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Flood and Debris Flow Risk Maps to Cultural Heritage of New Taipei City

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Abstract. Climate change has affected natural, economic and social environment. Due to constant threat from erosion and weathering, it is inevitable for the officials to set up mechanisms to preserve cultural heritages as soon as possible, its resistance to impacts from climate change declines rapidly than expected. This study aims to find possible risks thataffect scope of cultural heritages in northern Taiwan under extreme rainfall. The study also tries to understand projects of cultural heritage preservation and the planning and establishment of risk maps through analysis, incorporating current flood-prone area maps with GIS overlapping cultural heritage sites over northern Taiwan.The complete flood risk maps of cultural heritage will help outlining the land use planning and effectively manage and maintain mitigation measures before disasters strike.

Keywords: Cultural Heritage, Debris Flow, Flood, Risk Management, Risk Maps

1. Introduction

Due to global climate change, the normalization of catastrophe has become an unavoidable trend. Catastrophe causes serious damages more than ever. In 2009, Typhoon Morakot brought heavy rainfalland caused flooding and debris flow in Taiwan, resulting in massive damages and losses. According to the post-catastrophe cultural heritage inspection, the loss of cultural heritage reached about USD 17 million [1]. However, as for the cultural essence it destroyed, damages of at least six national historic sites, 11 county-designated historic sites, and 14 historic buildings were immeasurable [2]. Typhoon Morakot was not a single incident in Taiwan and various climate features will become more severe and frequent. Besides the hugethreat of life and property, we are now confronting the crisis on our spiritual level, historic memories, and the irreplaceable human civilization, which are disappearing fast.

Risk map is presently an important rational tool and the basic foundation for drawing up various strategies for disaster adjustment and relief. The risk map should not only reflect the present situation but actively grasp and respond to the development of future dynamic trends for lowering the uncertainty. Thus, it is our emergent task to set up our national risk map of cultural heritages.

2. Study Scope and Research Method

This study tries to find out advantageous,correct and disaster-reducing response measures when cultural heritages are facing floods. The other issue is how to reduce the risk when designing environmental plans. Therefore, the objective of this study is the immovable tangible cultural heritages that are hard to recover after they are damaged and their relationship with the surrounding environments. There are five categories, including historic sites, historic buildings, villages, relics, and cultural landscapes. This study takes New Taipei City (NTC) as the operation example. There are a total of 29 administrative districts in NTC, with a total area of 2,053 km^2. Based on the information provided by the Cultural Affairs Department, there are six national historic sites, 61 municipality-designated historic sites, 38 historic buildings, four relics andfourcultural landscapes in NTC.

Physical impacts on tangible cultural heritages caused by natural phenomena of climate changesand indirect impact means social and economic changes caused by climate changes. These changes indirectly impact the conservation, management and operation of cultural heritages. Based on the investigation in 2007, 46 cultural heritages worldwide are suffering from the threat of physical impact caused by the global climate change. Impact includes: hurricanes and storms, sea level rise, erosion, and flood. Categorized by their level of destruction,it can be separated into three levels, which arethe macro-level, mediate-level, and micro-level. This study belongs to mediate-level. The main objectives are the possibility of one absolute destructive event or large-scale destructive events.

2.1. Flood-prone area simulation

The rainfall analysis of the flood-prone simulation in this study adopts the Simple Scaling Gauss-Markov as the rainfall pattern. This simulation is set at a 24-hours quantitative rainfall and the accumulated rainfall of 150~1,200mm. The SSGM is a rainfall pattern in accordance with the random fractal features and the dimensionless feature of the Gauss-Markov process. This rainfall pattern describes the highest value event of the dimensionless year with nonstationary first-order Gauss-Markov process. It satisfies the features of Gauss-Markov process, the features of peak rainfall statistics, and can reach the maximum likelihood. Its advantages include [3, 4]:

- Meet the statistical features of peak rainfall percentage
- The time distribution of rainfallcorresponds with the features of maximum torrential rain event process
- Different types of torrential rain results in different rain patterns
- After correct scaling transfer, the rain pattern is applicable for various durations of designed torrential rain

In this study, the altitude of NTC is divided into 16 equal parts. 300maltitude is divided by the range of 20m (0~20cm; 20~40cm; …260~280cm; 280~300cm) and altitude above 300cm belongs to a single range. In addition, this study also considers the relationships between sea levels and the astronomical tide (tides) and storm tide (meteorological tide) [5]. The relationships of sea levels are taken at the downstream boundary which sets as a condition of the flood simulation in NTC. Therefore, theflood-prone chart is initially set at a daily rainfallof 200mm-600mm, t with an altitude below 300m. After simulating the rainfall, the height of flood is then divided into five levels, setting dividing borders at 0.5m, 1m, 2m, and 3m.

2.2. The geographic information system

This study utilizes the geographic information system (ESRI ArcGIS V10) for setting up layers of present cultural heritages in NTC. It integrates the numerical values to simulate theflood-prone layers for various rainfalls amount (200-600mm) and assess the relationship between cultural heritages and floods. This study overlays topographic chart and selected points of cultural heritages for understanding the dependence of cultural heritages upon its surrounding environment. Later, identify the initial distribution of cultural heritages in NTC, each impacted cultural heritages, the impact ratio of flood for each district and confirm the situation through the on-site field study. Finally, the study views the distribution of parks and green lands in each district in NTC for further overlaying and chooses the spot for flood detention, which will be the essence for implementing non-structural mitigation in urban planning.

3. Definition and Scope of Disasters

"Disaster" usually includes hazard and disaster. "Hazard" means the change of a situation or a series of situations which may cause the potential possibility of getting hurt or losing property. "Disaster" means the collapse of a series of social functions which cause the loss of human beings, materials, economy, or environment. The loss is unaffordable for those who used to consume the resources in the community or society [6]. However, for cultural heritages, besides the possibility of causing loss of life and property, the definition of disaster is expanded to the general value of cultural heritages and people whose ecological system may be impacted by the disaster[7]. UNESCO [7]thinks that disaster risk of cultural heritages mainly comes from external and internal causes. The external cause is the disturbance or damage of cultural heritages brought by external power. The internal cause is the cultural heritages' fragility in structure or material and their sensitivity to the environment. The damage might be caused by external power.

Disaster risk studies focusing on cultural heritages as the main subjectdid not attract people's attention until the 1990s. Ghose [8] divided the usually seen disaster risks of cultural heritages into unpredictable disasters and predictable deterioration. Figure 1 demonstrates common seen disasters and risks for cultural heritage.

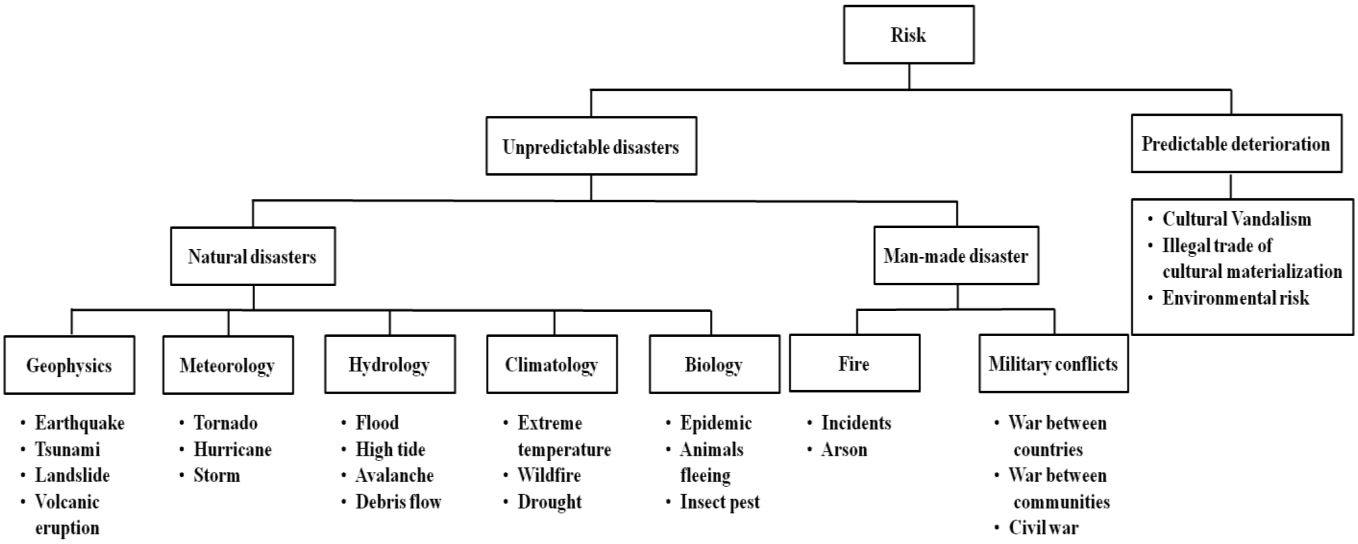

Fig. 1: Schematic diagram of common disasters and risks to cultural heritage

Risk management is the steps and process of effectively managing possible events and lowering its negative impacts. With the development of scientific knowledge and the increasing complication of the external environment, it gradually turns into a comprehensive emergency management.

The ISO/DIS 31000 risk management process is adopted by this study, which covers understanding the environment and situation, identifying the risk, risk assessment (risk analysis, risk evaluation), risk disposal, supervision, and audit. Risk assessment means the process of comprehensive risk identification, analysis, and evaluation.

- Risk identification: identifying the source, impact, scope, cause, and potential result of risks.
- Risk assessment: includes risk analysis and risk evaluation. Risk analysis deals with the details of changes, goals, available information and resources of risks. Risk evaluation determines the priority of risks based on the result of risk analysis, including the risk grades.
- Risk disposal: choose one or several suggestions and advice of risk management. Determine whether if the remaining risk can be lowered through the practical implementation.

Hazard potential map indicates the setting of hazard situations, warning values, hazard potential areas, main landmarks, or possible impact scope and objects [9] andprovides potential of hazards with related concepts. Hazard risk map presents the probability and the impact of disasters clearly. The presented information is the evaluation of loss caused by the disaster in certain area or the probability of certain-scale disasters (i.e., earthquake risk classification map) [6]. The assessment shows different risks in various areas. It is helpful for drawing up projects and strategies for all phases of disasters. The predictable or unpredictable impact of disasters will be reduced then.

The UN's International Strategy for Disaster Reduction (ISDR), asserted natural disaster risk is the result of the mutual impact between hazard, vulnerability, and capacity [10]. The analysis of various factors shows the distribution of risk value in each area so that we can carry out the risk management strategy at areas with high risk. Hazard analysis aims at assessing the impact scope and extent of natural disasters. The possible impact scope and extent can be understood when the disaster happens.

Italy began the study and establishment of cultural heritage risk map firstly in 1992. Figure 2 shows the distribution of cultural heritage density in Italy. The European Union also presented the Noah' s Ark Project based on the essence of Italy in 2002. The goal was to discuss the impact of the global climate change upon building heritages and cultural landscapes. It was the first time for Europe to carry out systematic investigation and study about the causes and possible situations of damages for cultural heritages by climate changes.The World Heritage Committee formally integrated cultural heritage risk map into important conserving tools in 2010.

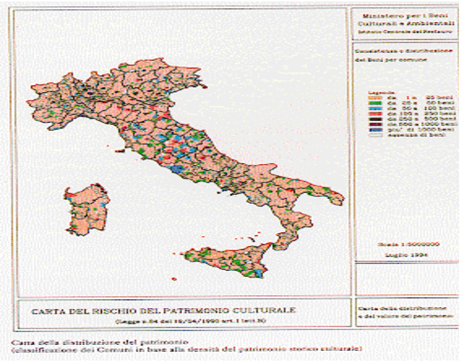

Fig. 2: Distribution of cultural heritage density in Italy http://www.cartadelrischio.it/

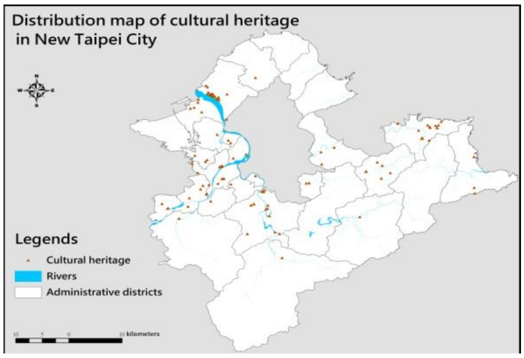

Fig. 3: Distribution map of cultural heritage in New Taipei City

4. Initial Flood Risk of Cultural Heritage in New Taipei City

As for the overlay of rainfall, the main analyzing rainfalls are 200, 350, and 600mm. With various rainfalls, the height of flood remains within 0.5m to1.5m, with the height surpassing 2.5m in a few areas (i.e.,Luzhou, Sanchung, Xinzhung, and Banciao District). Figure 3 displays the distribution of cultural heritage in NTC. The landform, the poor design of the surrounding environment, and the decay of cultural heritages will enhance the damage and attack of rainfall. Mountain areas such as Bali, Yingge, Sanxia, Wulai, Shenkeng, Shiding, Pinglin, Pingxi, and Ruifang District are not impacted by flood.

Through the overlay of GIS, the amount of cultural heritages impacted by flood is 44% of the total amount of cultural heritages in NTC. The most impacted objects are historic buildings which occupy about 11% of the total amount. Affected national historic sites are the least with apercentage of 6%. One historic relic is impacted and the percentage is 1%. No cultural landscape is impacted at all. The different altitudes and landforms in each area lead to different risk features of cultural heritages. The design of drainage is also an important issue. Presently, easily impacted cultural heritages are distributed in the north-western area in NTC, which is plain and has a high population density.

Tamsui occupies the most number of impacted cultural heritages and other areas have fewer impacted ones. Besides the historical context of Tamsui, the landform is also a closely related factor. Cultural heritages should be integrated into future urban planning and urban design. The risk of cultural heritages impacted by disadvantages of natural environment should be lowered through planning and designing. Municipality-designated historic sites are the most affected, followed by historic buildings and national historic sites. Surprisingly, relics and cultural landscapes are effect-free whatever the rainfall is (Figure 4a and b).

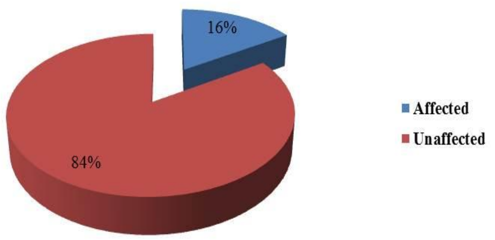

Fig. 4a: Affected cultural heritages in 600mm rainfall

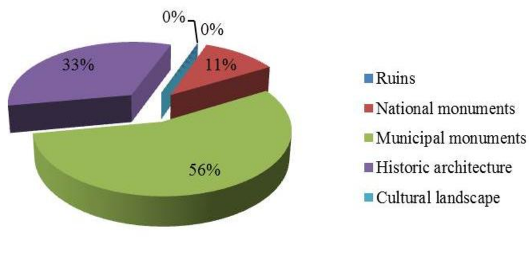

Fig. 4b: Affected cultural heritage types in 600mm rainfall

5. Discussion

From the perspective of practices, the issue of cultural heritage conservation is the same with that of the sustainable development. It should be based on the thinking that "we have only one globe" and thateach case of cultural heritage is unique. Therefore, the gathering of collective wisdom and the enhancement of collective movements have their key functions. Vertically, the cross-country system and tool communication or active participation aim at improving the important practicing mechanism in response to climate change for cultural heritages through the sharing of experiences and techniques.

From the perspective of sustainable management, conservation of cultural heritages is generally regarded as a thought of property. There will be more and more dependence upon insurance in the future. Risk maps can serve as an important tool for insurance. The maps will be improved to be more precise and serve as a more effective protective tool in response to the preventive conservation. The realization of risk in the drawing of maps is responsible for instruction and functions as a public education.

6. Initial Conclusions and Further Discussion

Cultural heritages confronted by the global climate change and the risk management of disasters have been ignored for a long time. Lots of scientific techniques have been constantly developed and various tools are created nowadays. We should develop and use various rational tools in response to the uncertainty. It is a necessary and active response to foreign disasters. In addition, this study also suggests more researches should pay attention to the study of various disaster categories (such as earthquake and mudflow) in order to establish the overall landscape of natural disaster risks confronted by cultural heritages in Taiwan.

7. Acknowledgements

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