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Multi-Hazard Risk Assessment and Management in Tourism Industry- A Case Study from the Island of Taiwan

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***Abstract*—**Global environmental changes lead to increased frequency and scale of natural disaster, Taiwan is under the influence of global warming and extreme weather. Therefore, the vulnerability was increased and variability and complexity of disasters is relatively enhanced. The purpose of this study is to consider the source and magnitude of hazard characteristics on the tourism industry. Using modern risk management concepts, integration of related domestic and international basic research, this goes beyond the Taiwan typhoon disaster risk assessment model and evaluation of loss. This loss evaluation index system considers the impact of extreme weather, in particular heavy rain on the tourism industry in Taiwan. Consider the extreme climate of the compound impact of disaster for the tourism industry; we try to make multi-hazard risk assessment model, strategies and suggestions. Related risk analysis results are expected to provide government department, the tourism industry asset owners, insurance companies and banking include tourist disaster risk necessary information to help its tourism industry for effective natural disaster risk management.

***Keywords*—**Tourism industry, extreme weather, multi-hazard, vulnerability analysis, loss exceeding probability, risk management.

I. Introduction

THE special geographical environment of Taiwan has given rise to its unique beautiful scenery and varied climate, as well as numerous valuable natural tourism resources. However, it is also the primary cause of frequent natural disasters. In recent years, Taiwan's government has actively promoted various tourist promotion plans and encouraged local people to develop tourism. To make full use of the natural resources, most investors choose to build hotels in scenic areas facing the mountains or the sea. However, Taiwan is geographically fragile, with frequent natural disasters and ever increasing incidence of extreme rainfall. According to statistics released by the World Bank in 2005 [6], 73% of Taiwan's population is under the threat of exposure to more three kinds of natural disasters concurrently; as many as 90% are under threat of exposure to over two natural disasters concurrently, ranking the island first in the world (see Table I) [1].

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TABLE I
Ranking of Countries Exposed to the Threat of More than 3 Types of Natural Disaster Risks

Country	Percentage of Total Area at Risk	Percentage of Population in Areas at Risk
Taiwan	90.2	95.1
El Salvador	51.7	77.7
Costa Rica	38.2	77.1
Philippines	45.6	72.6
Dominica	70.8	71.1
Antigua and Barbuda	46.2	69.5

Disasters such as typhoons and floods are natural phenomena which cannot be prevented with existing science and technology, but the losses they may inflict and the impact on individuals, industries and governments can be reduced with disaster alleviation or risk diversification measures taken in advance. Therefore, determining how to realize tourism disaster risk identification, evaluation, control and transfer with appropriate disaster risk management tools, and establishing a typhoon and flood disaster risk and loss evaluation model unique to the tourism industry so as to reduce their loss and impact on operations, are extremely important and urgent tasks for the tourism industry in Taiwan.

II. Probability Catastrophe Assessment Model for Typhoons and Flood

According to the above, the first step to evaluating the influence of natural disasters on tourism (frequency, scale and degree of damage) must begin with disaster risk analysis. Furthermore, the scope of the influence of typhoons and floods is wide, and the number of subject-related matters that have to be estimated is huge and cannot be directly estimated or individually calculated manually. That is why it is necessary to establish a tourism typhoon and flood risk evaluation model. It is hoped that through the high efficiency of computers and the knowledge of experts, the evaluation of risk and loss brought by typhoons and floods can be achieved.

The typhoon and flood risk evaluation modules for the tourism industry are shown in figure below, with the functions and theoretical basis illustrated as follows:

A. Stochastic Event Module

The rainfall event estimation module mainly uses historical data for rainfall triggered floods in Taiwan, including: rainfall amount, rainfall duration, rainfall pattern and atmospheric information, to estimate the scale of the possible future rainfall

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events and the probability of future flood events. The patterns of rainfall in Taiwan can roughly be divided into: typhoon rain, plum rains, warm front, cold front, stationary front, northeast monsoon, and thunder showers. For Taiwan, the primary possible rainfalls include: typhoon rain, plum rains and afternoon thunder showers. Generally flood events can be expressed as follows.

TABLE II
RAINFALL EVENT ILLUSTRATION

Event code	Rainfall pattern	Rainfall duration (hr)	Rainfall amount (mm/hr)	Annual occurrence rate
1	v_1	w_1	z_1	λ_1
2	v_2	w_2	z_2	λ_2
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
m	v_m	w_m	z_m	λ_m
n	v_n	w_n	z_n	λ_n

B. Hazard Module

This module plans to use the flooding disaster potentiality data provided by the National Science Council [2], and the flooding potentiality data updated regularly by the Water Resources Agency to simulate the accumulated rainfall within 24 hrs and the flooding depth of the flooded area of each basin when the accumulated rainfall reaches 150mm, 300mm, 450mm and 600mm. Then output is the maximum flooding depth of the basin and can be sued to estimate the flooding disaster losses for each basin. Fig. 1 shows the basin flooding depth sketch provided by the Taiwan National Science Council.

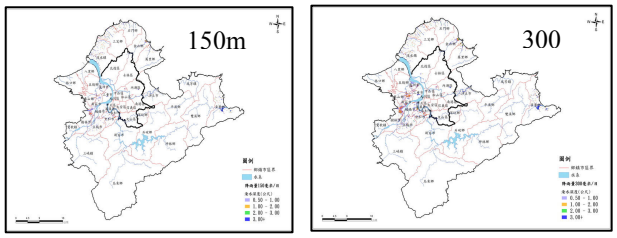


Fig. 1 Sketch of the basin flooding depth due to accumulated rainfall

C. Financial Analysis Module

The financial analysis module is used to estimate the possible economic losses caused by flood events according to the risk analysis results and to establish loss probability distribution curves to be used to calculate insurance loss under different insurance conditions, such as earthquake loss, as well as further give suggestions for flood disaster insurance premiums for buildings. In the face of catastrophe risk, the loss exceedance probability curve provides an integrated framework, plus risk evaluation and risk management strategy, for the arrangement of subsequent insurance rates and related hedging strategies [3].

III. CASE ANALYSIS

A. Case Study

Nearly 90% of the typhoons that make landfall in Taiwan approach from Hualien located on the east of the island. In order to understand the influence of typhoon and flood disasters on the tourism industry, this study has carried out typhoon and flood disaster risk analysis on 110 hotels in the Hualien region. The goal is to understand the influence of extreme torrential rainfall events, and thereby propose feasible typhoon and flood disaster risk management strategies for the tourism industry. The distribution of the hotels in Hualien region is shown in the figure below.

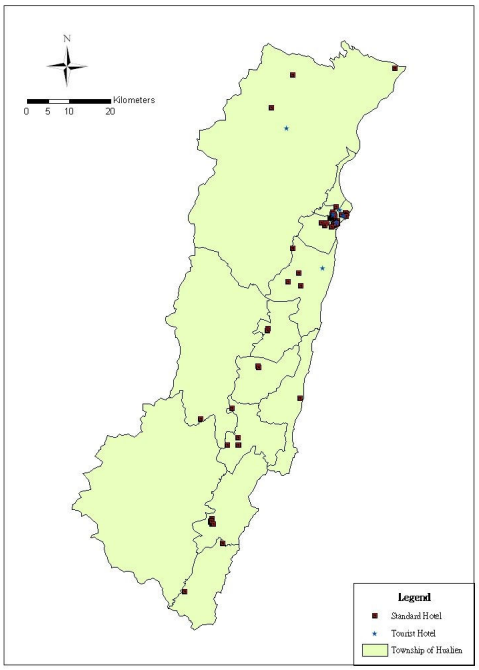


Fig. 2 Distribution map of legal hotels in Hualien region

B. Analysis Resultl

Analysis is carried out to understand the financial losses caused by typhoons to the hotel industry in Hualien County. Two typhoons: Nari (2001) and Sinlaku (2009) are selected for specific event evaluation. They are divided into three situations in order to understand possible typhoon and flood losses under different situations, as follows:

Situation 1: no deductible

Situation 2: deductible: 10%; upper limit of indemnity: 50%; business interruption: 24 days

Situation 3: deductible: 20%; upper limit of indemnity: 50%; business interruption: 24 days

From the results of analysis with the typhoon and flood risk evaluation model established in this study, it can be seen, as shown in Table IV, that Typhoon Sinlaku caused the greatest damage, with a loss ratio of 0.0480%; Typhoon Nari had the smallest influence, with a loss ratio of 0.0477% under Situation 1 and 0.0144% under Situation 3. The analysis results also show

that hotel operators in the region adjoining the Meilun River or Hualien River are subject to certain flooding disaster potentiality and losses.

TABLE III
POSSIBLE INSURANCE LOSSES FOR SPECIFIC TYPHOON AND FLOOD EVENTS UNDER DIFFERENT SITUATIONS

Event	Situation 1		Situation 2		Situation 3	
	Loss (USD)	Loss ratio	Loss (USD)	Loss ratio	Loss (USD)	Loss ratio
Nari	90,339	0.0477%	34,406	0.0182%	27,192	0.0144%
Sinlaku	91,027	0.0480%	34,780	0.0184%	27,489	0.0145%

In the typhoon and flood risk evaluation model there are 244 events, with losses displayed as loss-exceedance probability or loss-return period curves. The estimation results can act as the basis for evaluation of PML (possible maximum loss). Based on the estimated AAL (average annual loss) and standard deviation, we can further estimate reasonable insurance premiums under different situations (different insurance conditions) to provide as reference for insurance requirements for the relevant industries. Only the net insurance premium is considered here, not the actual insurance premium after being adjusted by the insurer according to the market mechanisms.

C. Typhoon and Flood Risk Management Strategy

The damage caused by typhoons to the hotel industry can be mainly divided into wind damage and water damage: the former mainly refers to damage to hotels and their ancillary facilities by strong winds; the latter refers to damage to building facilities, interior decorations and property due to flooding of the hotel buildings. Beyond this, concentrated torrential rainfall can also often result in landslides and rock-falls and, consequently, sightseeing road traffic disruption, plus the direct or indirect losses from booking cancellation due to the changes in the sightseeing impression, which can also inflict severe loss on the hotel industry [4], [5]. Some specific strategies are summarized in Table IV.

TABLE IV
SUGGESTIONS FOR NATURAL DISASTER RISK MANAGEMENT STRATEGIES FOR HOTELS IN THE HUALIEN REGION

Disaster risk	Suggested measures
Typhoon and flood disaster risk	1. Establish a system of staff shifts on duty and flexible assignments in case of typhoon or heavy rainfall. 2. Establish a disaster reserve fund of over 100,000 USD. 3. Reduce decorations in the entrance hall on the ground floor. 4. Establish a joint insurance mechanism through the Hotel Trade Association of Hualien County (compared with the Tourist Coach Trade Association).

IV. CONCLUSIONS

In this paper, we establishes a typhoon and flood disaster risk and loss evaluation model specific to Taiwan's tourism industry. The probability disaster risk evaluation method commonly used at home and abroad is used. The relevant outcomes and estimation modules are expected to further provide reference for the planning.

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