TRANSACTIONSNASTPHL

https://transactions.nast.ph

ISSN 0115-8848 (print)
ISSN 2815-2042 (online)

Vol. 36 Issue No. 2 (2014)
https://doi.org/10.57043/transnastphl.2014.2985

Transactions NAST PHL, is the official journal of the National Academy of Science and Technology Philippines. It has traditionally published papers presented during the Academy's Annual Scientific Meeting since 1979 to promote science-based policy discussions of and recommendations on timely and relevant national issues as part of its functions as a national science academy. Starting in 2021, this journal has been open to contributions from the global scientific community in all fields of science and technology.

Flood Risk Management Towards Resilient Communities: DPWH Approach

Maria Catalina E. Cabral

Undersecretary for Planning and Public-Private Partnership Services, Department of Public Works and Highways (DPWH), Philippines

Citation
Cabral MCE. 2014. Flood risk management towards resilient communities: DWH approach. Transactions NAST PHL 36 (2): 259-274. https://doi.org/10.57043/transnastphl.2014.2985

Trans. Nat. Acad. Sci. & Tech. (Philippines) Vol. 36 (No. 2), 2014 259
ISSN 0115-8848

FLOOD RISK MANAGEMENT TOWARDS RESILIENT COMMUNITIES: DPWH APPROACH

Maria Catalina E. Cabral

Undersecretary for Planning and Public-Private Partnership Services, Department of Public Works and Highways (DPWH), Philippines

Abstract

Flooding in the Philippines occurs annually in many areas and in varying frequencies and magnitude. Located along the cyclone path, the country suffers from floods and other water induced disasters. In late September and early October 2009, Tropical Storm Ketsana ("Ondoy") and Typhoon Parma ("Pepeng") hit the country in succession and inflicted extensive casualties and physical damage to the country. Tropical Storm Washi ("Sendong") in December 2011 severely devastated Cagayan de Oro City in Southern Philippines, wiping houses and claiming lives on the island formations in the river area. Again, in December 2012 the city was hit by Typhoon Bopha along with other provinces in Mindanao Island.

The country suffered severe devastation from super typhoon Haiyan (locally known as Typhoon Yolanda), which wreaked havoc in the Visayas and South Luzon regions on November 8, 2013. The extreme event turned out to be one of the strongest storms to make landfall in history.

The Department of Public Works and Highways (DPWH), at the forefront of mitigating the impacts of water related hazards through the provision of structural measures, is constantly challenged to provide efficient and innovative technologies to address current and emerging risks. This paper describes the country's integrated flood risk management approaches and DPWH's thrusts, programs, policies and strategies towards the establishment of resilient communities.

Introduction

Most weather-related disasters in the country are due directly or indirectly to tropical cyclones. Destructive typhoons inflict severe damage on property, infrastructure and crops, and cause loss of lives. The World Risk Report of 2012 ranked the country third in the world risk index with an index of 27.98%, based on exposure, vulnerability, susceptibility, lack of coping capacities and lack of adaptive capacities. A study (WB, 2005) reported that the country's vulnerability to natural hazards cost the government an average of PhP 15 billion (U$ 350 million at 2013 rate) annually in direct damages, or more than 0.5 percent of Gross Domestic Product (GDP).

The damages inflicted by the successive occurrence of Tropical Storm Ketsana ("Ondoy") and Typhoon Parma ("Pepeng") were so widespread that they affected not only most parts of Luzon including Metro Manila but also some areas in Mindanao Island. The Master Plan for Flood Management in Metro Manila and Surrounding Areas showed that for the Pasig-Marikina River Basin the 2 day rainfall experienced during tropical storm Ketsana in September 2009 is equivalent to a 70-year return period while the one day rainfall is equivalent to a 120-year return period (DPWH-WB, 2011). In 2012 and 2013, the southwest monsoon ("Habagat") rains caused massive flooding in Metro Manila and in various parts of the country, including some areas that have not experienced such extent of flooding before.

Figure 1 Shows the frequency of passage of tropical cyclones in the Philippine Area of Responsibility (PAR) as tracked by the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA).

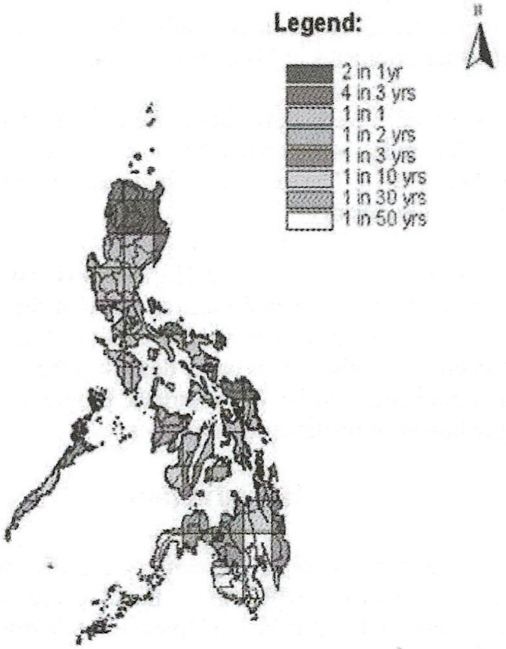


Figure 1. Frequency of Cyclone Occurrence

The flood disasters are not only attributed to the natural conditions but are also exacerbated by anthropogenic drivers, such as: degradation of forests, rapid urbanization, unregulated development of flood plains, obstruction along waterways, encroachment in river easements and waterways, clogging of waterways and drainage and land subsidence.

The World Bank defines "resilience" as the ability of a system, community or society exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures (WB 2012). Building resilience in communities requires not only the government's efforts at mitigating the impacts of the hazards, but also the disaster response and recovery programs.

Flood Risk Management Measures

Flood risk management measures have always been the government's responsibility. However, recognizing that the government alone cannot provide adequate mitigation, and that the country is highly vulnerable to water-related hazards, the increased participation of the civil society, the academe, private sector, and other stakeholders has been encouraged. This is enshrined in two recent environmental laws recently enacted, *i.e.*, the Disaster Risk Reduction and Management Act of 2010 and the Climate Change Act of 2009. Flood risk management measures basically consists of structural measures and non-structural measures.

Infrastructures for Flood Mitigation

Structural measures against floods, which are considered as direct countermeasures, are implemented for disaster mitigation. Vulnerability to flooding is exacerbated by the absence or inadequacy of infrastructures to reduce the magnitude of flood hazard. Structural measures are infrastructures to reduce frequency and magnitude of flooding. They require high capital expenditures and much time to implement for comprehensive plans. The Department of Public Works and Highways (DPWH), the country's engineering and construction agency has been constantly challenged to provide effective and sustainable flood control infrastructures.

The engineering measures are effective up to a certain design standard or safety level, *e.g.*, 10-yr. flood, 25-yr. flood, or 50-yr. flood. If the flood exceeds the design level, damage will still occur. As such, it is acknowledged that flood mitigation is reduced or may be lost with the onslaught of extreme events with higher magnitude floods than those used to design the structures.

Overview of Structural Measures

Flood Control structures are designed to preserve and enhance the retention and detention capabilities of river systems and constructed to withstand flooding of a pre-determined magnitude or flood return period. The DPWH has been implementing proven engineering technologies such as dikes, retention ponds, sedimentation basins, sabo ("sediment movement and control") dams, channeling, river walls, revetment, spur dikes, groundsills, flood ways, pumping stations, floodgates. Construction and improvement of drainage facilities are also undertaken to mitigate the negative effects of floods, particularly in urban areas.

Majority of these structural measures are categorized according to purpose as follows: a) to increase discharge capacity; b) to reduce and/or control the peak discharge of flood; c) to prevent inland flood; d) to prevent bank collapse; e) to prevent harmful degradation of riverbed; and f) to prevent obstruction against river flow and/or maintain/conserve the good condition of the river in order to keep the flow uninterrupted.

Increase of discharge capacity

The most common flood control measure is increasing the discharge capacity of the conveyance channels (rivers, waterways). This may be done by constructing a dike, widening or deepening of the channel, dredging for maintenance or increase of capacity, or a combination of these measures.

A dike is a flood prevention structure constructed higher than the ground elevation of the inland, in order to confine the flood discharge in the channel and to prevent the inland from flooding, particularly the flood prone areas. Most dikes are constructed of earth materials because of low construction cost and easy operation and maintenance.

Reduction and/or Control of the Peak Discharge of Flood

The peak discharge maybe reduced and/or controlled by a dam or a retarding basin. A dam is a structure built mainly for water resources development but can also provide storage for flood control. In line with flood control, the dam can retard flood runoff and in this case reduce the peak discharge of flood.

Prevention of Inland Flood

Inland flood may be prevented by lateral/tributary improvement or by the use of a pumping station. A pumping station is a facility usually located in areas where gravity drainage is not feasible. It pumps floodwater out from the landside to the main channel/lake/sea. It must have continuous operation in case of continuous flooding or inundation.

Prevention of Bank Collapse

Bank collapse should be prevented as this may cause the shift of river or channel flow. This can be achieved with the use of revetment, spur dike or a cut-off channel. Revetment is a flood control structure for protection of the riverbank from collapse brought about by erosion, scouring and riverbed degradation. A spur dike is a river structure built on the riverbank to protect it from scouring and erosion by reducing the flow velocity near riverbank and/or redirecting the river flow away from the riverbank.

A cut-off channel is a shortened waterway made by excavating a new river course to correct/straighten conspicuous meandering by connecting the beginning and end of the meandering portion. Some functions of the cut-off channel are: a) to adjust and modify river channel alignment; b) to deepen water depth for navigation; c) to provide discharge for diversion at the point of channel diversion; and d) to improve rivers cape and to preserve and develop the ecosystem.

To prevent harmful degradation of riverbed

A groundsill is a river structure constructed to prevent riverbed degradation, to stabilize the riverbed and maintain the longitudinal and cross-sectional profiles

To prevent obstruction against river flow and/or maintain/conserve the good condition of the river in order to keep the flow uninterrupted, it is important that the river flow is unimpeded and conveyance of water towards a discharge outlet is smooth. This condition may be attained by regular maintenance of the waterways and/or the use of sabo works.

Other Infrastructures

Sabo works are used as flood control measures for: a) debris flows in steep streams which directly attack infrastructures; and b) the gradual aggradations of riverbed in a drainage area. Countermeasures include sabo dams and channel works as well as training dikes, sand pockets, groundsill, etc. A sabo dam is a dam structure made of concrete or gabions constructed to control potential damaging sediment or debris by retaining existing sediment in the riverbed, trapping sediment being transported downstream in the river, and detaining sediment temporarily during peak flow events thus attenuating sediment load.

Other flood control infrastructures in the country include the underground detention tank, which was constructed in the Fort Bonifacio Global City, meant to detain 'post development runoff' only. Likewise, two (2) retarding basins are being initiated in Imus, Cavite and are scheduled to be constructed and completed by 2016.

Non- Structural Measures

Flood risk management requires a comprehensive approach to help the communities cope with disasters. Thus, non-structural measures are adopted to complement the structural measures. With the country's high vulnerability to many disasters and financial constraints to implement adequate infrastructures, responsive non-structural measures form an integral part of disaster mitigation programs. Among the non-structural approaches in flood management are: flood hazard mapping; flood forecasting and warning systems, awareness raising, watershed management, land use management, and even solid waste management (to avoid clogging of drainage and choking of waterways in urban areas). Damage to properties, agriculture and infrastructure may not be reduced considerably with the absence or inadequacy of structural measures, but non-structural measures will avert loss of lives and mitigate impacts. The general approach is towards flood management, shifting from the traditional flood control (structural measures) approach. The main agencies involved in the non-structural measures are the Department of Environment and Natural Resources (DENR) for watershed management, Department of Science and Technology-Philippine Atmospheric Geophysical and Astronomical Services Administration (DOST-PAGASA) for flood mapping, forecasting and warning, Office of Civil Defense for disaster preparedness, rescue and recovery. The local government units are mainly tasked with the implementation of disaster management and evacuation plans, land use planning and resettlement of communities from hazard prone areas, among others.

Policies in Flood Control Infrastructure Development

Tasked with mitigating the impacts of hazards, the DPWH provides flood control infrastructures facilities such as dikes, revetments, spur dikes, groundsills, pumping stations, as well as drainage systems. Sabo (sediment movement control) dams and sabo engineering works to contain sediments, which are transported in the rivers, resulting in reduced channel conveyance capacity, are now increasingly used in landslide-prone and sediment-transport-prone areas. The use of a retarding basin in

Imus River is being introduced in a newly commenced JICA-assisted Flood Risk Management Project for the Cagayan, Tagoloan and Imus Rivers.

The provision of flood control structures is presently insufficient. This is caused mainly by insufficient budget and absence of river improvement plans. To rationalize investments in the provision of flood infrastructures, several policies and strategies are being pursued by the DPWH, such as:

a) Prioritize flood control projects in major and principal river basins to address climate change based on master plans;
b) Provide adequate flood control and upgrade drainage facilities in flood-disaster- prone areas;
c) Promote innovative technologies such as geotextiles and coco-netting in slope protection and soil erosion control;
d) Promote use of rainwater harvesting (e.g., rainwater cisterns, retarding basins for non-domestic use); and
e) Support other agencies' efforts in non-structural measures such as hazard mapping, slope management plan, proper garbage collection and disposal, relocation of informal settlers living along rivers/creeks, waterway/creek cleaning

Other DPWH strategies are being pursued for adaptation of infrastructure to the increasing water-related risks and challenges such as: a) nationwide flood risk assessment of river basins; b) master plan and feasibility study of principal river basins (catchment of greater than 40 square kilometers); c) institutional capacity development; and d) new engineering approaches.

The nationwide flood risk assessment study completed in 2008 produced a long list of 120 principal river basins screened based on socio-economic and natural conditions, and ranked for prioritization. Finally, 56 river basins were identified for project implementation from 2009-2034 using foreign and local funding. The list is now used as a reference in river basin flood and drainage management investments.

New engineering approaches and the use of indigenous materials are also being implemented and adopted. Coconut bio-Engineering products and solutions are prescribed under DPWH Department Order 41 of August 2010 for slope stabilization, soil erosion prevention, river bank protection and/or hydroseeding. The use of retarding ponds or basins is part of the flood control system proposed in the Cavite Lowland area, wherein channel improvement is constrained because of highly urbanized areas in Cavite province and cities. The inclusion of impounding reservoirs, retarding basins and sabo engineering structures in DPWH's flood management program is directed through a Memorandum by the Secretary in August 2010. The DPWH Secretary also approved in July 2010 a Prioritization Criteria for Flood Control

Projects. The criteria include project preparedness, classification/importance of the river, and development policy for projects costing PhP 500 million (USD 12 million) and more. The prioritization ranking was resorted to because too many requests from the field offices, local government units, or other proponents, for the construction and maintenance of flood structures compete for funding. In 2011 alone, the ratio of project requests to available funds under the General Appropriations Act is about 50:1.

The assessment of potential impacts of climate change is now included in the conduct of master plan and feasibility study of flood control and drainage projects in principal river basins. Structural measures and non-structural measures are requisite components of basin studies.

Master Plan for Flood Management in Metro Manila

Metro Manila epitomizes urban flooding problems in the country, and as the center of the country's economic activities, huge losses are inflicted by tropical cyclones and even by monsoon rains. The economic losses are coupled with loss of lives, particularly in areas where there is encroachment into rivers and waterways.

The Master Plan for Flood Management in Metro Manila and surrounding areas, completed in 2012, aims to establish the blueprint or road map for a sustainable and effective flood risk management system. The factors that caused the extensive damage by the Ondoy flood are as follows 1) Many settlements exist in the dangerous flood risk areas such as inside or very near river channels as well as the low-lying areas along the Laguna lakeshores and even in the lake; 2) Small flow capacity of the rivers, resulting in the overflow of floodwater; 3) Insufficient drainage system against heavy concentrated rainfall; 4) Unsatisfactory protection level for residents around the rivers and beside the Laguna Lakeshore; 5) Lack of consistent management of the river system including river area and river channel; 6) Non-existence of integrated flood control and mitigation plan and activities; and 7) Insufficient action and activities with regard to warning and evacuation.

Framework for Integrated Flood Risk Management Plan

The proposed Macro-Framework for Integrated Flood Risk Management Plan is composed of the following: a.) Flood Risk Maps, b.) Flood Safety Levels, c.) Institutional Improvement for Flood Risk Management, d.) Priority Projects and, e.) Implementation Program. Local Government Units (LGUs) are encouraged to apply the Flood Risk Maps for land use plans and managing lands.

Flood Risk Level

The Flood Risk Map on Danger of Casualty for the rivers and Laguna Lake indicates the areas with varying risk levels, *i.e.,* low risk, medium risk, high risk and very high risk. Table 1 presents the criteria for assessment of the flood risk levels.

Table 1. Flood Risk Levels

Flood Risk Level	Condition	River Water Depth
4	Very high risk of casualty	5.0 m < D
3	High risk of casualty	2.0 m < D ≤ 5.0 m
2	Medium risk of casualty	0.5 m < D ≤ 2.0 m
1	Low risk of casualty	D ≤ 0.5m

Flood Risk Level 4 is described as: "very difficult to evacuate and people lose the safety of their house during the flood event." Risk Level 3 is described as: "the safe place during flood is only roof area in case of two-story house." Risk Level 2, is described as: "in the case of a single story house the safe place during flood is only roof area." The least risk level is Risk Level 1, which is described as: "people can evacuate to evacuation places by themselves during flood event."

The population in the study area exposed to Risk Level 3 or Level 4 is estimated at 1.17 Million, which is about 6.8% of the total population in the study area. Considering flood risk management, the Flood Risk Management Plan comprises of priority structural mitigation measures, non-structural mitigation measures and preparedness measures. Institutional improvement for flood risk management, *i.e.*, refers to amendments of laws and regulations for flood risk management and delineation of responsibilities. The non-structural mitigation measures include: a) land use management in the very high and high flood risk areas; b) watershed conservations and recovery including reforestation; and c) on-site and off-site retention. Such measures are necessary for flood risk reduction and management. Likewise, the performance of structural measures is ensured/ enhanced with these measures.

To ensure that the communities are strengthened and adequately warned for evacuation, the Flood Risk Management Plan also emphasizes preparedness measures. These include the improvement of the warning system, installation of new telemetric rainfall and water level gauging stations as well as radar rainfall gauge for PAGASA, capacity building for strengthening community-based flood risk management and the improvement of management information system (MIS) for disaster risk management.

Flood Risk Management Projects for River Basins: Cagayan De Oro River Case

The recent policies on Disaster Risk Reduction and Climate Change Adaptation, and infrastructure strategies are integrated in a recently completed study "Preparatory Survey for Flood Risk Management Project for the Cagayan de Oro River". Cagayan de Oro City, located in the northern Mindanao Island, was heavily devastated by Tropical Storm Washi (TS Sendong in the Philippines) in December 2011, with more than a thousand people's lives lost. The casualties were mainly attributed to the settlement of people in the island of sediments that formed in the river area, and the lack of warning and evacuation system. The discussion is based on the final report of the Study (DPWH and JICA 2013).

Conceptual Measures

There are proposed short term and long term projects. The short term measures focus on the core areas only, particularly the urbanized areas where the potential impacts are high. The structural measures for the core area comprise of river improvement in downstream for 25-yr flood. These include the construction of dikes/retaining walls, construction of new road/raising of existing road for evacuation, improvement of Kagayan Bridge, construction of retarding basin, and removal of sedimentation and sand bar. The non-structural measures include: 1) preparation/update of flood hazard map, evacuation planning; 2) flood forecasting and warning system; 3) community-based flood early warning system; 4) information campaign and publicity campaign for the project (structural measures for DPWH); 5) technical assistance for Geographic Information System (GIS) for land use regulation for habitually inundated areas; 6) technical assistance for riparian forest establishment in the agricultural lands; and 7) technical assistance for mangrove forest establishment along the coastal areas. The long term measures are proposed for a 50-yr flood, with the plan for a dam upstream.

River Boundary and Flood Risk

Under the Study, the river boundary along the Cagayan River was established, considering the wider flood prone area than the No Build Zone (NBZ) declared after TS Washi, and based on the results of studies for river morphology, inundation analysis and flood risk assessment.

The flood risk was assessed based on the evaluation criteria adopted by the World Bank Study, Master Plan for Flood Management in Metro Manila (DPWH and JICA

2013) and surrounding areas. The alignment of river boundary is set along the outer line of Flood Risk Level 4., which is described as: "very difficult to evacuate and people lose the safety of their house during flood event." The area of Level 4 in Cagayan de Oro River was repeatedly damaged by recent floods; hence this area is not a safe place where people can live. Under this concept, people living in Flood Risk Level 4 will be relocated, and people living in the Flood Risk Levels 1 to 3 will be protected.

Relocation of People from High Risk Areas

The potential impacts of the Project include: a) impacts on people residing in the project area; b) impacts on land (right of way for structures and lands which become river area at very high flood risk after construction of structures); c) impacts on structures (those which need to be relocated); and d) impacts on improvements, trees and crops.

There are 21 existing resettlement sites that were developed by Cagayan de Oro City government, National Housing Authority and non-governmental organizations, in order to provide housing units for persons affected by the massive flooding caused by TS Washi. In addition, there are 7 resettlement sites being proposed.

The city government created the Shelter and housing Development Multi-Sectoral Task Force in August 2013 in order to address and work on the following: a) preparation of a city comprehensive housing and urban development master plan, b) formulation of a strategy to provide basis service and sustainable development assistance for internally displaced persons and communities, c) identification and recommendation of priorities and other concerns in the implementation of housing program, d) coordination of all activities with key government agencies, and e) provision of an effective strategy to ensure the gradual and substantial reduction in the numbers of illegal settlers in the city.

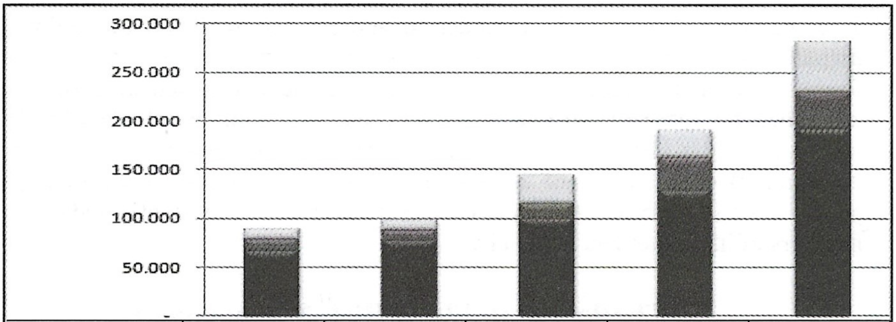
Challenges in Flood Risk Management

A major challenge in flood risk management is increasing protection of communities and properties under threat of flood and other water-related hazards. Engineering measures are effective only up to a certain design standard or safety level, such as 10-yr flood, 25-yr flood, *etc.* With the country's meager resources allocated for many disaster-prone areas, the provision of infrastructures is often inadequate. This means that there should be increased budget for infrastructure and integrated provision of infrastructure. It is also necessary that people are relocated from high risk areas to safe areas. This would require resources and logistics for land acquisition and development, provision of ancillary services like electricity, water and transportation.

Other challenges are: a) pursuing integrated flood management; b) improving watershed/river basin management; c) increasing public and private sector awareness and participation and d) good governance.

A major hindrance to implementation of flood mitigation projects downstream of rivers is the proliferation of densely packed houses along the river channel, which require an extremely large number of resettlement for river channel improvements. In Cavite, a rapidly urbanizing province near Metro Manila, the selection of alternative structural measures was constrained by the high density of households along the channel, such that the option of capturing flood waters through retarding basins has been selected instead. Moreover, the laws and policies relating to relocation and resettlement have made it difficult for projects to be implemented without providing socialized housing units to displaced people.

The DPWH investment for flood control under the General Appropriations Act for 2014 and 2015 has increased substantially compared to the previous years, see Figure 2 for the annual investment. The increase in budget allocation may be attributed to the strong support of the current Secretary of the DPWH for disaster mitigation projects. However, with the country's high vulnerability to floods and other water-related hazards, there is a need for more funds for infrastructures.



	2011	2012	2013	2014	2015
Highways	68.041	78.099	100.930	129.412	191.662
Flood Control	11.323	10.817	15.852	33.620	38.259
Others	11.308	10.575	27.557	27.898	51.611
Total	90.672	99.490	144.339	190.930	281.532

Figure 2. 2011-2015 DPWH Infrastructure Program: Capital Outlays – Projects

Meanwhile, the evacuation of affected persons in times of disaster is hampered by the adequacy, accessibility of evacuation centers. There is a need to construct disaster-resilient classrooms. The school buildings in areas prone to typhoons, earthquakes and other natural hazards should be designed not only to be disaster-resilient but also for them to function as adequate evacuation centers during disasters.

Pursuing integrated flood management at the very least will need: 1) strengthening national and local capacities for integrated flood management; 2) establishing a proper management system of data/information (effective operation of adequate rainfall and stream flow gauging stations, updated maps, database systems); 3) reliable hydrological, meteorological and hydraulic information for planners and forecasters; 4) human resources development; and 5) logistics: equipment, computers, software, etc.

Improving watershed/river basin management is critical for flood risk management. Because of continuing deforestation, only 45 percent of classified forestlands remain. An analysis of satellite-based maps elaborated by the EU's Joint Research Centre (JRC) in 2007 revealed that, possibly, only 19 percent of the country's land area remains forested (NEDA 2011). This situation has increased siltation. As referred from studies, NEDA (2011) declares that the main threats to Philippine forests come from the collection of fuel wood, settlements in forestlands, conversion to agricultural uses, *kaingin* (slash and burn farming), forest fires, and illegal logging. Deforestation has made many poor communities more vulnerable to natural calamities such as typhoons, flash floods, and landslides. Aggradations of sediments in river channels reduce conveyance capacities, thereby necessitating not only flood control infrastructures but also sediment transport control infrastructures.

Good governance is needed to ensure that the concerned environmental laws are strictly implemented. Solid waste management is important particularly for urban areas where clogged drainage systems contribute to flooding. Encroachment of people in waterways should also not be allowed as they will be at high risk of exposure and the encroachment reduces the conveyance capacity of the channels. Other laws and policies relating to the health of the watershed and the ecosystem should also be imposed. Land use zoning is also critical in flood risk management.

Conclusion

The country's high risk for floods and other water-related hazards is not only characterized by the exposure to the natural hazards but also by the vulnerability of the community as well. Flood risk management measures which consist of structural and non-structural measures are critical to ensure that the communities become resilient and can readily cope with and recover after disasters. The new laws that directly address climate risks and flood management concerns may seem adequate.

Likewise, the strategies being pursued and the programs being implemented may contribute to adaptation and disaster risk reduction and management. The increase in infrastructure investment is laudable and is long overdue, given the country's vulnerability to natural hazards, and this should be sustained. However, unless critical gaps, constraints and barriers are addressed, flood management will be very difficult, people will continue to be exposed to high risk, and sustainable development will be hardly attained. Aside from river overflow risks, flashfloods and debris flows, there is also high risks for people living in the coastal areas as the country is also extremely vulnerable to storm surges and tsunamis. It is critical that other strategies aside from relocation, such as providing sea barriers and infrastructures, are strengthened and implemented.

References

Dargantes BB, Predo CD, Dargantes MAI. 2007. *Community Responses to Climate-Related Disasters: Case Studies of Flooding and Landslide Experiences in Leyte, Philippines.* Proceedings: International Conference on hydrology and Water Resources Management for Hazard Reduction and Sustainable Development (HRSD-2007). IHP Technical Documents in Hydrology No. 7. UNESCO Office, Jakarta.

[DPWH, JICA] Department of Public Works & Highways, Japan International Cooperation Agency. 2008. *Study on Comprehensive Flood Mitigation for Cavite Lowland Area. Final Report.* DPWH, JICA, Philippines.

[DPWH, JICA] Department of Public Works & Highways, Japan International Cooperation Agency. 2009. *Preparatory study on Disaster Risk Management for a sector loan. Final Report.* DPWH, JICA, Philippines.

[DPWH, JICA] Department of Public Works & Highways, Japan International Cooperation Agency. 2013. *Preparatory Survey for Flood Risk Management Project for Cagayan de Oro River (FRIMP-CDOR). Draft Final Report.* DPWH-JICA, Philippines.

[DPWH,WB] Department of Public Works & Highways, World Bank. 2011. *Master plan for flood management in Metro Manila and surrounding areas. Final Report.*DPWH-WB, Philippines.

[NEDA] National Economic and Development Authority. (2011). *Philippine Development Plan 2011-2016.* National Economic and Development Authority. Philippines.

[PAGASA] Philippine Atmospheric, Geophysical and Astronomical Services Administration. 2001. *Documentation and analysis of Impacts of and responses to* *extreme climate events.* Climatology and Agrometeorology Branch Technical Paper No. 2001-2. PAGASA, Quezon City. Philippines.

[WB] World Bank. 2005. *Natural Disaster Risk Management in the Philippines: Enhancing Poverty Alleviation through Disaster Reduction*. Philippines.

[WB] World Bank. 2009. *Typhoon Ondoy and Pepeng Post Disaster Needs Assessment Report.* Philippines.

[WB] World Bank. 2012. *Building Urban Resilience Principles, Tools and Practice*. NWWashington, DC 20433, USA