VULNERABILITY TO FLOOD IN THE VIETNAMESE MEKONG DELTA: MAPPING AND UNCERTAINTY ASSESSMENT

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Introduction
The Vietnamese Mekong Delta (VMD) is located at the end of the Mekong River (Figure 1) which is one of the 10th largest rivers in the world. It plays an important role, especially in terms of food security for not only Vietnam but also the world. However, the VMD is heavily impacted by the annual flood and even stronger after different projected climate change scenarios; particularly it is estimated the most vulnerable delta in the world. Besides, flood patterns would be changed due to climate change and sea level rise so flood hazards and flood risks also change. Therefore, the objectives of the study were:
(1) To identify priority areas for flood adaptation and mitigation,
(2) To provide an insight to local governments in the VMD in changes of future flood.

Methodology
1. Hazard
In the future, there would be projected sea level rise (promises up to 30cm for the both East and West sea with reference to that in 2000 [monetary BI]). In addition, there would be less renovation projects for the water drainage in Delta, Cambodia, developed by Mekong River Commission; Scenario 1: Underground projects according to the expected regional climate model without any governance in the Upper Mekong Basin; Scenario 2: Underground projects as in Scenario 1 but with the development of the Upper Mekong Basin after 2050. The results from the model were used to create flood hazard maps. There were many variables to define flood hazards, including flood depth, flood velocity, flood frequency, flood inundation, etc. However, flood depth is the most important variable. In addition, due to the limitations of the 1D model, the resulting inundation results were not used (e.g., flood velocity, flood frequency, flood inundation). These models, therefore, were closer to using only flood depth (in meters).

2. Vulnerability
Flood vulnerability was assessed using Coastal City Flood Vulnerability Index (CCFVI), with developing based on exposure, susceptibility and resilience to flood. The data were collected via available resources through the internet, their data of each indicator was summarized. Depending on positive or negative effect to vulnerability index, were used Equation 3.

\[ V_{index} = \frac{E}{x \cdot S + R} \]

The standardized results of all indicators would be multiplied with weight of each indicator which depends on their importance to vulnerability in the VMD. The CCFVI was calculated by Equation 4.

\[ CCFVI = E + S + R \]

3. Risk
Flood risks were identified depending on hazard and vulnerability values (presented in Equation 4).

\[ PRC = V_{index} \]

4. Uncertainty
In the study, measurement of vulnerability uncertainty was done by using weight of indicators as an estimated parameter. The values of weight would be changed in range of weight ±1. After that vulnerability values were identified based on changed weights.

Results
1. Hazard maps
Comparing to hazard map of the 2000-flood, hazard areas would increase about 4.82% and 2.59% in scenario 1 and scenario 2, respectively (Figure 2). There were insignificant increases of hazard in the future. However, high hazard would concentrated the coastal areas of the East sea where are rarely impacted by the annual flood.

2. Vulnerability
The provinces in the coastal areas along the East sea had higher vulnerabilities than other provinces due to sea level rise, long coastal line and storm surge. On the other hand, An Giang and Dong Thap had great experience for adaptation to flood so they got low vulnerabilities (Figure 3).

3. Risk
In the future, risk areas would concentrate in the upstream of the VMD, along the Mekong and Bassac River due to annual flood while Tra Vinh province in the coastal area of the East sea due to sea level rise (Figure 4).

4. Uncertainty
Although there were changes of the vulnerability index (Figure 5), provinces along the coast of the East sea also would be the most vulnerable areas.