The Empirical Study of Flood Risk Maps to Cultural Heritages in Taiwan

Jieh-Jiuh Wang

***Abstract*—**Due to extreme climate change, catastrophe normality has turned into a global trend. The idea of "preventive conservation" is now the epic of cultural preservation worldwide; many countries begin to plan adaptive strategies and steps towards impacts to cultural heritage under climate change. Application of risk map has become the tool to predict cultural heritage vulnerabilities. However, cultural heritage preservation in Taiwan remains emphases on insect-resist, antisepsis and structural reinforcement, fire prevention of architectural heritage. Unfortunately, these limited approaches can barely confront with disasters by extreme weather. This study aims first to analyze and explore current global approaches then try to build a domestic risk map targeted on cultural heritage combining disaster-prone area analysis in Taiwan. Analysis is made with research methods, i.e., thematic analysis, field study, in-depth interview, and focus group discussions. Finally, based on cultural heritage vulnerability, examining present cultural heritage preservation strategy, rediscovering the three aspects of "sustainable management, disaster management, climate change and adaptation" in response to cultural heritage management respectively.

***Keywords*—**cultural heritage, risk map, sustainable management, preventive conservation.

I. 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 rainfall and caused flooding and mudflow in Taiwan, resulting in massive damages and losses. According to the post-catastrophe cultural heritage inspection, the loss of cultural heritage reached about NTD 0.5 billion. However, as for the cultural essence it destroyed, damages of at least 6 national historic sites, 11 county-designated historic sites, and 14 historic buildings were immeasurable. Even the Executive Yuan approved a NTD 280 million recovery project to repair these damages, the value of the genuine cultural heritage could never be duplicated. Typhoon Morakot was not a single incident in Taiwan and various climate features will become more and more severe and frequent. Besides the huge threat 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.

Disasters are the crucial challenges for the conservation of cultural heritages. More tools should be developed and presented for facing the rising uncertainty. Besides, we should keep following the future trends. From the perspective of emergency management chain, the connection of risk management, disaster management, and consequence management is very important and it is the current developing direction of present emergency management. 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.

II. Scope and Method of this Study

According to Article 3 of *Cultural Heritage Conservation Law*, cultural heritage means the seven designated or registered types of heritages that hashistoric, cultural, artist, and scientific value. 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 as the operation example. There are a total of 29 administrative districts in New Taipei City, with a total area of 2053 square kilometers. Based on the information provided by the Cultural Affairs Department, there are 6 national historic sites, 57 municipality-designated historic sites, 30 historic buildings, 3 relics, 4 cultural landscapes in New Taipei City, adding up to 100.

Physical impacts on tangible cultural heritages caused by natural phenomena of climate changes (such as change of atmospheric moisture and temperature), while indirect impact means social and economic changes caused by climate changes (i.e., the climate change changes the utilization of land, economic structure, and population structure). These changes

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indirectly impact the conservation, management, and operation of cultural heritages. Based on the investigation in 2007, 46 global cultural heritages are suffering from the threat of physical impact caused by the global climate change. The most powerful impact includes: the frequency of 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. The sample category is flooding. The main methods of research in this study are literature reviews, geographic information systems, and field studies.

- *Literature review*

The literature review in this study is roughly divided into study subject and study method. The study subject will be approached from two perspectives. The first is the research results and applications of disaster risk management for handling the climate change that focuses on the conservation of cultural heritages. This perspective serves as the essence of cultural heritage risk assessment in our country. The other perspective is related to studying methods and collection of information. There are few studies related to this issue in our country, so this study will adopt several social and scientific studying methods for comprehensive information collection. This perspective tries to provide a cross-field communication platform and it will set up the domestic cultural heritage risk assessment and risk map with the help of professional knowledge (such as disaster risk management) and technical tools (such as the system of geographic information)of other fields.

- *Flood-prone 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 150~1200mm. 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 [1, 2]:

- Meet the statistical features of peak rainfall percentage
- The time distribution of rainfall corresponds 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
- The rainfall adopted by the pre-set rainfall pattern is roughly the same with the rainfall of the pre-set rainfall intensity duration—frequency curve

This study uses the New Taipei City river map and the administrative district map. In this study, the altitude of New Taipei City is divided into 16 equal parts. 300m altitude 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) [3]. The relationships of sea levels are taken at the downstream boundary which sets as a condition of the flood simulation in New Taipei City. Therefore, the flood-prone chart is initially set at a daily rainfall of 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.

- *The geographic information system*

This study utilizes the geographic information system (ESRI ArcGIS V10) for setting up layers of present cultural heritages in New Taipei City. It integrates the numerical values to simulate the flood-prone layers for various rainfalls amount (200-600mm) and assess the relationship between cultural heritages and floods. Through the displaying and consulting functions of ArcMap, this study tries to understand related spatial information and present needs through the edition, review, and statistic analysis of patterns and attribute information in these layers. This study overlays topographic chart (elevation map, or slope map) 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 New Taipei City, 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 New Taipei City for further overlaying and chooses the spot for flood detention, which will be the essence for implementing non-structural mitigation in urban planning.

III. Discussion

- *The definition and scope of disasters*

The essential meaning of "disaster" 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 [4]. 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 [5]. UNESCO [5] 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 source of the power might be natural disaster (i.e., typhoon and tsunami) or human disaster (i.e., breaking on purpose and war). 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 [6] divided the usually seen disaster risks of cultural heritages into unpredictable disasters and predictable deterioration. Unpredictable disasters include the usually seen disasters caused by natural phenomena and human behaviors. The categories of natural disasters are based on the five categories listed in the international emergency database, such as geophysics, meteorology, hydrology, climatology, and biology. Human disasters include fire, accidents and military conflicts. Predictable deterioration includes vandalism, illegal trade of cultural materialization, and the risk caused by the environmental deterioration.

- *The disaster risk management strategies of cultural heritages*

Risk management is the steps and process of effectively managing possible events and lowering its negative impacts. In other words, it is for preventing existing hazard from turning into disasters. In recent years, the core value of risk management lies not only in passively lowering the threat but in actively pursuing the possibility of innovation and public value. With the development of scientific knowledge and the increasing complication of the external environment, it gradually turns into a comprehensive emergency management. There should be three important elements:

- Hazard: to review present situation through past studies, documents, history, scientific analysis, and to understand and predict the possible disasters in the future for lowering the loss.
- Risk: includes the "probability" or "likelihood." The probability analysis can be determinedwith the probability of certain disasters and their possible intensity;
- Vulnerability: is closely related to hazard. Impacted by constant changing concepts, it is usually the result of the interaction between the dynamic natural environment and the complicated social and economic environment.

This study adopts the ISO/DIS 31000 risk management process, including understanding the environment and situation, identifying the risk, risk assessment (risk analysis, risk evaluation), risk disposal, supervision, and audit. In particular, we should think of the cooperation of risk management process with the internal and external environments. Risk assessment means the process of comprehensive risk identification, analysis, and evaluation.

1. Risk identification: identifying the source, impact, scope, cause, and potential result of risks.
2. Risk assessment: divided into 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.
3. 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.
4. Supervision and audit: besides recording the process of risk management, continuous monitoring of environmental changes to readjust the measures of risk disposal.

- *Risk map*

Hazard map is also called hazard potential map or hazard risk map. Hazard potential map indicates the setting of hazard situations, warning values, hazard potential areas, main landmarks, or possible impact scope and objects [7] 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) [4]. The risk map is the substantiation of risk assessment on the map. 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 [8]. 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.

IV. THE INITIAL FLOOD RISK IDENTIFICATION OF CULTURAL HERITAGES IN NEW TAIPEI CITY

As for the overlay of rainfall, the main analyzing rainfalls are 100, 200, and 350mm. 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). The landform, the poor design of the surrounding environment, and the decay of cultural heritages will enhance the damage and attack of rainfall. There are totally 100 cultural heritage sites in New Taipei City. There is no designated cultural heritage in Shimen, Jinshan, Wanli, Shuangxi, Shiding, Wulai, and Linkou District. Mountain areas such as Bali, Yingge, Sanxia, Wulai, Shenkeng, Shiding, Pinglin, Pingxi, and Ruifang District are not impacted by flood.

Through the overlay of geographic information systems, the amount of cultural heritages impacted by flood is 44% of the total amount of cultural heritages in New Taipei City. The most impacted objects are historic buildings which occupy about 11% of the total amount. Affected national historic sites are the least with anpercentage of 6%. One historic relic is impacted and the percentage is 1%. No cultural landscape is impacted at all. The amount and distribution of various categories are shown in Table 3. The different altitudes (i.e., Linkou is high while Banciao is low) and landforms (i.e., Xindian is the mountain area while Xinzhung is the plain) 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 New Taipei City, which is plain and has a high population density (i.e., Banciao City, Xinzhung City, and Sanchung City, Figure 1).

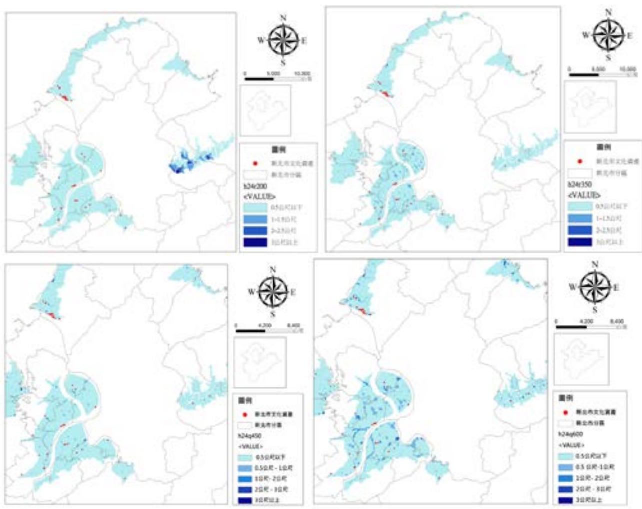

Figure 1 Distribution of cultural heritages impacted by flood in New Taipei City

Source: drawn by this study

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.

In addition, based on the initial information, the flood-prone situation in New Taipei City seems to be extreme. In other words, the impact of constant rainfall almost happens at the same area. As the rainfall keeps increasing, the expansion of flooded area is limited but the depth of flood will be increased. Relatively, it also means that cultural heritages easily suffer from the risk of flood caused by 200mm rainfall and will confront constant and more severe impacts in the future.

V. Risk disposal: non-project consideration

For cultural heritages that has a relationship with environmental dependence, their designing and planning should adopt the concept of non-structural mitigation and preventive projects in response to flood. The precious cultural heritage will be protected in this way. For neighboring areasthat easily suffer from flood, the possible measure is a “flood detention pool.” Taking advantage of the altitude, it is possible to direct water to gather at the lower place, parks, and green land, and reduce the risk of flood confronted by cultural heritages. This study makes use of elevation maps which overlay cultural heritages, parks, and green lands in various areas. The basis is using park as the center and select service areas suitable for flood detention withina radius of 500m. Through related achievements, we also discover that there is not enough space in some areas to serve as the flood detention region. For example, there are a lot of cultural heritages in the Tamsui District, but there are only two parks here. The risk is relatively high and surrounding region will be integrated into the next step for constant field studies and analysis. Relatively, areas lacking parks and green lands should consider nearby parks and green landsto use toreduce the possible hazards brought by flood with the flood way.

IV. Discussion

> *“Risk management is a political will. The political will is the comprehensive operation of the leading officers, overall motives, pressure, and discourses…. Risk management owns precious knowledge and techniques, but how can we enter the field of policies? This is the core of the mitigation discourse…”* [9]

From the perspective of theories, it has led us to wonder whetherifis there enough considering tools for present risk maps.If we can take advantage of the promotion of the national policies, integrate various experts through the power of the country, andthere will be possible effects upon the legitimacy and smoothness of policy promotion by both local and central departments. More hopeful results can be achieved for future cultural heritages in response to disasters caused by the climate change.

We should grasp the present location of cultural heritages, the possible impacting disasters, the potential of disasters, and the risk before discussing the necessary measures with the same level of protective capabilities. However, if the extent of protective capabilities is not enough, cultural heritages might be completely damaged once or gradually. From the perspective of disaster management after thedevelopment of risk map, if cultural heritage protection could accept the truth that cultural heritages might be harmed, the risk can be lowered only by facing the truth. The discussion of emergency planning, intervention of response measures, and the drawing of emergency response plan or measures will be meaningful then. Or, if the relics are the only things left after the damage, what can we do or whether we should prepare for the second intervening conservation?

Moreover, the present risk map has a broad coverage. From dealing with earthquakes, air pollution, and human pressures, these are all taken as different factors causing pressure to cultural heritages. “The cause of disaster” should be defined in a broader way and be integrated into this study. The thought of compound disaster should also be introduced to the discussion of cultural heritage conservation. Like the factors considered in the present risk map of Italy, the possible issue for further discussion is the compound result caused by various disasters happening at the same time. From the compound perspectives, the compound causes of disasters and the results of expanded disasters lead to double damages. The different thoughts of single-hazard and all-hazards also lead to various risk maps. Take Venice as an example, the rising water level and the population pressure of tourists might lead to more serious results. We have to think of an effective mechanism or measures for response.

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. The movements of ICBS connected non-governmental organizations and set up a platform. It is an important beginning. Horizontally, the cross-field cooperation must have further enhancement so that risk maps will be improved in their functions and effects in a more precise and effective way.

From the perspective of sustainable management, how should we respond to the trends of climate change and disaster development under the requirement of cultural heritage reuse? Conservation of cultural heritages is generally regarded as a thought of property. There will be more and more dependence upon insurance in the future. Judging from the trend of disasters in recent years, the annual average compensation cost for damages of historical architectures reached about 750 million Euros in Britain in the 1990s. The annual average amount increased to1.5 billion Euros during 1999 to 2001. In 2000, the compensation for flood reached 2.2 billion Euros. Therefore, if the conservation of cultural heritages is connected with insurance in the future, the commercial essence of insurance companies will invest more energy inresearches and calculations. Relatively, risk maps can serve as an important tool for insurance. It will work as the American flood insurance rate map. Through the experiences and actuarial capacity of private insurance companies, 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.

Climate change and disaster issues will create more difficult challenges for cultural heritage conservation. Risk map is also an important rational tool now. Nevertheless, there should be more tools developed for confronting the increasing uncertainty. This is also a common issue we should handle together.

IIV. Initial conclusion and following tasks

This essay collects the present measures in other countries and uses New Taipei City as the example. It sets up the initial studying procedures and provides the initial results of risk identification. Based on the extent of hazard and vulnerability analysis, this study provides the steps and methods of risk analysis and assessment accompanied by field studies. It gradually figures out the possible impact of natural disasters upon cultural heritages and feasible strategies in Taiwan.

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.

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Identifying the competence of delineating the subsurface extension of Eppawala apatite deposit using magnetic survey

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Abstract— Host rock of the Eppawala apatite deposit is suggested to be a carbonatite in origin, which has been intruded and altered over the geological time. The high apatite/phosphate occurrences are demarcated by hillocks revealing the weather resist character of apatite formations.

One of the associated minerals of apatite is magnetite, and a high concentration of magnetite has been observed at the fringe of the apatite occurrences within the carbonatite host. The same character is a common phenomenon in many rock-phosphate deposits throughout the world.

A magnetic survey has been conducted to identify the magnetite concentrations at the fringe of the apatite deposit selecting two specific areas of interest within the deposit. The collected magnetic intensity data were corrected for diurnal variations and resultant anomalies were extracted. In this the anomalous area in deposit was marked as positive and negative anomalies. To remove overlapping 3D analytical signal maps were constructed and it shows the exact anomalous area in the study site.

Anomaly and the 3D analytical signal reveal that the magnetic survey technique is reliably applicable to identify magnetite and it can be indirectly apply to demarcate apatite body.

Keywords—3D analytical signal, apatite deposit, magnetite, magnetic anomaly, magnetic survey

I. Introduction

Mineral exploration is one of the main target areas in exploration Geophysics. Quantifying the known mineral reserves and identifying hidden resources is an integral part of the development of the national mineral wealth that generates revenues to the national economy.

Eppawala apatite occurrences are one of the major non-metallic mineral rescores that has not been fully explored with its resource extension and economic potential. Magnetic method is a very successful approach for exploring of mineral deposits with magnetic signature, which is a measurement of magnetic minerals of the host body. Ferrous mineral content of rocks produces an induced field due to the influence of the Earth's geomagnetic field. The vector sum of two fields; induced and the Earth magnetic field makes the magnetic anomaly [1].

This method is commonly used for mineral exploration in many countries though Sri Lanka is yet to apply the same in detail. Despite few attempts on iron-ore deposits, this method has never been applied for identifying any other mineral commodity such as apatite. Instead, identifying the subsurface extension of mineral deposits is largely based on surface mapping assisted by drill-holes, which is costly and time consuming [3]. This is an attempt to assess the applicability of geophysical techniques, particularly magnetic method, in demarcating apatite extension in selected area within Eppawala deposit.

Apatite usually occurs along with magnetite and the cooling history of the geothermal (or carbonatite) emplacement produce zonation in apatite and magnetite minerals [4]. The co-existence of apatite and magnetite is a common feature of the phosphate deposits. In general high magnetite concentration is observed at the rims of the deposit as a result of zonation [2]. To test the applicability of magnetometer surveys in screening apatite occurrences, Eppawala phosphate deposit was selected as a pioneer project.

A. Materials and methods

GSM-19 portable high-sensitive magnetometer system was used to conduct the survey. The rowing component of the system, which is integrated with a GPS (Global Positioning System) receiver, was deployed in the field for raw data acquisition while a base station is maintained at a fixed point in the vicinity of the survey to identify the time dependent variations of the total magnetic field within the survey area.

B. Survey Planning

Two survey plots were considered for this study where phosphate mining has been carried out. In southern study site, the mining process has already completed, and the fringe of the mine consists of apatite bearing host rock. Northern study site is presently in operation and opencast mining is conducted

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