Impacts of climate change on the population health associated with pluvial disaster

EGU2013- 319

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Introduction

Many metropolises located in lowlands suffer pluvial inundation disaster more than pluvial flood disaster. During the post-inundation period, some water-borne illnesses would be induced from the polluted area. For improving mitigation strategies, population health risk assessment is an important tool of post-inundation disaster management, especially in the countries suffering tropical cyclones and monsoon with high frequency. Locating in the hot zone of typhoon tracks in the Western Pacific, Taiwan suffers three to five typhoons annually. Furthermore, the trend of 24 global circulation models (GCMs) shows that climate change would enhance rainfall in Taiwan. The purpose of this study is to evaluate the impacts of climate change on the population health associated with pluvial disaster.

Methodology: Study flowchart

This study applies the concept that risk is composed by hazard and vulnerability to assess the risk of the population health associated with pluvial disaster. Stochastic simulation of bi-variate Gamma distribution is developed to downscale the GCMs' monthly data to extreme rainfall event scale in time domain. According to A1B scenario in short-term period of climate change, two-dimensional overland-flow coupled with drainage systems simulation is performed based on a design extreme rainfall event to calculate the impacts of climate change on pluvial hazard to population health, including flood depth, velocity and the duration of flood recession. The environmental vulnerability for population health is carried out according to the factors of resident and environment. The risk matrix is applied to show the risk by composing the inundation hazards and vulnerabilities associated with population health.

The Taipei City, the Capital of Taiwan, is selected as the case study because the highest density of population in Taiwan causes high exposure to the risk of water-borne illnesses. Through assessing the impacts of climate change on the population health associated with pluvial disaster of the Taipei City, the analytical results of pluvial-induced health risk can provide useful information for setting mitigation strategies of post-inundation disaster management

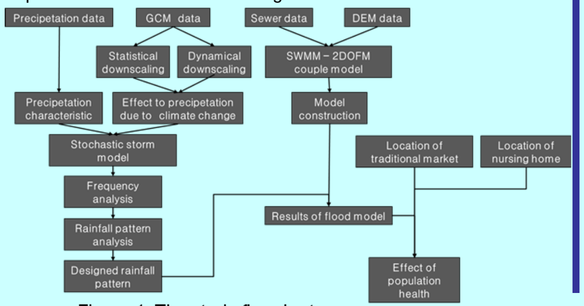

Figure 1. The study flowchart.

Methodology: Precipetation analysis

Through stochastic storm model based on the precipitation characteristic from downscaling of GCMs, the frequency analysis and rainfall pattern analysis for a 100-year return-period event are performed based on 500 runs (1-year hourly rainfall/run) as shown in Figure 2.

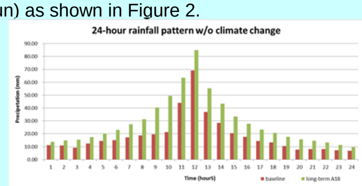

Figure 2. hourly rainfall of a 24-hour storm w/o climate change.

Methodology: Pluvial analysis

●*Storm water management model* (SWMM)

The amount of surcharged flow is defined as Q_s=Q_{in}-Q_f ; in which Q_{in} is the total inflow discharge from the upstream conduit, and Q_f is the design full capacity of the downstream conduit.

SWMM can give hydrographs for each surcharged manhole; but it cannot deal with detailed information such as inundation zones and depths caused by surcharged water.

The distribution of surcharged water is treated by the 2D overland-flow model.

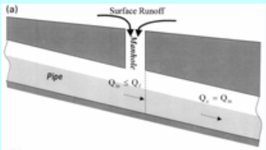

Figure 3(a). Inflow discharge below the conduit capacity

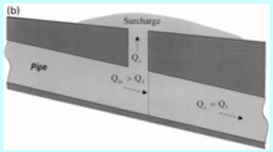

Figure 3(b). Inflow discharge greater than the conduit capacity

●*Noninertia 2D Flood Inundation Model*

Assuming that acceleration term of water flow is small compared to gravitation and friction terms, the inertial term in motion equations is neglected.

●*Coupled 1D SWMM and Noninertia 2D Flood Inundation Model for Simulation of Urban Flooding*

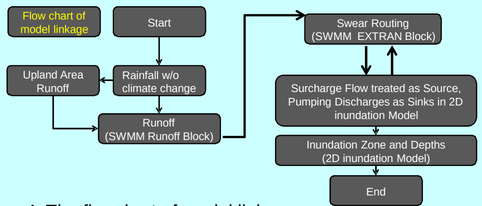

Figure 4. The flowchart of model linkage.

Case study

With 604 hectares of catchment area, Shuang-Yuan drainage system is located in the Wanhua, Zhongzheng, and Daan Disdricts, where are the earliest urbanization of Taipei city. Therefore, high ratio of vulnerable population and traditional markets provides exposure sources of population health to pluvial disaster.

Sixteen sub catchments are identified based on the DTM and the drainage system as shown in Figure 5. Fig. 5 also shows the locations of traditional markets, nursing and handicapped homes.

Figure 5. The area of Shuang-Yuan drainage system with 16 sub catchments and exposures of population health.

Figure 6. The Shuang-Yuan drainage system.

Table 1. The impacts of climate change on the population health associated with pluvial disaster.

		Exposure of population health					Baseline				Climate change of long term A1B			
No.	Area (m^2)	No. of TM	No. of nursing home	No. of handicapped home	Density of vulnerable points	Vulnearbility of population health	Area of inundation (m^2)	Average water depth of inundation (m)	Hazard of population health	Risk of population health associated with pluvial disaster	Area of inundation (m^2)	Average water depth of inundation (m)	Hazard of population health	Risk of population health associated with pluvial disaster
1	342296	3	0	1	1.169E-05	0.9286	161600	0.81	0.9	0.83574	164800	0.96	0.9	0.83574
2	428734	3	1	0	9.330E-06	0.7143	40000	0.5	0.5	0.35715	54400	0.57	0.5	0.35715
3	206830	0	0	0	0	0	0	0	0	0	0	0	0	0
4	313310	3	0	0	9.575E-06	0.7857	144000	0.46	0.6	0.47142	168000	0.52	0.7	0.54999
5	174721	2	0	0	1.145E-05	0.8571	9600	1.04	0.6	0.51426	9600	0.66	0.5	0.42855
6	424040	1	0	0	2.358E-06	0.2857	51200	0.29	0.4	0.11428	112000	0.4	0.4	0.11428
7	803177	1	0	0	1.245E-06	0.0714	0	0	0	0	0	0	0	0
8	252017	1	1	0	7.936E-06	0.5714	0	0	0	0	0	0	0	0
9	331180	1	0	0	3.020E-06	0.4286	0	0	0	0	0	0	0	0
10	322250	3	0	1	1.241E-05	1	0	0	0	0	0	0	0	0
11	474881	1	3	0	8.423E-06	0.6429	0	0	0	0	0	0	0	0
12	268532	0	0	0	0	0	0	0	0	0	0	0	0	0
13	562471	1	0	0	1.778E-06	0.2143	0	0	0	0	0	0	0	0
14	185473	1	0	0	5.392E-06	0.5	0	0	0	0	0	0	0	0
15	542870	1	0	0	1.842E-06	0.1429	0	0	0	0	0	0	0	0
16	343513	1	0	0	2.911E-06	0.3571	0	0	0	0	0	0	0	0

Results and Discussions

The frequency analysis and rainfall pattern analysis show that the impacts of climate change on rainfall are not only the quantity from 441.6 to 686.9mm, but also the intensity from 69.1 to 84.9mm/hour. Because the designed capacity of all drainage systems in Taipei city is 78.9mm/hour, the impacts of climate change on pluvial inundation is slightly increase that inundation area increases from 406400m^2 to 508800m^2 and average water depth from 0.54m to 0.60m as shown in Figure 7.

The assessment of exposure of the population health and its risk based on climate change is listed in Table 1. It shows that No. 1 sub catchment suffers the highest risk of population health induced by pluvial inundation due to climate change because high density of exposure of population health and high potential inundation

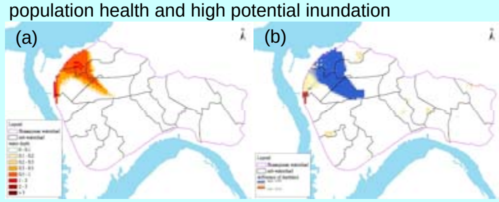

Figure 7. comparison of pluvial inundation w/o climate change: (a) baseline; (b) difference of baseline and climate change

Conclusions

This study not only applies inundation model to perform the pluvial hazard based on the drainage system and climate change, but also uses the locations of traditional markets, nursing and handicapped homes to assess the vulnerability of population health to pluvial disaster. The results shows that climate change could increase the risk of population health problem.

Briefly, the study provides a simple and quick methodology to evaluate the impacts of climate change on population health problem due to pluvial disaster. In the future, we will add more other factor that would effect environmental sanitation into our map.