Solutions to deal with flooding by using green buildings in Vietnamese urban areas from Japanese experience

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Abstract. One of the major problems of big cities in Vietnam is deep flooding in the rainy season, frequent traffic jams, fewer green areas, green parks are narrowed or exploited for commercial exploitation and services. The above consequences are due to many reasons such as rapid urban development, encroachment of rivers and streams that break the natural landscape, lack of synchronous planning ... there is still a lack of reasonable technical solutions. Japan is a country with a lot of experiences in flood prevention, about preserving a safe and close environment to nature. These solutions can be an idea for strategic decision makers, governments and the whole community to refer to Vietnam, especially big cities like Ho Chi Minh City learning and applying. Here are some experiences from Japan analyzed and opened by the author to contribute ideas for our city to become more civilized and worth living.

1. Introduction
For many years, Ho Chi Minh City has invested a lot of money and effort in solving the flooding problem for the city from rainwater, tidal water and floodwater with a range of structural and non-structural solutions but the results are still very limited, affecting to the daily life of the people. Not without reason that Ho Chi Minh City is associated with the phrase "the city suffers year-round flooding". In fact, the city did not need rain, it was flooded by high tide. When it rains, the road becomes a river. From the beginning of the rainy season every year, areas of Ung Van Khiem, Nguyen Xi, National Road 13 (Binh Thanh District), An Duong Vuong (from My Thuan Bridge to Ben Phu Dinh), Go Dau, Mai Hac De, Luong Van Can, Cao Van Lau, Mai Xuan Thuong ... are all mentioned in the list of serious flood points [4], [5].

In addition, there is a serious lack of green parks in Ho Chi Minh City, including in central districts. According to the Nguoi Lao Dong newspaper on August 03, 2018, Binh Tan district is the most populous district and the area is also the second largest in the city, but “there is no green parks, although there are still many large plots of land is abandoned ”, or another example" Thao Dien Ward (District 2) is considered spacious, the infrastructure is quite synchronized, people live and work hard but there is not existing a real park” [4]. All of the above issues, from flood control to the construction
of a green park system for community activities, improving the living environment in a big city like Ho Chi Minh City, are being discussed very lively in the meetings of the City Council, the city government for many years, but there has not been an effective solution. So, in addition to the needing for huge amounts of money, a synchronized development mechanism to control the urbanization process, we need to look outside to learn about flood protection and create solutions. Establishing sustainable green environment, Japan is a typical example. In this paper, the author explores natural features, urban development rules, solutions for green building and flood protection in Tokyo, thereby making some useful recommendations that can be used for Ho Chi Minh City in the near future.

![Figure 1](image1.png) In the rainy season the roads in the city center turn into rivers.

2. Solutions for flood control for Tokyo from Japanese experience

2.1. Natural conditions

The Japanese archipelago is located in East Asia, stretching in an arc about 3800 km long on the Pacific Ocean, including 4 large islands: Hokkaido, Honshu (accounting for 61% of the total area), Shikoku, Kyushu and thousands of islets.

![Figure 2](image2.png) Japanese natural map.

![Figure 3](image3.png) Rainfall greater than 50 mm or 80 mm per hour has been on an upward trend in recent years in Japan.
Japan is located in an area with monsoon climate, heavy rain. 73% of Japan's terrain is mountainous, and the residential area in the western part of the country is mainly built on steep slopes, which can easily lead to flooding, landslides.

2.2. Japanese urban characteristics
Tokyo - the capital of Japan, is one of the largest cities in the world. The enormous economic growth and dizzying urban process of Japan in the 1960s, 70s and 80s of the twentieth century - typically Tokyo - has surprised the whole world. The prosperity of Tokyo has made the population and the city grow continuously, until 1996 Tokyo was a special administrative unit with an area of about 2,187 km² and a population of 11,782 million people. In 2000, Tokyo and 3 adjacent provinces of Saitama, Kanagawa and Chiba formed the megacities of Tokyo. This megacity has a total population of 32.58 million people, accounting for 26% of the Japanese population (according to Tokyo Metropolitan Government); has a population density of 104.4 people per hectare - twice the corresponding figure in European cities, and 7 times the average density in American cities (Andre, 2000). The average radius of this area is 50 km from Tokyo Station.

Prioritizing economic development, the state was unable to control the huge megacity, leaving empty land to be used mostly for construction, with very little land left and the soil cannot absorb all the water, leading to serious landslides, causing great casualties. In 2018, with a four-day rain from July 5 to July 7, some areas in Japan suffered from 300-500 mm, even in places like Hiroshima, Okayama and Hyogo, the rainfall sometimes reaches more than 500 mm, 4 times the average monthly rainfall. Besides, the river system in this country is not less, when heavy rain impacts, the river water rises, strong enough to break the solid embankment system.

So how do Japanese have comprehensive flood control measures to ensure the sustainable development of a large and crowded city like Tokyo? Here are some useful experiences that during the 50 years of development they have gained:
2.3. **Japanese flood protection solutions**

2.3.1. *Improve river canals, build dams, discharge canals and retain catchment basins*

Include canal expansion, dyke construction and reinforcement, and river bed dredging so that floods can be discharged without flooding the land along the river. In addition, construction of artificial canals to carry flood water from the middle or downstream of one river to another river or directly to the sea. Flood drainage canals were built when river improvement did not meet the flood discharge flow as designed.

Basins and catchment control: Restores basins and catchment controls to minimize flooding in the lower regions. In the case of a flood or a majority of flood water flows into the basin. The water stored in basins can also be used as a source of water or for agricultural irrigation.

![Before and after dredging rivers in Tokyo](image)

**Figure 7.** Before and after dredging rivers in Tokyo [1].

Measures to protect the river basin from the government's point of view are [1]:

- Maintaining control of the rate of urbanization in hot developing areas in terms of population or economic growth;
- Preserving fields in areas adjacent to modern urban areas;
- Building an artificial reservoir in low-lying areas;
- Building underground rainwater tanks in the heart of the city;
- Building of permeable pavement and manholes that naturally absorb water into the ground.

![Multipurpose basin of the Tsurumi River](image)

**Figure 8(a).** Multipurpose basin of the Tsurumi River [1].
2.3.2. **Building underground regulation lake**

After several historic floods, the Tokyo government began flood protection, such as making giant artificial reservoirs in crowded urban areas where land is limited to construction. The underground space under the TMG motorway is a great solution. The cellar is a 4.5 km long underground canal, with an internal diameter of 12.5 m and a depth of 40 m above the natural ground. The volume of this reservoir is up to 540,000 m³, and the largest of the 12 underground reservoirs is currently in operation.

![Figure 9](image-url)  
*Figure 9. Underground channel containing 540,000 m³ of rainwater for irrigation of all greenery in Tokyo [2].*

2.3.3. **Building an anti-flood control lake**

The government is very interested in the development of rainwater regulating space for Tokyo. Specifically, using the concentrated reservoir method to regulate rainwater; the distributing rainwater reservoir in residential areas and households. At the same time, integration of water regulation into existing lakes; integrate drainage function in urban embellishment and development population projects.

![Figure 10](image-url)  
*Figure 10. A solution to combine sports facilities and a regulation lake in Tokyo [1, 2].*  

![Figure 11](image-url)  
*Figure 11. A solution to turn a school playground into a rainwater reservoir in Tokyo [1, 2].*
3. Combining with green buildings to create landscapes for urban areas

[Graph showing data on greenery density and annual rainfall in Tokyo]

Figure 12. Data on greenery density and annual rainfall in Tokyo [3].

Looking at the chart above, we can see that the density of trees per capita in Tokyo (2014) is only 2.9 m², the rainfall reaches a record of 1550 mm. Therefore, comparing to other cities in the world, using green parks to allow rainwater to naturally absorb is not feasible, and the public land fund to increase the density of green trees in the city is also very limited. So, how have Japanese combined green buildings to control flooding caused by rainwater? Here are some illustrations of this combination:

3.1. Natural drainage on sidewalks and self-infiltration roads in residential areas

Using of pavement and water-proof pavement structure: We are getting used to the sealed pavement and rainwater pavement structures that will create surface flow to the water collection locations (outlet on the pavement bundle) to underground drains and into the river. With this type of structure, it can be seen that in high-density urban areas, the amount of water generated by rainfall creates a surface flow of up to 95%, therefore, requiring a large drainage system, which actually only serves a short period of year (months of rainy season).

[Diagram showing changes in surface flow and natural permeability]

Figure 13. Diagram showing changes in surface flow and natural permeability [8].

In Japan, a paving system that allows rainwater to seep down and be temporarily stored at the bottom of the paving layer has been apply, slowly absorbing into the ground below or being led transversely to water storage locations.
3.2. **Embellishing the building with green areas that drain water during the rainy season**

| Ditch drains next to the house | Planting boxes | Vegetation |
|--------------------------------|----------------|------------|
| ![Image](image1)               | ![Image](image2) | ![Image](image3) |

**Figure 14(a).** Creating a direct rainwater drainage from the roof to the infiltration area on the side of the house.

**Figure 14(b).** Helping drain rainwater from sidewalks, parking lots and on the street.

**Figure 14(c).** The underlying vegetation has an organic humus layer that helps capture and filter rainwater.

| Green plate on the street | Green roof | Self-absorbing pavement or sidewalk |
|---------------------------|------------|------------------------------------|
| ![Image](image4)          | ![Image](image5) | ![Image](image6) |

**Figure 14(d).** Purposing to store or allow rainwater to naturally penetrate and then be collected into the sewer system located below.

**Figure 14(e).** The green roof covered with growing vegetation allows for an amount of rainwater to enter and evapotranspiration of stored water.

**Figure 14(f).** Road surface paved with materials that can allow rain water to be temporarily stored in the ground by natural blotting.

3.3. **Making small indoor scenes combined with partially draining rainwater from the roof**

Small landscape not only contributes to partly draining rainwater from the roof but also contributes to creating wonderful relaxing landscapes in townhouses.

| A small scene in front of the house. | A small landscape built in the bathroom. |
|--------------------------------------|----------------------------------------|
| ![Image](image7)                     | ![Image](image8)                        |

**Figure 15(a).** A small scene in front of the house.

**Figure 15(b).** A small landscape built in the bathroom.
3.4. Collecting rainwater between buildings in residential areas for irrigation

![Figure 16](image1)

**Figure 16.** Solution to store rainwater in residential areas in Tokyo [3]. The rainwater is collected to pipelines and taken to storage in underground tanks containing water to irrigate trees in the area for the dry months.

3.5. Making tour to waste water treatment facilities

When arriving in Japan, many visitors are invited to visit the underground reservoir area deep in the city of Kasukabe in Saitama province. This huge underground space is 78 m wide and 177 m deep with 59 pillars, 18 m high and each weighs 500 tons to keep the ceiling of the building so that it can bear the weight of the thick layer of soil above [2].

![Figure 17(a)](image2)

**Figure 17(a).** Outside the underground reservoir

![Figure 17(b)](image3)

**Figure 17(b).** Tourists visit the underground reservoir

4. Recommendations and conclusions

4.1. Conclusion

**Causes of flooding in large cities in Vietnam or Japan are due to:**

- Asynchronous development mechanism when rapid urbanization is uncontrolled, leading to the overload of drainage ground and drainage system, where the urban development is flooded.
Figure 18. Causes of inundation due to unsustainable urban development [16].

- Not respecting nature such as filling ponds and lakes, cutting down trees, removing vegetation that is responsible for water storage in the rainy season. Concreting from residential buildings to infrastructure such as roads, or constructing to encroach on main water drainage lines.…
- Finally, there is a lack of appropriate flood protection engineering solutions that incorporate effective green buildings that should have been implemented from public to private housing.

4.2. Recommendations

Proposing the plan of "Building an underground regulation reservoir with Cross-wave technology (based on Japanese technology) in the city's parks". The goal is to make these reservoirs collect rainwater and serve irrigation, in addition to the site clearance can make green areas in the park to create landscapes [4].

We can completely apply Japanese solutions in the application and development of green buildings in a crowded city like Tokyo through the following carefully analyzed data:

| Serial | Type of solution for absorbing and storing | Unit | Ranking |
|--------|------------------------------------------|------|---------|
| 01     | Cover green roof with 12 cm layer of organic soil | 0.020 m$^3$/㎡ | 11 |
| 02     | Vegetation | 0.532 m$^3$/㎡ | 4 |
| 03     | Intrusion planting | 0.232 m$^3$/㎡ | 5 |
| 04     | Peat | 0.050 m$^3$/㎡ | 9 |
| 05     | Plant tree | 0.050 m$^3$/㎡ | 10 |
| 06     | Vacant land | 0.002 m$^3$/㎡ | 15 |
| 07     | Permeable pavement (sidewalks) | 0.020 m$^3$/㎡ | 13 |
| 08     | Land for the project | 0.002 m$^3$/㎡ | 14 |
| 09     | Permeable pavement (for cars) | 0.050 m$^3$/㎡ | 8 |
| 10     | Deep pavement of bricks | 0.020 m$^3$/㎡ | 12 |
| 11     | Ditch drains the side of the house | 0.100 m$^3$/㎡ | 6 |

So that, according to the ranking in the table above, all solutions contribute to limiting flooding in urban areas by naturally absorbing water or storing water in the rainy season and reusing irrigation for greeneries or parks in the next sunny season.

- For low-lying areas such as District 2, District 7 and Nha Be, in natural river basins, limiting and stopping the granting of permits for sedimentation of drainage canals, stopping urban development and solidifying construction works to facilitate flooding on the banks of the natural floodplains to minimize flooding in the central residential areas during high tide. In addition, the
combination of new parks to increase the density of urban greenery from 0.8 m$^2$/person to 2.4 m$^2$/person, suburban area of 12 m$^2$/person (According to the planning of Ho Chi Minh City green park to 2020 and vision to 2025) [18].

- Inviting Tokyo's leading experts and flood planners to advise the Vietnamese government to tackle chronic flooding in big cities and avoid spreading investment is not as effective as the current way [16].

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