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Street floods in Metro Manila and possible solutions

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ABSTRACT

Urban floods from thunderstorms cause severe problems in Metro Manila due to road traffic. Using Light Detection and Ranging (LiDAR)-derived topography, flood simulations and anecdotal reports, the root of surface flood problems in Metro Manila is identified. Majority of flood-prone areas are along the intersection of creeks and streets located in topographic lows. When creeks overflow or when rapidly accumulated street flood does not drain fast enough to the nearest stream channel, the intersecting road also gets flooded. Possible solutions include the elevation of roads or construction of well-designed drainage structures leading to the creeks. Proposed solutions to the flood problem of Metro Manila may avoid paralyzing traffic problems due to short-lived rain events, which according to Japan International Cooperation Agency (JICA) cost the Philippine economy 2.4 billion pesos/day.

Introduction

Metro Manila is located on an isthmus between the Manila Bay and Laguna de Bay. The entire region is composed of one major catchment called the Marikina River Basin, which covers 535 km^2, and eight smaller, river sub-basins, which cover 683 km^2 that drain directly into Manila Bay and Laguna de Bay. The Marikina, Pasig, San Juan and Tullahan rivers serve as the main outlets for a network of tributaries of the Marikina River Basin and smaller catchments of Metro Manila (Fig. 1). Highly urbanized and populated by almost 12 million residents (Cox, 2011), the metropolis lies on one of the widest floodplains in the Philippines.

Apart from devastating floods like those spawned by Tropical Storm Ondoy in 2009 (Lagmay et al., 2010) and the typhoon-enhanced southwest monsoon rains in 2012, 2013 (Lagmay et al., 2014) and 2014, more frequent floods caused by short-lived thunderstorms are also a problem. Once parts of the road network are blocked by floods, traffic develops and paralyzes the entire city. According to JICA, traffic jams due to thunderstorm-related flashfloods costs PhP 2.4 billion a day from wasted gasoline and lost economic productivity (Rodis, 2014).

Flashfloods are traditionally blamed on the loss of infiltration due to urban concrete, a century-old drainage system, and clogged streams. This study analyses nuisance floods caused by brief, heavy downpours. It identifies other factors to find relatively inexpensive solutions to flood-generated traffic problems.

1. Methods

The Metro Manila Development Authority (MMDA) released a list of flood-prone areas in the National Capital Region

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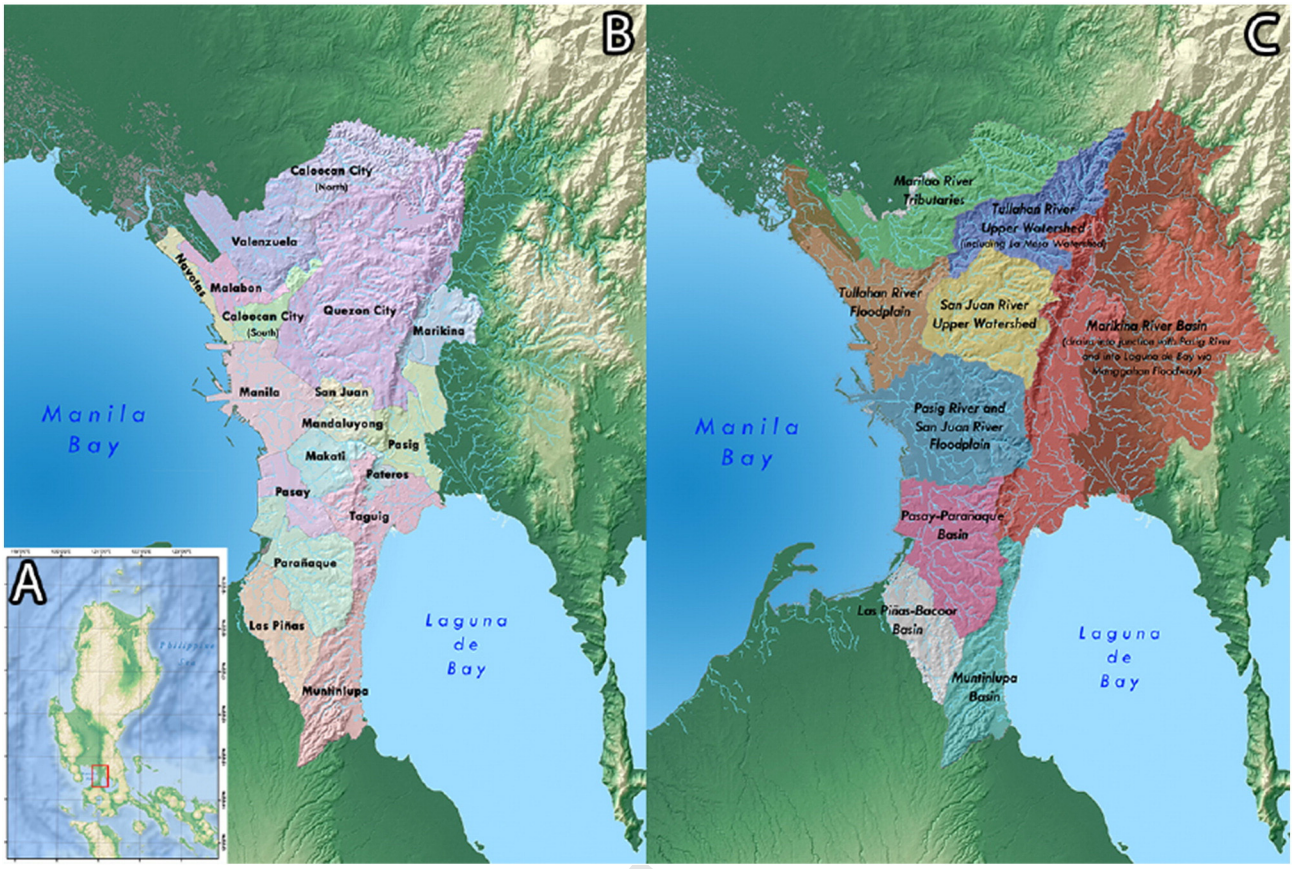

Fig. 1 – Metro Manila natural drainage A) location of Metro Manila, B) administrative boundaries of component cities and C) watersheds and tributaries.

(Table 1), verified by accounts collected from photographs posted in social media.

Crowd-sourced data (Fig. 2a) were overlaid on a 100-year rain return flood-hazard map (Fig. 2b, NOAH, 2013).

LiDAR-derived topography was used to create profiles of the main roads in these areas, as well as profiles of the road sides. A Roces Street and CP Garcia Avenue in the University of the Philippines (UP) were also examined. Field work was also conducted to check the drainage crossing the streets in those areas.

Floods were simulated in FLO-2D GDS PRO using the St. Venant equations for continuity and momentum (Eqs. (1) and (2)) and the finite-difference scheme to compute flood velocities:

$$\frac{\partial(Vh)}{\partial(x)}+\frac{\partial(h)}{\partial(t)}=i \quad (1)$$

$$S=S-\frac{\partial(h)}{\partial(x)}-\frac{\frac{V}{g}\partial(V)}{\partial(x)}-\frac{\frac{1}{g}\partial(V)}{\partial(t)}=0 \quad (2)$$

where V is the average velocity in m/s, h is the flow depth in meters, and i is the excess rainfall intensity in mm/24 hr. Other variables are slope (S), acceleration due to gravity (g), pressure gradient $\frac{\partial(h)}{\partial(x)}$, and the local $(\frac{\partial(V)}{\partial(t)})$ and convective $(V\frac{\partial(V)}{\partial(t)})$

Table 1 – Metro Manila Development Authority list of flood-prone places in Metro Manila.

Street name	City
1. Espana–Antipolo–Maceda	Manila
2. P. Burgos (City Hall)	Manila
3. R. Papa, Rizal Avenue	Manila
4. Buendia Extension–Macapagal Avenue	Manila
5. Buendia–South Superhighway (northbound)	Manila
6. Buendia–South Superhighway (southbound)	Manila
7. Osmeña–Skyway (northbound)	Makati
8. Makati	Makati
9. Don Bosco	Makati
10. EDSA Pasong Tamo, Magallanes	Makati
11. West Service Road, Merville	Paranaque
12. East Service Road–Sales street	Muntinlupa
13. McKinley Road	Taguig
14. C-5 Bayani Road	Taguig
15. C-5–BCDA	Taguig
16. C-5 Bagong Ilog	Pasig
17. EDSA–SM Megamall	Mandaluyong
18. EDSA–Camp Aguinaldo Gate 3	Quezon
19. Quezon Ave.–Victory Ave./Biak na Bato	Quezon
20. NLEX–Balintawak Cloverleaf	Quezon
21. North Avenue fronting Trinoma Mall	Quezon
22. EDSA–North Avenue	Quezon
23. Philcoa area	Quezon

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