Challenges in Water Resources Management in Taiwan - Chain Reactions from Increased Rainfall Intensity under Global Warming

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Challenges in Water Resources Management in Taiwan - Chain Reactions from Increased Rainfall Intensity under Global Warming

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Extended Abstract

In the summer of 2015, a super typhoon strike in the Taipei City, the capital of Taiwan [1][2]. This super typhoon which strikes northern Taiwan was triggering a massive landslide in the upstream of the water treatment plant. Due to this condition, most of the Taipei citizen suffered from the turbid tap water [3,4]. The river water was too turbid to be treated due to the sediment from the landslide; therefore the turbid water was delivered directly through the pipe to people houses[2]. In the last view decade, this event has become the most significant threat the water resources management in Taipei. On the other hand, this event can be evidence of climate change. Last years, in 2018, there are lots of flooding event all over the world for example in France[5], Myanmar[6], India, Spain, Indonesia[7], Mexico and Taiwan.

Typhoon is a two-edged sword for Taiwan. Due to its geographic location, Taiwan suffers from typhoons/hurricanes almost every year. However, in Taiwan, there is a positive correlation between damage cost and typhoon-induced rainfall. Without typhoons, there will be no damage, but there will be no water resources either. On the other hand, with typhoons, there will be abundant water resources but lots of disasters as well [8][9,10]. The average annual precipitation in Taiwan is three times higher than the global average. However, if the population is taken into consideration, the precipitation share per capita per year in Taiwan is only 1/5 of the global average. Although Taiwan potentially has 750 unit of water resource, most of them are directly drained to the ocean. Eighteen major reservoirs connected to 44 unit of water supply. However, the total volume of the reservoirs is limited to 11 units, which means all the reservoirs need to be refilled four times to fulfil the water demand. Like most of the countries in the world, agriculture is one of the biggest users. If we looked at the rainfall data, the amount of rainfall during the typhoon season is slightly increasing. However, the rain hours are significantly decreasing, resulting in an abrupt increase in rainfall intensity.

Moreover, it is happening island-wide from north to south and west to east. by classified the annual daily rainfall data into ten categories based on their intensities, we found that in Taiwan, it is getting harder to rain. However, if it rains, it will rain a lot. Also, it is temperature-dependent. Which means a higher temperature will result in more extreme weather conditions.

We can see these phenomena clearly from the satellite-based GPCP rainfall data in between 60 deg north and 60 deg south of latitude. With the unit increment of temperature, the high-intensity rainfall has increased by 100%. However, the GCMs underestimate and simulated

only 10%. The high-intensity rainfall is mainly from typhoons. It is found that the characteristics of typhoons invading Taiwan are also changing. The numbers of generated typhoons are relatively the same. However, the life cycle of the typhoon is increasing, from 23 days to 30 days. Also, the typhoon duration in Taiwan is also increasing, from 45hours to 53 hours, owing to the slower moving speed of typhoons. The slower the typhoon, the more to the rainfall[9]. A study shows that the typhoon-induced rainfall over Taiwan is significantly increasing, particularly in West Taiwan.

Regarding rainfall, we are facing more frequent flood and drought in Taiwan. In the past, the flood occurs in the frequency of 19 years, but now in the frequency of 7 years and it is getting more extensive. As for drought year, from the 17 years to 9 years. Moreover, the drought is getting more serious. Therefore, the variability of rainfall is getting larger, following the curve of global temperature anomaly. However, the variability of runoff is even more significant.

The increased rainfall intensity and surface runoff, together, result in more erosion. The observed data shows that when the rainfall intensity doubled from 10 to 20, the erosion rate will increase from 0.1 to 100, 2-order magnitude increase. Landslides mainly contribute this erosion. On the other hand, the typhoon triggered a massive landslide that burying the village, resulting in the death of 500 people. From the measurement, we found that the volume of the landslide is 12.5 times larger than the landmark building in Taipei.

Another example of the typhoon in Taiwan is Morakot typhoon[11,12]. This typhoon increased the sediment in the river from landslides and transported to the downstream which elevated the riverbed[13]. This condition might be getting worse because studies show the strength of typhoons will be increasing, particularly for those landfalling typhoons, owing to the warming ocean surface[11].

Taiwan government have implemented two brilliant ways to extend the life of the reservoir. There are initially two underwater tubes for power generation and directly created a new tunnel to discharge sediment. Taiwan government is very proud of this engineering because it is not easy when the reservoir is during the operation while some works were under the water. Taiwan government gives this engineering a nice slogan, return sand to the river. Taipei government is also planning to build a new tube delivering the clean water directly from the reservoir to the water treatment plant. Even if we prepare a cup that we think it is large enough, unexpected flood or drought could still fail our system. There are still more challenges ahead because temperatures everywhere around the world are much higher than their long-term average and are increasing. Because the hydrological cycle is temperature dependent, water resource management will be more and more critical.

References

[1] Guardian “Super typhoon” Dujuan kills two and injures hundreds in Taiwan | World news | The Guardian
[2] Fakour H, Lo S-L and Lin T-F 2016 Impacts of Typhoon Soudelor (2015) on the water quality of Taipei, Taiwan *Sci. Rep.* **6** 25228
[3] Chen C-W, Oguchi T, Hayakawa Y S, Saito H, Chen H, Lin G-W, Wei L-W and Chao Y-C 2018 Sediment yield during typhoon events in relation to landslides, rainfall, and catchment areas in Taiwan *Geomorphology* **303** 540–8
[4] Chen C-W, Chen H and Oguchi T 2016 Distributions of landslides, vegetation, and related sediment yields during typhoon events in northwestern Taiwan *Geomorphology* **273** 1–13
[5] BBC France floods: 1,600 evacuated, German missing at campsite - BBC News
[6] CNN More than 100,000 forced to flee homes in Myanmar floods - CNN
[7] kompas Banjir dan Longsor Kembali Terjadi di Beberapa Wilayah Indonesia - Kompas.com
[8] Shih H-J, Chen H, Liang T-Y, Fu H-S, Chang C-H, Chen W-B, Su W-R and Lin L-Y 2018 Generating potential risk maps for typhoon-induced waves along the coast of Taiwan *Ocean Eng.* **163** 1–14

[9] Pan T-Y, Yang Y-T, Tan Y-C, Lai J-S, Chang T-J, Lee C-S and Hsu K H 2013 Improvement of watershed flood forecasting by typhoon rainfall climate model with an ANN-based southwest monsoon rainfall enhancement *J. Hydrol.* **506** 90–100
[10] Young C-C, Liu W-C and Wu M-C 2017 A physically based and machine learning hybrid approach for accurate rainfall-runoff modeling during extreme typhoon events *Appl. Soft Comput.* **53** 205–16
[11] Kuo Y-C, Zheng Z-W, Zheng Q, Gopalakrishnan G, Lee C-Y, Chern S-W and Chao Y-H 2017 Typhoon induced summer cold shock advected by Kuroshio off eastern Taiwan *Ocean Model.* **109** 1–10
[12] Min C, Li Y, Hongshuai Q, Liang W, Aimei Z, Linnan S and Qi F 2019 The influence of season and Typhoon Morakot on the distribution of diatoms in surface sediments on the inner shelf of the East China Sea *Mar. Micropaleontol.*
[13] Tu H-M and Chen H-M 2017 Slopeland hazard and respiratory health: The example of Typhoon Morakot in Taiwan *Landsc. Urban Plan.* **157** 375–82