentage of the floor area for all elements at risk, or further elaborated into **optimized level of economic losses** considering the current market value for all the elements at risk cumulatively.

On this basis the loss prediction and seismic risk optimization methodology might be implemented in order to develop technically consistent and economically justified measures for effective pre-disaster risk management or planning for post-disaster reconstruction and revitalization of the stricken region based on previously defined long-run social and economic necessities. In any case, the decision should be made through balancing the pre-disaster capital inputs required for achievement of the accepted level of seismic protection and safety, and the estimated value of damaged or lost property. In other words, the trade-off should be made between the capital inputs necessary for repair and strengthening, or between total replacement of the vulnerable building classes and the value lost in the repeated seismic activity of the same or even larger size. The optimization should be performed separately for each element at risk and cumulatively for the entire area considering the existing and the physically improved land use conditions.

6.2 Earthquake Protection Planning

The most effective way of reducing the local losses from future earthquakes is to build stronger structures. Appropriate building engineering and construction quality is immensely important. The occupant of a weak masonry building in an intensity IX MM earthquake is 20,000 times more likely to be killed than someone in a reinforced concrete framed building designed and constructed to a seismic building code. Other factors, such as the siting of a building can also affect the probability of future damage from an earthquake. The difference between very bad and very good ground conditions may influence the intensity of ground shaking by up to one unit of intensity, which will change the probability of damage for a structure, but not as much as increasing the strength of the building. For this reason, management of building stock to ensure the quality of design and construction is a central element in earthquake protection planning.

6.2.1 Background Factors of Vulnerability

The basic vulnerability of a city is determined by several underlying factors that shape the earthquake protection problem. It is necessary for the planner to understand these factors in order to design an effective protection strategy. These factors include.

- Economic capability of the community
- Investment levels in physical building stock
- Housing demand and supply
- Locational pressures and land price in determining siting
- Occupancy densities and population pressures
- Processes of housing design and construction
- Demographic changes and trends, migration and growth
- Fashions and cultural preferences in buildings

Only by a thorough understanding of the current pressures and dynamics of how the building stock is changing and is likely to evolve in the future can the protection planner hope to exert effective influence on the process of building stock change and bring about improvements to make the city safer against the impact of future earthquakes.

6.2.2 Alternative Protection Strategies

In areas where enforcement of building controls and other legislative measures are possible, for example within municipal boundaries, the range of techniques for improving building stock are different from where the enforcement of a code is not realistic, for example in rural areas or in squatter settlements. In these areas measures to induce the population to carry out certain activities are more effective than penalizing non-compliance. These two different approaches are called passive and active measures of building stock management. Illustrative techniques of each type are summarized in table 6.2.1-1.

Table 6.2.1-1
Earthquake Protection Policies in Urban or Rural Areas

PASSIVE BUILDING STOCK MANAGEMENT
Authorities prevent undesired actions through using controls

- Enforcement of Building Codes: On-Site Checking
- Legislation and Court Proceedings Against Offenders
- Economic Penalties: Property Taxation
- Land-Use Zoning: Control by Building Type and Form
- Denial of Utilities and Infrastructure
- Compulsory Insurance

ACTIVE BUILDING STOCK MANAGEMENT
Authorities promote desired action through using incentives

- Planning Control Dispensations
- Training and Education
- Economic Aid (Grants and Preferential loans)
- Building Material Subsidies
- Housing Provision
- Peer Pressure ("Safe is Smart")
- Public Education
- Voluntary Insurance

Passive control systems require the following
- An established enforceable system of control
- Acceptance by the affected community of the objectives and the authority imposing the controls
- Economic capability of the affected community to comply with the regulations

Active programmes require the following
- Aim to create self-perpetuating safety culture in areas of weak authority or poor ability to comply with existing controls
- Require large budget and skilled manpower
- Are useful in areas of low-income where traditionally there is no external jurisdiction over building activity.

6.2.3 Passive Measures to Manage Building Stock

Government-inspired programmes in urban areas to improve the quality of building stock should begin with the thorough enforcement of existing building codes and planning regulations. The best plans in the world are ineffectual unless they are properly enforced. Enforcement procedures should include the methods of checking; simple guidelines are more easily checked than complex or computational qualifications--number of storeys of a building for example is an easier requirement to check for compliance than whether the correct seismic design coefficient has been used in the calculation of steel reinforcement. The procedure of checking compliance should also be considered. Drawings registered and countersigned may be insufficient evidence of safety standards. Major gaps often occur in the difference between design and construction. Checking of quality of construction and compliance with designs submitted on site is an important part of maintaining the standard of new construction.

Manpower to carry out checks should be carefully considered. The number of buildings under construction at any particular time should be estimated and the time required for site checks should be calculated in terms of the number of municipal engineers needed to ensure that buildings are visited. Investment in the salaries of more and better municipal engineers may be the most cost-effective investment in earthquake safety made by a municipality.

Local property taxation systems can be used effectively to penalize the most vulnerable buildings in the community. This may require a reformulation of the way that property tax is assessed, and require some level of vulnerability appraisal as part of the taxation rating system. If successful, the penalization of vulnerability can bring about a gradual change in the vulnerability of the entire building stock.

At a most extreme, legislation can be passed requiring the owners of the most vulnerable classes of buildings to upgrade their structures or face demolition orders. This has been carried out with various degrees of success in California and in New Zealand.

6.2.4 Active Measures to Influence Building Quality

The most effective methods of persuading communities to improve their safety without enforcing change is through education. When people are fully conversant with the risk and are familiar with techniques to protect themselves, the argument for self-protection becomes self-apparent. Training programmes for the builders themselves have proved very effective in convincing builders of the need for building safety and quality in construction and have empowered builders to convince their clients of the need to build earthquake-resistant structures. Examples of this are builder training programmes carried out after the earthquake in the Yemen Arab Republic in 1982 and after the Ecuador earthquake in 1986.

Other methods include offering grants and economic incentives to build to earthquake-resistant standards, to absorb the initial cost-resistance of having to include strengthening elements in construction. When the practice is established, the strengthening elements become a recognized part of the normal building cost and are accepted by the community, but the initial resistance to spending an additional 5% or 10% for earthquake resistance may be eased by using grants. Other methods include subsidised building materials and other input factors to make it easier for builders to change well-engrained construction habits.

6.2.5 Locational Controls

Locational planning also has a role in earthquake protection, but it is more effective in density control and avoidance of sites prone to suffer from ground failures than for controlling placement to reduce earthquake shaking. In areas where ground failures may occur, locational planning is important to reduce the likelihood of key facilities incurring damage through liquefaction (such as Dagupan) or slope failures (such as Baguio). In special cases, where certain soil conditions are known to resonate at specific frequencies under earthquake conditions, there may be a zoning requirement to prevent buildings with natural periods close to that resonant frequency from being built (for example by a building height restriction): such buildings are likely to experience extreme forces in an earthquake and their probability of failure will be significantly greater than other structures.

6.2.6 Deconcentration of Densities and Key Facilities

A service provided by a single facility will always be more at risk from earthquake than the same service provided by several smaller facilities. An example of this is the destruction of the central telephone exchange in Mexico City by the earthquake in 1985 which cut telephone communications for 48 hours. In the reconstruction, the telephone system was redesigned into a number of smaller interconnected local exchanges to make the system less vulnerable to earthquake disruption. The same concept can be applied to hospitals, water supply and other essential service facilities.

Deconcentration of population may also be important. Urban densities of vulnerable buildings, particularly those prone to fire or with poor access routes through them, may be reduced over a period of time through planning measures. Population densities and target limits may be developed as guidelines for planners.Road widening and urban plot limitations are also important methods of controlling the urban morphology and structure that influence density levels.

6.2.7 Creation of a Safety Culture

At the local level the basic objective is to reduce risk by getting people to protect themselves. The general public and the private sector are the main determinants of how safe a society is. If they can be persuaded that seismic safety is an issue and that they can, through their own efforts protect themselves, their families, businesses and employees, then this is more effective in the long term than government regulation and safety enforcement. The challenge is to create a "safety culture" where people make everyday decisions with an awareness of earthquake risk and accept earthquake safety as part of the normal costs of constructing a building or placing a bookcase. A public education programme using the news channels, informal communication and a working relationship with entertainment media can bring about increased acceptance and demystification of earthquake risk.

6.3 Regional Development Strategies to Minimize Impact of Future Earthquakes*

Beyond its immediate impact on local structures and sectoral activities, the Luzon earthquake of 16 July 1990 has been enormously disruptive to economic activities. The value of production losses and the economic burden of resulting price inflation far exceed the cost of repairing the physical damage caused by the earthquake. In some cases, the production losses reflected damage to physical facilities such as hotels, factories, fishponds and rice paddies. In a significant number of other cases, however, the loss of production resulted from the failure of key economic support systems. The damage to the roads leading from Baguio to the coast has severely constrained the flow of ore from mines in the CAR to the port in San Fernando. The closing of the Dalton Pass prevented fertilizer from reaching the Cagayan Valley when it was critically needed for the rice planting season. Similarly, the collapse of the market structure in Dagupan has forced much commercial activity out on to the streets where it has to compete with vehicular traffic and reconstruction activity for space. In each case, production effectiveness was compromised by the failure of a critical element in an economic system. In seeking to minimize the adverse impact of future seismic events it will be important not only to protect against human injury and loss of life and physical damages, but also to minimize the potential for economic disruption.

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*N.B. The term "regional" as used in this section refers to a sub-national area with an internal coherence of social, political and economic networks and functional linkages with the rest of the nation. It does not necessarily correspond directly with a formal "Administrative Region."

6.3.1 Reducing Vulnerability of Critical Systems

Earlier sections of this report describe technologies for assessing seismic threats at the local level and for designing or strengthening structures to reduce their vulnerability to these threats. Taken together, these technologies can be used to protect against human injury and loss of life, and to minimize the potential cost of physical damage. But this is only part of the problem. It is vitally important to reduce the vulnerability of critical life line and economic systems. The failure of a vital link such as a bridge on a critical transport route can cause vastly more damage to the economy of the affected area than the cost of replacing the bridge. In the reconstruction and development phase following the earthquake it is important to consider not only the reduction of vulnerability of key structures, but the reduction of vulnerability of entire systems critical to the area.

There are at least three different, but complementary approaches to reducing system vulnerability : 1) strengthening key elements to reduce their risk of failure so they will not cause the system to fail; 2) decentralizing or deconcentrating critical functions to provide alternative capabilities should one element fail; and 3) restructuring system to reduce or avoid the risk of earthquakes.

The techniques for assessing vulnerability and for reducing the risk to individual structures has been described above. To reduce the vulnerability of critical systems, however, it is essential to first identify those systems that are most vital to the economy of the area (e.g. urban water supply, roads, ports, markets) and then within each of these systems identify critical elements that need to be considered for special strengthening to prevent earthquake damage. If they play a vital role, their failure is not permissible. As an example, an analysis of the transport network linking Region I and the CAR with Metro Manila indicates that most of the traffic crosses the Carmen Bridge. This structure is a key link in the system, and when it is rebuilt it will be important to ensure that the design provides an adequate measure of security.

In some cases, it may not be possible to ensure adequate security at acceptable cost by strengthening critical elements. It may be preferable to spread the risk by creating complementary capabilities that do not share the same type of risk. The objective is to ensure that while some capacity may be lost in an earthquake (or other natural disasters) the system will not collapse. The three roads linking Baguio with the low lands might have been expected to provide such capacity. Although all were well used before the earthquake, one or even two of them could have been closed without cutting the city's functional linkage with outside areas. Unfortunately all three roads were vulnerable to the same earthquake and hence did not provide effective alternatives.

In extreme situations, such as the problem of ensuring secure road access to Baguio, it may be necessary to create new capacity that avoids the threat altogether. This would suggest developing a new route through a corridor, probably further north, that is significantly different, in terms of seismic vulnerability, from the current three routes. The objective would be to ensure that at least one route would remain functional even if the others were closed. The same strategy can be applied to the supply of electric power or water. In the case of water, deep boreholes may be vulnerable to different types of threat than surface reservoirs. A system that included both, although not spatially dispersed, may provide a measure of security that could not be achieved with a single technology.

6.3.2 Planning Critical Systems in the Context of Regional Development

Risk management for large scale critical systems such as urban water supplies and regional transport networks typically requires a regional or multi-regional perspective on the issues. These systems are usually large and complex, and cannot be adjusted without broad reaching consequences. Solving the water supply problem for Baguio, for example, will quite likely involve the tapping of sources outside of the city. Dagupan faces the same type situation. Building a new road to link Baguio with the coast would undoubtedly have an important impact on several municipalities.

Programs of such significance require regional or multi-regional planning. Most have the potential to contribute strongly to economic growth, and the nation cannot afford to miss the opportunity. The challenge is to minimize economic vulnerability to earthquakes while at the same time stimulating development in the region.

Regional development yields an increase in per capita productivity with the potential for improved standards of living and quality of life, as well as the capacity to build more earthquake resistant structures. Regional development typically involves three parallel and complementary processes: (1) increasing employment opportunities (division of labor); (2) increasing integration of local economic activities; and (3) increasing interaction or linkage with the larger national economy.

6.3.3 Generation of Employment (Division of Labor)

As the region develops and productivity increases, a growing percentage of the labor force will be employed in the manufacturing, service, and associated sectors. This can be seen in the economic statistics for the administrative regions of the earthquake inspected areas.

Table 6.3.3 - 1
PERCENT OF EMPLOYED PERSONS,
BY REGION, BY MAJOR INDUSTRY GROUP,
(third quarters of 1980 and 1987)

Sector	Region							
	National		I		II		III	
	1980	1987	1980	1987	1980	1987	1980	1987
Agriculture	51.4	48.3	60.4	55.0	70.7	67.7	38.3	38.1
Mining	-	-	2.0	2.9	-	-	-	-
Manufacturing	11.0	9.6	7.6	7.0	5.3	4.3	13.5	11.5
Construction	3.6	3.5	3.8	3.9	2.9	1.8	3.3	5.7
Trading	10.1	13.5	6.8	10.6	6.1	9.2	12.2	14.6
Transport/Com.	4.5	4.3	3.9	4.3	2.9	2.6	6.4	6.5
Services	18.0	19.7	15.7	16.3	10.3	13.1	22.7	22.8

Note: CAR data aggregated with Regions I and II
Source: NEDA.

The data suggest particularly strong growth in the wholesale and retail trading and service sectors. The declining percentage of the work force in agriculture suggests the growth of employment opportunities in other sectors. While the manufacturing sector suffered nationally during the political crisis from 1983 to 1986, it was relatively more robust in Regions I, II, and III.

A preliminary analysis of the situation suggests that the Baguio City and its hinterland have a comparative advantage in vegetable production, tourism, and educational service. The area, for example, supplies the majority of Metro Manila's vegetable requirements. It is also the number one tourist destination outside Metro Manila. In terms of educational service, Baguio City has an extraordinarily large student population, about 91,000, compared to its total estimated resident population of 155,000. About one-third of its students are non-residents.

In planning for the post-earthquake reconstruction of critical systems, especially infrastructure, particular attention should be given to creating networks and capacities that will support the development of these sectors well into the twenty-first century. In many cases growth in the last few years has been constrained by limited or unreliable transportation and communication linkages with the rest of the country, especially the lowland and Metro Manila markets, development has also been constrained by inadequate utility services, particularly water and electricity. With the earthquake necessitating reconstruction of these systems, the government has the opportunity to eliminate earlier constraints and create an environment supportive of new development.

Wholesale and retail trade represent sectors that provide opportunity for the use of this strategy. On a small scale they can often be efficiently intermingled. But as the level of activity increases, there are opportunities for economics of specialization and scale as well as earthquake vulnerability reduction. As Dagupan plans for reconstruction it may be appropriate to encourage wholesale and regional distribution activity to relocate from the traffic-congested and space-limited downtown area to a convenient nearby area that would have better seismological characteristics, lower land costs per unit area, less congestion, and better access to key transport routes. As roads and bridges are planned, they could be structured to support their relocation process.

6.3.4 Integration of Local Economic Activities

Integration of local economic activities is critical to increasing the division of labor and economic specialization. The tourism industry in Baguio is dependent on the local supply of fresh vegetables and many of the fastfood snack-type restaurants are dependent on the large student population attracted by the educational institutions in the city. The small holder producing vegetables for the Metro Manila market is efficient because of the wholesale trade and transport services provided in Baguio. These have been expanding rapidly.

As an area develops relationships like these become more numerous and more complex. They need to be enhanced. If constrained, they can begin to impact negatively on one another. Urban traffic congestion and the associated pollution, for example, can contribute to the deterioration of the urban environment and make it less attractive for tourists. The development of interactions between local economic activities needs to be encouraged, but also guided to minimize negative impacts.

Reliable transport, power, water, and telecommunications, infrastructures with capacity for expanded services is critical to integration of local economic activities. Good service must be available for new activity both in the urban core and at the periphery of expansion. Systems with adequate capacity to meet future growth from a well articulated series of spatially dispersed supply modes are generally less vulnerable to total failure as a result of an earthquake than the more commonly found centralized systems operating at full or overload capacity.

Deconcentrated systems can be designed to be flexible in response to changing patterns of development as well as to emergencies such as earthquakes. Urban water supply networks, for example, can be designed to accommodate the integration of new supply sources as demand grows, as well as to distribute water from the different sources through alternate linkages in the event of partial system failure.

In Dagupan, the thriving wholesale trade and intra-regional distribution of goods from Manila is highly dependent on local transport services. Similarly, retail commercial activity is closely integrated with the large volume of potential customers who arrive in the city on local transport. Farmers in surrounding areas come into Dagupan to buy many of their agricultural supplies.

6.3.5 Linkage with National Economy

Regions cannot function effectively in isolation. They are highly dependent on interactive linkages with the national economy. The Cordillera Administrative Region depends on the demand of the Metro Manila market for its vegetables. It also depends on the rest of the nation to supply the students for its educational institutions. Education can be provided efficiently in Baguio because of the relatively large scale of operation. This scale, however, far exceeds local demand, and therefore linkages with the rest of the nation are critical.

San Fernando, through its port and highway system, links much of Region I and the CAR with the rest of the nation. The mines in Benguet are able to be productive because they have good access to national and international markets for their products.

Dagupan is well linked to Metro Manila. This provides access to a large market, and as a result, residents of the Dagupan area can make large-scale effective use of their specialized fish production resources.

In planning for reconstructions, it will be necessary to deal with a series of critical decisions, particularly with regard to transport infrastructure. The cost of damage to the road network far exceeded the total cost of damage to buildings. The reestablishment of transport networks provides the opportunity to reduce earthquake vulnerability while at the same time contributing to regional development by strengthening linkages between the local economy and the rest of the nation. Although Baguio has been well served by transport links to the coast (interaction port at San Fernando) and Metro Manila, the northern part of the Cordillera has remained much more isolated. The limited access to sources of agricultural inputs and to market for outputs has put a severe constraint on development in the area. The creation of upgrading of east/west roads through the area would improve linkages dramatically, and provide Baguio with an alternative to reliance on its earthquake - vulnerable current access to the south. Similarly it may be useful to consider an international airport for Baguio to facilitate access for international tourism, and to support the Export Processing Zone with direct international air freight services. Such a facility, if constructed to withstand earthquakes, would be invaluable in times of future disasters.