Modelling and Simulation of Adaptation Measures for Flood Events on Land Use and Transportation Fields: The Case of Khon Kaen Area, Thailand

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Introduction: Extreme weather changes due to global warming have been bringing about unexpected natural disasters. To tackle these problems, mitigation policies are being implemented all over the world. For example, the international community has recognized the need to reduce greenhouse gas (GHG) emissions by 50% by 2050 to keep global mean temperature change within 2-degree centigrade compared to pre-industrial times. However, in recent years, occurrences such as floods, sea-level rise, etc. have increased in many parts of the world, and it is impossible to avoid the damage before any effect of mitigation measures is seen. Especially, in developing cities, the policies for flood occurrences lack proper validation. Thus, it is imperative to be specified clearly urban activities which are affected by the application of adaptation policies for the problem related to flooding. On the other hand, in many existing studies, impacts of adaptation policies have not been evaluated dynamically by the integration between urban activities and flood events. Therefore, this study focused on the relationship between urban activities and flood events and simulated changing urban activities with the adaptation measures dynamically when the floods occur. As a case study, this model was applied in the area of Khon Kaen in Thailand and the impacts of proposed scenarios were estimated.

Methodology: In this study, we designed the model by adding Flood Events Model to existing urban model which mainly consists of Transport Model and Land Use Model (Residential and Workplace Locations). Figure 1 shows the main structure of the proposed model. Through interactions between sub-models, the impact of flood will be fed back to the activities in the city such as modal choice, route choice, locational choice, etc. The Transport Model affects Land Use Models by Accessibility link. In contrast, the Land Use Models affect the Transport Model by Spatial Distribution links. Additionally, in this study, the Flood Events Model is added to represent the impacts to urban activities. In this model, the influence of the flood generated stochastically in the Flood Events Model becomes the inputs of the Transport Model and influences travel behavior, and then this change on travel behavior becomes the inputs of the Land Use Model and influences the relocation choice behavior. Also, this model runs for 20 years from 2010 to 2030 with adaptation measures for the flood events.

Metropolitan Activity Relocation Simulator (MARS) which is a one of land use and transport model developed by Pfaffenbichler (2003) is used to simulate urban activities such as movement of people and transportation in the city. The MARS is an approach for better understanding land use and transport interaction based on the principles of system dynamics and synergetic. Also, this model is a one of the dynamic Land Use and Transport Integrated model as an urban model. The MARS includes a transport model which simulates the travel behavior of the population related to their housing and workplace location, a housing development model, a household location choice model, a workplace development model, a workplace location choice model.

At next, the structure of the flooding model is shown in Figure 2. Although this model easily consists of the stock diagram, flow variables and auxiliary variable, the probability of flood events can be calculated by using a Random function in Vensim® software. Moreover, in order to calculate its probability, this model is possible to take into account a frequency of flooding events based on statistical data in the past.

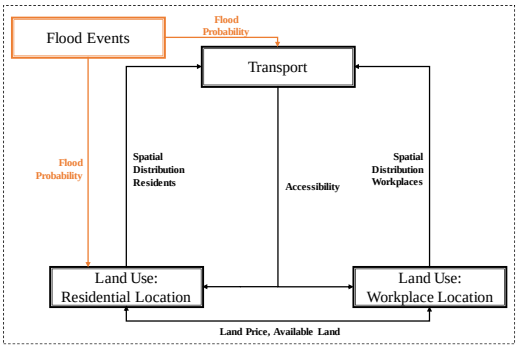

Figure 1 Conceptual model and its relationships

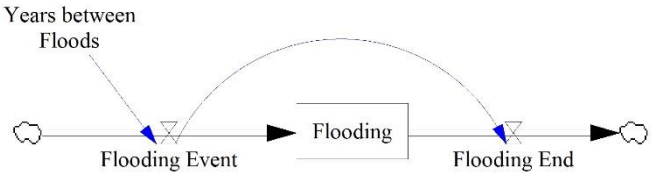

Figure 2 Construction detail of Flood Events Model

Results: In this study, two scenarios were prepared to implement adaptation measures which are the elevation of major arterial roads in flooded zones scenario and Do-Nothing scenario as shown in Table 1.

Table 1 Summary of scenarios

Scenario	Measure	Detail
A	Flood Occurrences: **Without** adaptation measure	**Not** implemented adaptation measure.
B	Flood Occurrences: **With** adaptation measure	Implemented adaptation measure of elevation of major arterial roads.

As following Figure 4, the result of the sensitivity analysis for total VKT of cars with the flood adaptation measure is shown. That has a trend to increase every year, however, when floods occur, it is decreased in the short term. The reason is that usage of cars is decreasing due to many road networks at flooded area are closed to traffic when the areas are inundated. In addition, the impact of the implementation of adaptation measure to benefit from travel time reduction was calculated. As the result, the following Figure 5 shows the accumulated benefit from travel time reduction every year. Total benefit from travel time reduction is estimated at 2,634 million THB for 20 years.

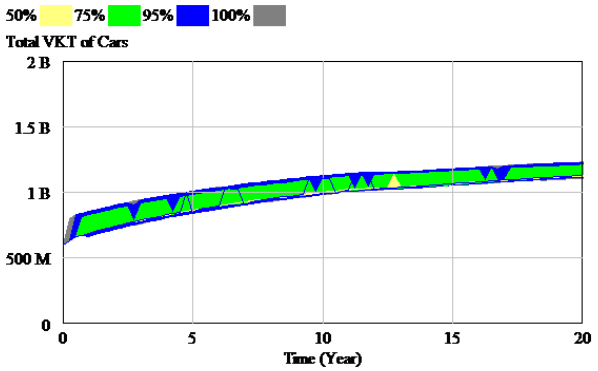

Figure 4 Total VKT in Flood Adaptation scenario

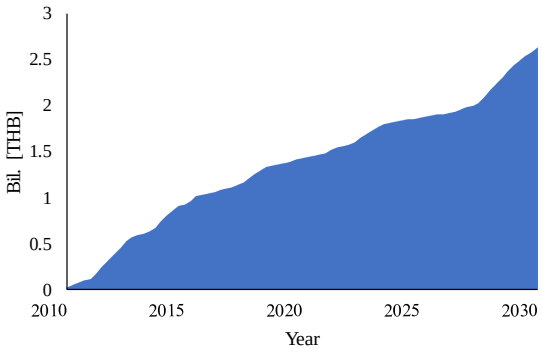

Figure 5 Benefit from travel time reduction

Conclusion and discussion: In this study, the impacts of implementing adaptation measure for the transportation field in the flood occurrences were simulated by modifying the MARS model for 20 years. As the result of the simulation, VKT of cars tends to increase every year because the number of cars goes on increasing year after year. However, total VKT did not have a significant difference between both scenarios. The reason is that cars which departed from some zones attempt to run to the destination in the shortest travel time regardless of the travel distance while avoiding inundated roads. Hence, the effect of implementation of adaptation policy has been shown indisputably as the benefit from travel time reduction. Finally, it is concluded that the adaptation measure will contribute to mitigating the flood damages in the transportation field.

References

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