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Urban dimensions of flooding and holistic flood risk management:

The case of the Pasig-Marikina River Basin in Metro Manila[1]

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Introduction

Metro Manila has several highly urbanized river basins. The Pasig–Marikina River Basin, in particular, is the major one that runs through a large portion of Metro Manila. The Marikina River Basin, located northeast of Metro Manila, joins the Pasig River and drains to Manila Bay. Nearby is the Laguna de Bay (Laguna Lake) Basin which is an extensive and urbanizing lake region in the southeast portion of Metro Manila. Laguna Lake is connected to the Pasig–Marikina River through the Napindan River and the Manggahan Floodway, which was built in 1985 to serve as temporary storage of floodwaters from these two rivers.

Metro Manila experiences severe flooding hazards due to meteorological events, such as typhoons from the Pacific Ocean that occur between August to November, the southwest monsoon from the Indian Ocean around June to September, or the occasional severe thunderstorms from overheated land surfaces. The major flood-prone areas of Metro Manila that experience yearly flooding along the Pasig–Marikina River Basin are at the heart of highly urbanized areas, such as Marikina City, Cainta, Eastwood–Libis–Manggahan area, San Juan City, and the Paco–Tondo–Sampaloc area. Around the Laguna Lake, several lakeshore towns become flooded for three to four months when severe typhoon or monsoon events occur since floodwaters from the Marikina River are diverted to the Laguna Lake and the lake has a severely restricted channel outlet to Manila Bay to remove the excess floodwaters. With changing climate, land use/cover changes, and unabated urban sprawl, it is necessary to periodically reassess Metro Manila's flood risk management schemes, including its major flood control infrastructures.

In view of the urban flooding situation in Metro Manila, particularly along the Pasig–Marikina River, this policy brief discusses the need for holistic flood risk management for urban areas, particularly in the Pasig–Marikina River Basin. Holistic flood risk management in an urban setting must follow the frameworks of integrated flood management, sustainability science, and a transdisciplinary approach (Tabios 2010).

[1] This policy brief is based on the author's paper of the same title which is part of the research project "A Study on the Implications of Federalism in the National Capital Region and Considerations for Forming the Federal Administrative Region" of the University of the Philippines Center for Integrative and Development Studies (UP CIDS), the Department of the Interior and Local Government–National Capital Region (DILG–NCR), and the Local Government of Quezon City. The project is funded by the DILG–NCR.

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Major factors contributing to flooding

Three major factors that contribute to flooding are meteorological, hydrological, and human factors. In the Philippines, the meteorological factors are tropical cyclones or typhoons; the southwest monsoons which bring prolonged and intense rainfall; the intertropical convergence zone (ITCZ); and thunderstorms associated with flash floods. Hydrological factors include antecedent soil moisture conditions; absorptive capacity or infiltration rate of soil; overland flow characteristics; presence or absence of overbank flow; and channel cross-sectional shape and roughness. The human factors include land-use activities; occupation of floodplains; decreased conveyance capacity in river channels due to build-up of river debris or encroachment by human settlements; forest denudation that promotes soil erosion, resulting in the shallowing of rivers due to deposition of eroded sediments, mining, or quarrying activities that can alter watercourses and river topography; and, on a global scale, greenhouse gas emissions that result in climate change.

Nothing can be done to modify the meteorological factors. The hydrological factors are mostly a product of nature, but they can be modified to some extent through engineering measures. The human factors, in particular, are mostly created by socio-economic and even political developments. In urban areas like Metro Manila, the human factor may be considered a major contributor to flooding as discussed in the next section.

Flooding attributed to human factors

The following illustrate how human factors contribute to flooding in Metro Manila:

- *Increased sediment yield in the upper portion of Marikina River Basin*

  Forest denudation and quarrying in the upper Marikina River Basin are responsible for increased soil erosion and sediment loads into the river.

- *Reduction of river capacity to convey floodwaters efficiently*

  Due to increased sediment loads, the river can no longer move sediments according to its natural dynamics, which results in sediment deposition, shallowing, and consequently, reduction in its ability to convey floodwaters.

- *Residential and commercial developments in flood-prone areas*

  There are residential and commercial developments in the middle portion of the Marikina River that are essentially in the inner meander loops or flood-prone areas of the river such as residential subdivisions (e.g., Provident Village in Marikina), and a shopping mall (SM City Marikina) is located downstream. Both areas are floodplains that could have temporarily detained volumes of floodwater.

- *Reduction of channel conveyance capacity of the Manggahan Floodway*

  The Manggahan Floodway, which was constructed with a width of 260 meters, is now reduced to 220 meters due to human settlements along the floodway. This is an example of a blatant failure of the national or the local government in allowing and tolerating human settlements along the floodway.

- *Local drainage problem*

  Allowing human settlements on the fringes of Laguna Lake (e.g., the Lupang Arienda area) has obliterated local drainage channels. With constricted outlet into the major waterway and the disappearance of the Taguig River, the area lacks a drainage outlet.

- *Improper land-use zoning*

  Another blatant case of flawed land-use planning or complacency of government authorities is allowing the establishment of residential subdivisions around Laguna Lake.

Flood control design level of protection

Another issue related to flooding is the Department of Public Works and Highways (DPWH)'s major flood control projects, which only provide design levels of protection ranging from a 10-year to 30-year return period. The Ormoc Project is an exception, as it has a 50-year return period. The flood design of the Pasig–Marikina River is only for a 30-year return period. During Typhoon Ketsana

(Ondoy) in September 2009, the computed peak flow of Marikina River, which was 5,700 m^3/sec, had an associated return period way beyond 100 years. In this case, the government should seriously rethink if the only level of protection that they can provide the people is a 30-year design flood level of protection.

Alternative Metro Manila flood control schemes

In 2012, the World Bank funded the Metro Manila Flood Masterplan that covers several structural and non-structural flood control measures. Major schemes of the masterplan include managing land use in flood-prone areas; construction of flood control structures, especially detention ponds and reservoirs; strengthening of flood warning and information systems; and improvement of the institutional system for integrated flood risk management. This 352-billion peso masterplan is planned to be constructed over the next 25 years. Two alternative schemes suggested here but were not covered in the World Bank study are: (1) the Marikina River Stormwater Tunnel to Agos River, and (2) maximizing the flood storage function of Laguna de Bay.

Marikina River Stormwater Tunnel

This scheme will divert about 40% to 50% of Marikina River floodwaters (during flood months) to the Pacific Ocean through a flood tunnel that will traverse either through the Sierra Madre to the Agos River or directly to the Pacific Ocean. This way, flooding in Marikina City and its surrounding vicinities can be alleviated. Essentially, this flood solution aims to transfer the flood problem to the Pacific Ocean instead of bringing it to Marikina City, Libis, Cainta, and the towns around Laguna Lake. The Agos River is a watershed on the eastern slopes of Sierra Madre. However, it annexes the Marikina River Basin through the western slopes of Sierra Madre. The proposed point of diversion is either at the upstream part of Marikina River Basin around the junction of Montalban–Linatin–Tayabasan or at the Wawa Dam site. Preliminary computations have been done by the author, which showed that as much as 1,500 to 2,500 m^3/sec can be diverted, depending on the location of tunnel diversion point. Note that when Marikina River discharge is above 4,500 m^3/sec, the city is flooded.

Maximizing the flood control function of Laguna de Bay

As part of the flood control scheme in the Pasig–Marikina River system, floodwaters from the Marikina River Basin are diverted to Laguna de Bay or Laguna Lake for temporary storage through the Manggahan Floodway when the water surface elevation at Marikina River's Santo Niño Bridge is 14.5 m or higher. During the rainy season, the flood storage allocation of Laguna Lake can be maximized by draining it to environmentally-acceptable elevations, say at 11.5 or 12.0 m, to be able to contain significant amounts of floodwaters diverted from the Marikina River. After a storm, the lake can then return to the environmentally-acceptable elevations in preparation for the next storm. Likewise, if the lake reaches elevations that cause flooding in low-lying areas or towns around it, the lake levels should be drained as fast as possible to avoid prolonged flooding in these low-lying areas or towns. However, in the case of Laguna Lake, the only major outlet is the Napindan River, which has a very limited or restrictive conveyance capacity to allow proper and timely management of the lake levels. Schemes to facilitate draining of the lake include increasing the conveyance capacity of the Napindan River by dredging and, possibly, widening; and the revival of the Parañaque Spillway concept. Instead of an open channel spillway, an underground tunnel will be constructed with an intake structure at either Sucat or Lower Bicutan, with an outlet at Manila Bay. Alternatively, one can also extract significant amounts of water from Laguna Lake in a timely manner as a source of Metro Manila's domestic water supply.

Holistic flood risk management for urban areas

For an urban area like Metro Manila, a comprehensive flood management solution may be based on the Integrated Flood Management (IFM) advocated by the World Meteorological Organization–Global Water Partnership (WMO–GWP 2009). The IFM aims to manage the water cycle as a whole and recognizes the need to address various types of flooding (e.g., street, river, coastal, pondage, and design standard floods). The first element of IFM posits that flood management plans should include drought management and that urban flood plans must manage both stormwater quantity and quality. Secondly, the integration of land and water management synthesizes information sharing between land-use planning and water management authorities and between upstream and downstream linkages for flood management. Finally, the third element of IFM acknowledges that flood risks are related to hydrological uncertainties, which, in turn, are subordinate to social, economic, and political uncertainty (i.e., that unpredictable changes may come from population growth and economic activity). Flood risk management is therefore a cycle of preparedness, mitigation, adaptation, response, and recovery.

The overall aim of IFM is to improve the river basin's functions as a whole, recognizing that floods have beneficial impacts and can never be fully controlled. Thus, IFM seeks to maximize the net benefits from the use of floodplains and to minimize loss of life and property.

The above elements of IFM provide a very useful framework for dealing with urban flood risk management policies and strategies for an urban area like Metro Manila in general or the Pasig–Marikina River Basin in particular.

Sustainability science for flood risk management

Holistic flood risk management is actually very complex. For this reason, holistic management requires a new approach which can no longer be based on traditional science (i.e., conventional science, especially engineering science in practice) but rather on the framework of sustainability science (Komiyama and Takeuchi 2011). The following discussion is to guide holistic flood risk management with sustainability science. In the discussion below, the five elements of sustainability science, namely: (i) aim of study, (ii) mode of change, (iii) truth verification, (iv) result of research, and (v) expected outcome are taken from Yoshikawa (2011) and was adapted and articulated by Tabios (2015) in the context of flood management (*in italics*).

First is the **aim** of sustainability science which is to understand everything and manage the relations among the various components of the system, so that in flood management, this is *to understand flood and its relations to flora, fauna, and people for its adverse impacts and/or benefits and recognizing the geomorphologic-hydrologic-ecologic interactions* instead of the limited view in traditional science which is *to understand flood and mitigate flood to protect life and property*. In the **mode of change**, *flood changes with climate, weather, social, political, and economic changes* in contrast to traditional science which utilizes *design flood and return period assuming stationary conditions*. Under **truth verification**, nature is an evolution in reality and is therefore *uncertain and requires piecewise engineering through 4D lenses, through computer simulations and scenario building*. The final two elements are that the **result of research** is intended as knowledge for action especially *knowledge to develop flood management schemes,* and the **expected outcome** is *optimal management of impacts and benefits of floods to enhance and sustain ecosystem functions in order to support flora, fauna, and especially human life*.

Conclusions

The challenge of flood risk management in urban areas like Metro Manila comes from the fact that urbanization is inevitable due to population growth and economic progress. This leads to urban sprawl, expansion of paved areas, reduction of absorptive capacity of soils to infiltrate water including wanton, or unplanned occupation of floodplains—all of which result in increased risk of urban flooding. This can even be exacerbated by increase in rainfall intensity and duration due to climate change notwithstanding that with or without climate change, extreme rainfalls that result in floods will still be a normal occurrence due to weather anomalies and natural climate variability.

With regard to urban floods, it is advocated here that holistic flood risk management is needed. This requires integrated land and water management with the overall aim to improve the functioning of the river basin as a whole, recognizing that floods have beneficial impacts and can never be fully controlled, thus, holistic flood management seeks to maximize the net benefits from the use of floodplains and to minimize loss of life and property. In a bigger context, holistic flood risk management requires a new approach which can no longer be based on traditional science but rather on the framework of sustainability science. In the context of flood risk management, sustainability science views the flood problem as complex since it involves understanding and managing the relations and uncertainties of the global system (fluctuating natural processes, climate change and variability, weather disturbance), social system (dynamic and changing societal, political, economic objectives), and human systems (diverse cultural, behavioral, lifestyles preferences)—the latter three as key urban dimensions of flooding. Sustainability science thus requires a transdisciplinary approach (Tabios 2015) that embraces both natural and social sciences, such as scientific and technological tools to address the global system, socio-political-economic studies to address the social system and psychological and cultural studies to address the human system.

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