CHAPTER 10

LESSONS LEARNED FROM THE 1990-1991 DISASTERS

10.1 Introduction

Natural hazard mitigation and integrated development planning are essential tools in the hands of decision makers, planners and administrators in the attempt to reduce the impact of natural disasters. In the case of the Philippines, based on the lessons learned from the 1990-91 events, the development model adopted in Central Luzon needs to be revised and alternative solutions considered. Prevention, reduction and mitigation of disaster effects (UNDRO, 1991) involve three main steps:

- Risk Assessment, which defines the types and magnitude of disasters by means of a multidisciplinary task force of geoscientists, engineers, planners, sociologists, environmentalists etc.
- Planning and Decision Making, which organizes the social response to the risks posed by disasters, after alternative strategies have been considered and the relative cost-benefit analysis evaluated;
- Implementation, which translates plans and decisions into action at various levels.

A full discussion of this complex process is beyond the scope of this book. However, the lessons learned from the earthquake and the eruption have been summarized below in three sections:

- remarks pertaining to the vulnerability of the Philippines and social response
- observations on problems related to specific aspects of Luzon's disasters
- recommendations and suggestions.

10.2 Disaster proneness of the Philippine Archipelago and social response

Some disasters which struck during the period 1987-91, such as typhoons, floodings, landslides are frequent and occur virtually every year affecting some highly vulnerable and well identified areas of the Archipelago. On the other hand, major earthquakes (which occur almost anywhere in the country) and volcanic eruptions (which mainly take place along volcanic belts), are characterized by recurrence periods of centuries in the same area, even though in the Country as a whole they recur at much shorter time intervals.

As already mentioned in Chapter 2

- 6 earthquakes of magnitudes between 7.3 and 8.3 hit the Philippines during the last 40 years, that is a strong event about every 7 years (Table 2.1);
- 41 destructive eruption episodes occurred in the Archipelago during the last 422 years (1572-1994), that is an event about every 10 years on average.

Such a national scenario, with annual and decadal recurrence of disasters, must be taken into consideration by planners and administrators. The events that affected Luzon in 1990-91 represent, of course, an unfavorable coincidence: two major disasters following one another within a year in an economically developed and densely inhabited region. It is highly improbable that such a singular sequence would recur soon somewhere else in the Country. On the other hand, earthquakes or eruptions by themselves can be even more destructive than the recent disasters in Luzon. Mount Taal (60 km south of Manila), for example, often erupted in the last few centuries, with explosions probably more powerful than that of Mt. Pinatubo and with much longer episodes of activity.

The disaster proneness of the Philippine Archipelago is a fundamental characteristic of the country, since it is located in the boundary zone of colliding plates and in the western monsoon region of the Pacific.

During the events of 1990-91, the social response in terms of mitigation measures succeeded in alleviating some of the problems. Disasters and aftermath showed, however, the limits of pre-disaster development planning and the precarious condition of people, activities and investments in various sectors. At the same time it became clear that not-allocating more resources in a regional plan for disaster prevention, reduction and mitigation can be dramatically wasteful.

Political leaders, decision-makers, administrators and the people who most suffered the effects of the 1990-91 calamities have learned the lesson and gained a better understanding of the relationship between extreme geological events and human development. Essential during 1990 and 1991 were the action of the Government in allocating resources for disaster management and the function of the National Disaster Coordinating Council (NDCC), established in 1978 to strengthen disaster control capability and preparedness.

10.3 Problems related to specific aspects of disasters

10.3.1 Landform evolution and the formation of a new regolith

G.H. Dury (Gregory, 1977) indicates that landslides and major eruptions of tephra can deliver into the natural drainage system more sediments in a single episode than the natural drainage system from an entire continent in a year. This gives an idea of the importance of the magnitude of the phenomena which affected Luzon in the 1990-91 period.

Landslide sediments mobilized by the July 1990 seismic activity in Central and Northwestern Luzon mountains were estimated at 0.4 cu. km; an additional enormous and not quantifiable volume of loosened topsoil was also produced by the quake. Pyroclastic material deposited by Mount Pinatubo was estimated at about 7 cu. km, half of which were considered erodible within a few years, depending on the intensity of rains (Chapter 8, Para. 8.4).

This huge quantity of about 4 cu. km of mobile sediments (0.4 cu. km from slides, 3.5 cu. km from tephra plus the volume of seismically loosened materials) represents a formidable hazard for flatland areas, people and their agricultural and industrial activities. The ashfall mass, in particular, under normal weather conditions for the area, may cause significant changes in the geomorphology and hydrological regimes, and bring about river channel migrations and flooding of the lowlying lands.

The dynamics of Luzon's environment after the 1990-91 events will be strongly influenced by three interrelated phenomena: the intensity of seasonal rainfalls, the consequent sedimentation process and the formation of a new regolith layer.

The occurrence in the next few years of rainstorms with return intervals above 50-100 years could trigger another disaster by mobilizing considerable volumes of the loose sediments generated by the quake and the eruption Relevant to the uplands and plains covered by recent ash deposits and to the scars left by the quake is the third aspect: the formation of a new regolith layer.

Slope instability phenomena in Cordillera and Caraballo Ranges (see Chapter 6) were not uniform over the landscape. Surficial soils of gently undulating areas in many cases remained as nearly undisturbed «islands», but with some local movements. Numerous steeper slopes failed, and their vegetation cover with the regolith layer slid down. Loosened soils can partly recover their particle aggregation, if not subject to the immediate increase of the erosion rate. Slide material, on the other hand, with uprooted trees and minor vegetation easily becomes a source of debris, ready for further mobilization.

This, in fact, started during the heavy rains of August through October 1990. and caused a rapid and massive downstream movement of sediments with destructive effects on infrastructure and environment. The formation of a new regolith layer over the slide areas will follow different trends depending on local conditions. In the case of scars with fresh rock outcrops, the process will take millennia: in contrast, wherever failures involved a very shallow layer or simply slope wash and the bedrock was not exposed, the formation of new regolith will be much faster.

The impact of Mount Pinatubòs ashfall was more extensive and destructive than the numerous landslides induced by the quake and affected the entire environment around the volcano. Landforms, topsoil, vegetation, wildlife. the natural drainage system, water infiltration and aquifer recharge were all heavily affected at once, and the pre-eruption environment was obliterated. The ash blanket is presently undergoing a complex and dynamic process of erosion and deposition of sediments in the flatland areas during rainy seasons. The formation of a new regolith layer is expected to be relatively fast in the areas with a thin ash cover, and will probably be completed within a decade. The new humus will be different, but in the long run it would tend to become similar to that existing before the eruption. This is because the flat land around the volcano was affected by eruptions and ensuing mudflows in the past as well. Three pathways in soil evolution are expected:

- where the ash cover is erodible and the pre-eruption topsoil will be exposed again after a few rainy seasons, or remain covered by a thin veil of ash, the formation of the new soil will take place soon;
- in areas with less than 10-12 cm ash and little erosion hazard, a natural resurgence of vegetation can be expected and the process will be speeded up in the flatlands by farmers ploughing and puddling the land;
- in zones with over 12 cm ash where normal tillage will not reach the original soil surface, a much longer period will pass before adapted vegetation types colonize the gradually weathering ash. This type of evolution is likely to follow a similar trend in areas where meters-thick ash-pockets have formed near the crater and in the flat zones on both sides of the downstream river segments, where thick layers of sediments were deposited

These different trends of soil formation and vegetation resurgence are likely to condition the environment, agriculture and future development of Central Luzon.

Since farming activities are of primary importance for the economy of the Philippines. investments by the local Government and International Agencies are likely to continue in this sector for years to come. It is essential, therefore, that there is a portfolio of environmentally and agriculturally oriented projects with the capability of guiding human activities; this in turn should result in a proper use of available resources and safeguard natural processes and the environment. The need for multidisciplinary and multisectoral research and financing of specific projects in the area is beyond doubt.

Suitable reforestation programs could reduce the erosion rate, accelerate the stabilization of loosened soils and facilitate the formation process of a new humus-rich topsoil. Such an initiative should be associated with a watershed management project in turn accompanied by *a*) geochemical. pedological and vegetation studies, *b*) a comprehensive study on the magnitude of hydrological events during the last decades, *c*) research on evolution of the landforms (modification of river channels and migration of streambeds in the flood prone areas), and *d*) the implementation of remedial measures to decrease sediment mobility and discharge rates.

10.3.2 Agricultural development and future perspectives

The combination of the ongoing natural processes, human action through specific projects and government integrated planning could make the Central Plain a safer and productive farmland area. This complex process should achieve the following results:

- an acceptable and environmentally sound equilibrium between farmlands in the plains and the bordering mountain ranges. The progressive control of the erosion/sedimentation cycle through reforestation projects could in due course improve the safety of flood prone areas:

- the rehabilitation, modification and the reconstruction of the drainage and irrigation facilities during the next few years. This should control sedimentation and stabilize the agricultural land areas:
- the increase of the productivity of soils with the progressive weathering of the ashfall material. Based on the natural resurgence of vegetation and the ongoing researches at the BSWM and IRRI it should be possible to guide the agricultural sector towards a productive period;
- a reasonably secure distribution of land, based on the experience of the 1990-91 events. This should be achieved by facilitating resettlement in low-risk areas, through well directed investments, tax incentives and insurance programs. These would also focus the attention of the community on the importance of vulnerability reduction and compensate for damage that is likely to occur. The floodplain E and SE of the volcano will remain a dynamic system controlled by the interaction between natural phenomena (climate, volcanic activity, the evolution of Pampanga River basin) and human development. A renewed effort in terms of agrarian land reform could complete the process. This, of course, needs a strong political will and a high level commitment.

The control of inundations and sediment delivery remains essential. The selected system should be sufficiently flexible to cope with rainfall variations, different discharge conditions, sediment mobility and the monitoring action required for the safety of the population. Particular importance should be devoted to studies on the composition of the soil and its productivity, using the indications already made available by BSWM in terms of types of crop, growing conditions and use of fertilizers to speed up rehabilitation.

It is worthwhile, finally, to stress once more the importance of reforestation. Due to the indiscriminate exploitation of forest resources during the last decades, the forestry sector suffered the consequences of the eruption over an area of more than 300 thousand ha. Since reforestation is a labor-intensive activity, it should be widely adopted as a rehabilitation and disaster-prevention measure. Beyond the well known effects on the stability of slopes and the reduction of the erosion rates, it favors the recharge of aquifers, at the same time providing protection and food to wildlife. A long term return for the wood-based industry can also be expected. Last, but not least, reforestation programs can be regarded as an investment for future generations.

10.4 Recommendations and suggestions

10.4.1 Maps and data banks

The surveys of the region should be completed (physiography, geology, tectonics, hydrology, soils, vegetation, climate etc.), and multiple-hazard and landuse maps made available at municipal levels. Seismic microzoning and volcanic hazard maps are essential. A fundamental point in the vulnerability reduction process is that the only way to convince people to avoid the most hazardous areas near a volcano or an active fault, is to disseminate the proper information. People need to realize that their efforts and investment can be spoiled by natural hazards. At the present time, surveys and data banks do not cover some of the hazardous areas in Luzon.

10.4.2 Building codes and liquefaction-prone areas

Construction standards and building codes need to be revised and enforced, especially for areas where the intensity of the quake caused most damage (Baguio and Dagupan provinces). The majority of the seismically-induced damage to the infrastructure sector, in fact, can be attributed to the low construction standards and the disregard of appropriate building codes. These need to be updated on the basis of the experience of the 1990 earthquake and regulations be enforced by law and government controlling agencies.

A major and most destructive effect of the earthquake was the liquefaction in the Central Plain. Since surficial soils in this area also liquefied during previous strong earthquakes, there is a major risk that the phenomenon will occur again.

In general, land use maps could help in disseminating information on hazard zones and guiding development. Researches on former river meanders in Dagupan City (Torres et al., 1991) show that liquefaction-prone areas are often associated with river channel changes and the recent deposition of fine sediments. Based on this experience and using traditional investigation methods (drilling, SPT, etc) the entire zone affected by liquefaction in the Central Plain should be surveyed in detail.

One method for the rapid identification of liquefaction prone areas, based on shear wave velocity, was proposed by Stokoe et al. (1988) and by Tokimatsu et al. (1991). The method is based on the correspondence of high values of the velocity of shear waves to high resistance to liquefaction and vice-versa. Thus, through the measurement of ground vibrations artificially induced a shear wave dispersion curve is determined and variations in the soil resistance to liquefaction identified.

The experience gained in the area affected by liquefaction suggests in general that compact one-two storey buildings resting on square or rectangular reinforced concrete platforms (sides ratio up to 1:2) can better stand liquefaction without suffering the severe differential settlement and tilting seen in Dagupan City after the quake. The reconstruction of damaged buildings and infrastructure cannot be confined to these simple models, however; nor can it ignore the cost of land, which is high for one to two storey buildings on a platform foundation. Driven or bored piles for some particular structures (such as bridges and high-rise buildings for example), remain the only way to carry the loads, through the liquefaction-prone layer, into a firm substratum.

10.4.3 The performance of the rigid pavement of the road network during the quake

The adoption of rigid pavements (usually made of 3 by 3.5 m cement concrete slabs cast in situ) for most roads in Central and Northern Luzon resulted in devastation by the ground shaking induced by the quake.

It is generally accepted that a well done rigid pavement can last for decades and does not need costly maintenance. Overloading by trucks, low quality of the concrete and poor construction technique, however, resulted in poor performance of these pavements even before the 1990 earthquake. The quake caused most damage a) in the Caraballo mountains where the Dalton Pass road was crossed several times by the ground rupture, b) in the sections severely affected by slides, and c) in the flatland areas where liquefaction occurred. In the liquefaction areas, several kilometers of rigid pavement had to demolished because of the longitudinal cracks and the undulations of the road surface (with about 20-25 m between crests) induced by the quake.

Flexible pavements would have suffered as well, but the damage would have been more limited, and repair works faster and cheaper. The problem, however, is complex and alternating sections of rigid and flexible pavements, depending on local conditions, could represent an acceptable solution. Flexible asphalt-concrete pavements adapt in general to various types of deformation and the extent of failure is more limited than where contiguous rigid slabs influence one another during earth shaking.