Resilient urban water design - preventing floods with a blue & green synergetic system approach

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1 Introduction

The Philippines is one of the countries in the world that is most prone to being affected by natural disasters such as flooding, volcanic eruption, typhoons, earthquakes etc. As a country in whole the Philippines is affected by 15 and struck by 5-6 cyclonic typhoons a year. *(3CD City profile series, 2005)* These repeatedly bring great amounts of heavy rainfall when striking land and in combination with the fact that the annual rainy seasons of the country bring massive amounts of rainfall at short time intervals, flooding is a constant and ever present issue most of the inhabitants are confronted with. Furthermore, global warming is contributing to larger amounts of sky fall causing even more damage than before and during the years to come, most countries in the world must prepare for this increase in precipitation. *(Adams & Watson, 2011)* Due to insufficient stormwater systems in urban environments that are easily clogged and waterways blockage by informal settler structures and waste, canals that could help mitigating the rainfall masses from heavy typhoons and downfalls are blocked and the risk for flooding in the cities becomes increasingly higher. One especially exposed group is the urban poor, many of which are living in the hazardous areas close to the water bodies, constantly flooded.

According to UNDAC (*United Nations disaster assessment and coordination*) the whole of Metro Manila is equally vulnerable to typhoons. On August 25th 2004 continuous heavy rainfall from typhoons Aere and Chaba caused massive floods and landslides affecting around 24 000 people and causing eight unfortunate deaths. Furthermore hurricane Yolanda (Haiyan) caused enormous casualties to the Philippines as a whole and

even though the city regions averted the greatest damage, the flood that followed still inflicted tremendous casualties upon its dwellers. *(3CD City profile series, 2005)*

Governmental initiatives to prevent flooding include relocation of informal settlers and proper waste treatment as well as education in handling waste and rehabilitating and improving existing facilities. But one could argue that these governmental actions are insufficient. Small initiatives and urban design features could help mitigate the casualties or even prevent flooding as well as enhancing the urban environment. Moreover the overall attitude towards water in the cities is in need of alteration since maintenance of the waterways is made impossible if water in urban environments is continuously considered hazardous and waste bearing. Therefore this paper will discuss and present design initiatives and guidelines for creating a sustainable and flood-resilient urban areas as well as presenting best practice cases to inspire change.

2 Literature Review

To understand how to design resilient communities an understanding of the basics of the water cycle is necessary. In *"Design for flooding : architecture, landscape, and urban design for resilience to flooding and climate change"* Donald Watson and Michele Adams depicts the basics of climate processes and eco-system services related to water. Firstly, water rises to the atmosphere as water vapor as it evaporates from the land surface and oceans. As it rises it is continuously cooled down and finally condensed and turned in to ice, snow or small water droplets. Thereafter it is returned to the earth´s surface as precipitation, 23% to land areas and 77% to the oceans *(Adams & Watson, 2011)*. Large amounts of the precipitation is bound in trees and other vegetation and later released to the atmosphere through evapotranspiration. Some water is transported down through the ground to charge the groundwater reserves and the remaining water is run-off and is returned to the sea by the affect of gravity. In the natural landscape, run-off water is a small component in the cycle but as human developments progress, cutting down vegetation and paving previously permeable surfaces with impervious ground, run-off becomes the largest component. Hence, this becomes a problem for both handling heavy rainfalls and recharging the groundwater reserves. Furthermore research shows that global warming will cause rainfall associated with storms and hurricanes to increase by 10-31% since the air's capacity for storing moist increases with temperature, another incentive to review our development strategy. *(Adams & Watson, 2011)*

An area which leads the rainfall to a common body of water; lake, river or sea is called a watershed. These include the land area as well as rivers leading to the ending point for the water. Each watershed has a natural capacity to hold and slow down run-off through various natural water storages. These include wetlands, vernal pools, freshwater ponds, swamps, estuaries and salt marshes. In addition to holding freshwater run-off these storages are also thriving habitats for various animal species, some only existing within these eco-systems. In mitigating the speed of the run-off they further help the ground to absorb and transport water downwards, recharging the groundwater reserves. Working with these natural water-storages as well as taking into account the rainfall amount over a land area or watershed is crucial to planning and distributing water when developing new communities. *(Watson & Adams, 2011)*

Understanding the above and mimicking the natural system is vital for treating stormwater right Watson & Adams argues. Hence, they propose that flooding problems can be derived from two main factors; changes in land use and increased precipitation. As urbanization rapidly continues permeable land area is developed into hard surfaces and natural water bodies like streams are built over, causing fast run-off and flash floods. However it is not only development of cities that is problematic, e.g. over half of the worlds wetlands was intentionally drained for agriculture as early as the 1990s and agricultural land is far worse at binding water than the natural and native vegetation.

To prevent intensive floods we must therefore use waters resourcefulness and neglect the idea of it being problematic and something to be disposed of. Working with the water cycle is crucial for building resilient communities Watson & Adams argues. A fitting definition of resilience is given:

> ”Resilience is the capacity of a system, community, or society potentially exposed to hazards to adapt, by resisting or changing, in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures.”
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> *- International Strategy for Disaster Reduction” ISDR Secretariat. 2009*

In order to build resilience, we must carefully plan with water in mind. A successful example of this is the Cheonggyecheon river restoration project, carried out in Seoul,

South Korea and opened in September 2005. The natural water body was overbuilt in the 1950s and later developed as a highway in 1970s causing the area of the river to become associated with car traffic, congestion and pollution. By initiative of the then current (2002-2006) city mayor Lee Myung-bak later elected president (2008-2013) of South Korea the process of restoring the original river was initiated. The process was costly, some suggests rushed and involved corruption but after its completion the area and the residents have experienced a much welcoming change. *(Marshall, 2016)* The river has a capacity to prevent a 200-year flood event for the area, the water in combination with the extensively planted greenery along the waterway has reduced the urban heat island effect with 3-6 degrees Celsius compared to adjacent areas, air pollution has been reduced by 35 % and an incredible increase of 639% to the biodiversity has been achieved. Furthermore it welcomes 64 000 daily visitors which drive a now thriving local economy and property prices have increased with 30-50 %. *(Landscape performance series, 2017)*.

As projects like the previous extensively depend on restoration of a former water body, cities without these original water storages have to take other measures to cope with flooding. Kurt Pelzer and Laura Tam, members of SPUR (San Francisco Bay Area Planning and Urban Research Association) a member supported non-profit organization committed to solving urban issues regarding planning, have written a report on various strategies to be implemented in our cities to help handling the increasingly heavy rainfalls. In contrast to the cities grey infrastructure Pelzer & Tam propose a new green and more permeable one. This structure helps in mitigating flood-risk but also draws on several synergies. They suggest four carefully selected strategies in order to maintain cities:

1. Sink-it, a strategy designed to hold and transfer stormwater to the ground and groundwater. This green strategy uses plants and planters to filter water to the ground but also more permeable ground surfaces to transfer water slowly to an underground tank to store and then release it to the ground.

2. Slow-it uses green structure such as constructed wetlands and flow-through planters to slowly release the water to the sewage system. Flow-through planters provide cleaning services as well as water storage in plants and trees. Furthermore, creating vegetated roofs would use otherwise unused rooftop space to store rainwater as well as providing insulation for the buildings. Other design options within the category discussed by Pelzer & Tam are constructed wetlands, highly effective in flood prevention and

reduction of storm-water peak flows. Even detention tanks could be used to hold and store large amounts of locally collected stormwater.

3. Reuse-it is a strategy that presents the earlier mentioned idea of changing the attitude towards water from hazardous to resourceful by introducing rainwater harvesting. Non-potent rainwater could be used within the households flushing system or other services which do not require fully potent water to operate such as washing machines or irrigation. These collectors, stormwater barrels or cisterns, are great for areas where infiltration techniques are not an option and where sewage systems needs discharge.

4. Move-it, the last strategy and tool presented by Pelzer & Tam, involves restoration and uncovering of streams previously buried, creek daylighting, contributing to the public space and functioning as flood attenuation. This strategy, is embodied in the earlier explained river restoration project for Cheonggyecheon. *(Pelzer & Tam, 2013)*

These design strategies and suggestions juxtaposed to suggestions and information from Adams & Watson showcase a common initiative and goal but slightly different approaches on how to. These dissonances will be further discussed in the next section.

3 Argument, Critique or Discussion

CONTEXT OF MANILA

It is arguably an easy task, defending the idea that the water treatment system in Manila has to be revitalized. The US environmental protection agency estimates that watersheds covered to 10% by impervious surfaces show signs of decline. Highly urbanized watersheds cover up to 60% whereas ultra urban sites could draw up on 75%. *(Adams & Watson, 2011)* I am fairly comfortable with suggesting that Manila falls in the later category. Therefore, a highly developed strategy must be implemented in the city grid. Furthermore, with the Philippines located in the ring of fire, the resilience of the system should be able to cope with vast amounts of precipitation accumulated by typhoons, storms and hurricanes.

Strolling in Manila, one has trouble uncovering larger green areas, even smaller green patches are a rare breed within the city. Most ground coverage is composed of large concrete slabs or asphalt, impervious materials causing even the slightest rainfall to turn into run-off water, fed into the underground sewage system. Trees are not rejected from the cityscape but often built over at ground level, leaving little space for them to grow and

absorb stormwater in their root system. Furthermore, as mentioned in the introduction, waterways are often clogged with garbage and discarded as dumps. Garbage pollute the water and prevent water from flowing freely, increasing the risk of flooding. Metro Manila can not turn their back to the water but need to protect and appreciate the resources it presents. Additionally they need to acupuncture the city grid with green infills to cope with increased precipitation turning into run-off.

Settlements along waterways are common in Metro Manila, blocking the waterflow. *(photo taken by the author)*

Underground stormwater channels without grills *(photo taken by the author)*

Impervious paving causes instant and fast run-off flows*(photo taken by the author)*

COMPARISON OF REFERENCES

In comparison, the different publications illustrated earlier do have a slightly different approach towards designing for water resilient communities and cities. Moreover, I would claim that their views of urbanity is fundamentally different. However, the report written by Pelzer & Tam is not nearly as profound as ”Design for flooding” by Watson and Adams and does not depict the greater picture of water systems and eco-system services. Furthermore Pelzer & Tam discuss design suggestions that involves water detention in tanks and cisterns, later released to the sewage systems. This approach is totally neglected by Adams & Watson. They argue that this damages the water cycle as it firstly considers water as a nuisance, better to be lead off, and secondly diminishes the amount of water

recharging our groundwater reserves since the stormwater is not filtered through soil and vegetation and transported downwards. They argue that this conventional method of leading the water on as run-off is empowering one of the biggest problems with our city development. Precipitation continuously being conducted to run-off instead of naturally absorbed and transpired by nature. A process which prominent side-effects definitely include flooding. *(Adams & Watson, 2011)*

Furthermore both publications discuss green strategies for mitigating flood and bringing stormwater to the ground. They also agree on the synergies brought by these strategies. Green areas like wetlands and infiltration planters do not only filter water, they are aesthetically pleasing, decrease pollution in cities, create habitats for various species of wildlife and allow for recreational and contemplative activities in the city.

In this approach Adams & Watson are even more elaborate. As many cities might use lawns as ”permeable surfaces” Adams & Watson claim that these are ineffective in storing stormwater. Lawns lack sufficient root system for bringing water to the soil, they do not empower a diverse microbiological community and do not intercept rainwater from directly hitting the ground. Hence, extensive lawns are greatly contributing to the amount of run-off water. Instead, native and indigenous species should be used that would bind and enrich the soil and absorb larger amounts of water.

However, I would argue that *”Design for flooding…”* by Adams & Watson is slightly opposed to cities in its approach. In its suggestions for planning with the natural water cycle it romanticizes the natural landscape and provides arguments to why people should settle in more rural contexts. And I agree to some extent, cities do diminish the natural cycle of water and cities cause pollution, neglect the natural landscape and create unhealthy environments for most animal species. Furthermore, the rigid masterplanning of the 60s, the focus on housing production of the 60-80s and the self-help housing concept and more recent (and potentially superior) strategies of the 90s emphasizing the Habitat agenda and considering sustainability through brown and green agendas has had a mixed impact on urban environments in the developing countries. *(Jenkins, Smitt & Wang, 2007)*

But despite past planning mis considerations, interventions and knowledge is continuously growing and as experience increases, the possibilities of cities becoming thriving economies and functioning systems grows greater. The rapid urbanization that has been undergoing since the 60s is a notion which it is clever to embrace rather than neglect.

Moreover, rural communities rely heavily on frequent private transportation through motor vehicles, something that is commonly known for contributing to the most pressing issue of global warming. And as mentioned above, global warming is one factor accelerating the growing threat of flooding. Furthermore, cities have in recent history been counter-productive in relation to water treatment but modern technology and planning could contribute to changing this notion. Therefore, Pelzer & Tam's starting point of a city context is slightly more sympathetic and useful in its design aspects if applied to the context of Manila.

4 Design guidelines

Metro Manila and similar cities need to take action and realize the urgency of the issue with stormwater management. Therefore, a pragmatic and easily used set of strategies used to guide the planning process could be valuable. Hence, in this section I will make a number of suggestions that could be used in Manila or similar cities around the globe for mitigating damage to the local water cycles and aiding in the creation of a resilient urban environment.

Analysis of city context

The first step in designing for a resilient and flood preventive city is analyzing the city context as a system, uncovering the division in watersheds and the greater movement of the water. Where is the main waterbody that run-off targets and by what means does the stormwater transport itself to that point. By uncovering the larger system, weaknesses and possibilities are exposed and strategic places for interventions become evident. In this process, mapping land rise above the sea is crucial as this is the main physical factor guiding the run-off flow. Another important component is surface permeability, if areas are largely covered in impervious materials, actions need to be taken to mitigate run-off flows or change paving permeability.

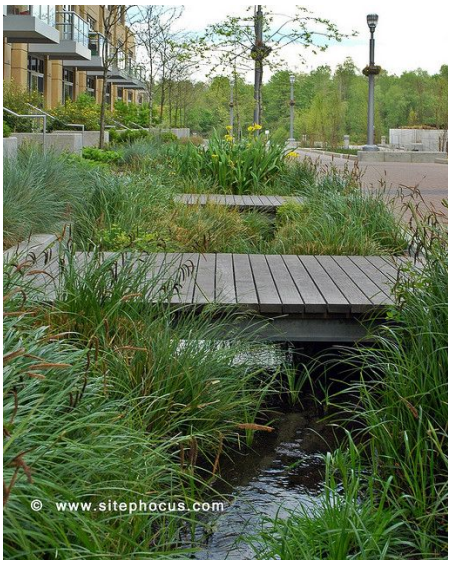
Zoom-out systematic strategies

Through using the strategies of Pelzer & Tam as a starting point and applying the knowledge from Adams & Watson a synergetic and regenerative strategy can be developed. At a macro scale, the city needs to have several larger green areas that could hold, store and sink the precipitation masses. Creating parks with indigenous and

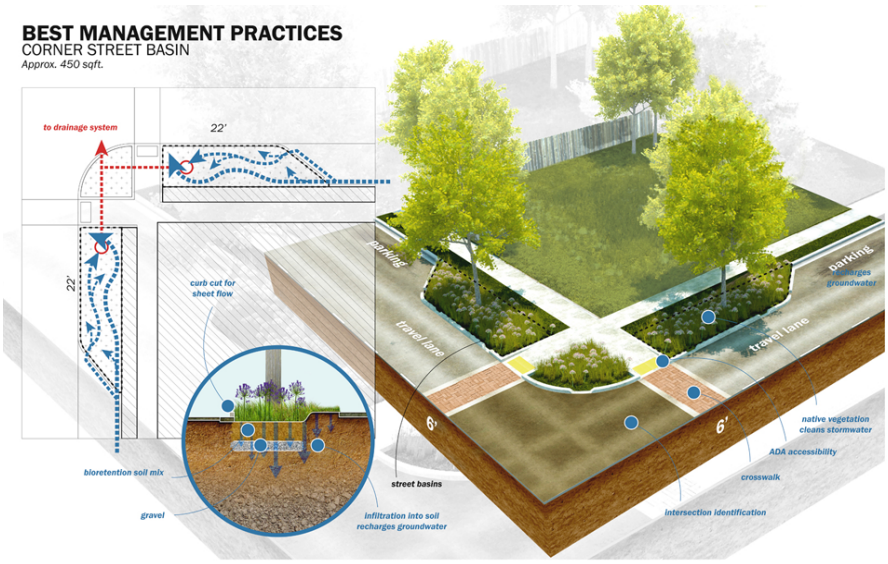
heterogenous composition of plants, greater depressions in the ground prepared for flooding, centrally located will allow water masses to be absorbed and transported to the ground water reserves as well as also mitigating run-off flow speeds. Furthermore, creek daylighting, as mentioned above will contribute in gathering water masses and transporting stormwater to a suitable waterbody. Vital for this strategy's functioning, without informal settlements appropriating the space through building, I would say is planning the space carefully. Creating walkways with permeable paving, planting along the edges, creating public seating and implementing a lighting strategy to vitalize the space during the dark hours. The parks and waterways should be cleverly connected in a intricate system that covers the whole city and takes in its consideration the varying heights of land, not exposing the wrong places to flooding. For areas where the ground is not suitable for water absorption, larger stormwater pools could be created. These might be flooded occasionally and in times of drought used for other functions, like amphi theaters or skateboard parks. However, emphasis should be put on creating green wetlands with the ability to sink and bind stormwater.

Zoom-in design acupuncture

At a micro scale, interventions should perforate the whole city grid. A strategic tool to be used is occasional planters, easily used as dividers of car lanes or placed along sidewalks. These should include a variety of species that can absorb stormwater. Trees with large trunks and foliage interrupt precipitation from instantly hitting the ground hence slowing flow rates and extending its ability to absorb water. A heterogenous composition of plants at the foot of the trees or by itself contributes to increase the biodiversity and allow the soil to become more porous, therefore increasing its capability to transport the water. These smaller planters could be extended in size at strategic point creating larger wetlands that could house greater water volumes. A grip that might be used for transporting water to these are open water canals running along streets and pave walks. In contrast to closed sewage systems these are not as easily clogged and could contribute to an understanding of the water cycle in the city. However, these are probably best avoided in traffic congested parts of the city as pollution might threaten to contaminate the water and create decayed canals, rather than recreational waterways.



Open stormwater canals/wetlands



Open waterways in Portland & Planters from HMGP

Building design interventions

Moreover, actions could be taken at a building level. In several of the areas visited by the Urban Shelter group in Metro Manila, water supply malfunctioned and the public system suffers from unpaid bills and interrupted water access. This, furthermore, leads to clogged sewage systems, costly water transports to areas and time consuming processes for accessing water for the tenants. A supportive system could be used where water harvesting and re-use is implemented. This system will gather rainwater in cisterns and tanks from rooftops (whence many unused) and using this brown water to flush toilets, supply washing machines or other activities where non-potent water could be used. Another option for gathering stormwater from rooftops are green roofs which contribute to both biodiversity, mitigating water flow and pollution decrease if properly thick and populated. However, these are costly and need an enforced construction to bear the loads and might not be an option in low-budget projects. In addition to these harvesting methods, water could be locally collected at ground level and then pumped into the system of the building for re-use.

Materials and species

As mentioned earlier, the importance of what species of plants to be used should be underlined. Grass is compared to native plants not as permeable and should if possible be the second choice, although it is still superior to impervious surface like concrete and

asphalt. As a compromise where hard surfaces is needed, grasscrete which is a combination of concrete blocks and grass/soil could be used to allow some absorption. Suggested species of plants used in planters, for a Metro Manila, would include the low maintenance Benjamin ficus, Chinese Ixora and Mango trees *(Galigan 2017)*.

5 The Role of Architects

Even though these guidelines and reflections are an accessible tool to use for anybody the real advocacy for change is made by the architects and planners. The responsibility of implementing and promoting these interventions lies heavily on our shoulders. Experience tells me that developers and contractors will not suggest any unconventional or costly design strategies if not carefully convinced about the synergies and long run benefits. This experience is based on a Swedish context, however, I dare argue that this is a generic attitude possessed by developers. Therefore it is crucial that we research and build a strong reference library that produce actual facts and figures as a strong evidence of the effects and synergies to be had. Moreover it is important that we inform developers and authorities about what damage ignorance of stormwater treatment could cause the urban system.

Furthermore, we could analyze the city context and come up with suggestions of improvement. We could initiate the process and create projects that could act as praxis within the profession. Strong projects like the Cheonggyecheon river restoration project will act as best practice examples. This project is already believed to have inspired other major projects, like the currently undergoing plan to restore the L.A. river and develop a green belt through the city. *(Revkin, 2009)*

Finally I would, with reservation for repeating myself, underline the importance and specially the synergies that could be had when working with water management. In addition to having a functioning system to handle stormwater and prevent flooding, the water system could help enhance the urban environment. Habitats for animals could be created and reintroduced to the city, the aesthetics of the city could be enhanced through green and blue inputs, interventions could create better places and thereby contribute to a rich social space and this would in a later stage affect an areas livability and attractiveness and supply a growing economy and rise in property value. Putting it more clearly, why not plan with water in mind?

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