

(Format No. 13)

SUMMARY OF DOCTORAL THESIS

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Title: Flood Risk Assessment and Community Resilience to Flood Disaster: A Case Study of Da Nang City, Central Vietnam

(洪水リスク評価と水害に対するコミュニティレジリエンスに関する研究 - 中部ヴェトナム, ダナン市における事例 -)

Floods are by far the most hazardous, frequent and widespread natural hazards in the world caused hundreds of thousands of deaths, loss of livelihoods and infrastructure, interruptions of economic developments and the loss of property worth billions of dollars. Better understanding on floods risk and the potential consequences is crucial for the development of flood control policies as well as flood risk management strategies. High concerns in flood risk is paid on the frequency and intensity of floods, the urbanization led to high expose of humans and assets to flood risk, the vulnerability and their susceptibility to suffer damage and recently the building resilience community to flood disaster. This dissertation addressed the flood risk in relation to urbanization and examined the dimensions that affect community resilience to flood disaster. The study conducted flood risk assessment in Da Nang city and analyzed the relation between flood risk and urbanization during past 20 years (1990 to 2010). And then it focused on 4 villages in the rural district to identify how different of community resilience in the context of socio-economic conditions, historical flood disaster and the policies of the local authorities. The studies combined quantitative and qualitative methods including remote sensing and GIS techniques, statistical analysis and questionnaire surveys to obtain the objectives of study. The focus of *the first chapter* is to provide the background, objectives and brief statement of the methodology used in the whole dissertation.

The study in *chapter 2* focuses on the theoretical and conceptual framework that used in the research. We selected the suitable definition of risk and the related concepts (hazard, vulnerability and resilience) in context of flood risk management. In this dissertation research, we approved the risk definition given by United Nation International Strategy Disaster Reduction (2004) in which, flood risk is a product of hazard and vulnerability and was represented as a formula: Risk=Hazard x Vulnerability. Community Resilience to flood disaster is also taking into account due to

its effective way for community preparedness, awareness, coping and recovery from hazards and disaster. We adopted the community assessment framework given by Wilson (2012) as its conceptual basic for assessment community since it applies to natural disasters, particular flood disasters. The model presented the interaction between three pillars of resilience including economic capital, social capital and environmental capital.

In *chapter 3*, I describe the background of study area of Da Nang city including characteristics of physical geography, socio-economic profile, and urbanization history and flood disasters during last 20 years. The study reveals that Da Nang city is a coastal city and high exposes to severe consequences of natural disasters. During last 10 years, Da Nang suffered from some severe natural disasters in 1964, 1999, 2006, 2007, 2009 and 2011 caused damage to life, houses, infrastructure, and agriculture products. In recent years, urbanization has taken place rapidly in Da Nang city. The coastal and central areas of Da Nang city witness a high rate of urbanization may face risk of flooding and environmental degradation especially during the rainy season.

In *chapter 4*, firstly I attempt to develop a method for flood risk assessment based on remote sensing and GIS techniques. Flood risk was obtained by evaluating the flood hazard and demographic vulnerability with a ranking matrix in two-dimensional multiplication model. The achievement of this analysis is the potential flood hazard was successfully derived by integrating the inundation extracting from ALOS PALSAR and flow direction extracting from ASTER GDEM. This method is effective when hydrological and meteorological data are inadequate and the remote sensing images taken during flood times are not available or insufficient. Secondly, we attempt to identify where exposed to high flood risks are during 20 years in Da Nang city. Time series Landsat TM/ETM+ images and multi seasonal ALOS images were analyzed to generate temporal land use/cover maps (for 1990, 2001, 2007 and 2010), which was then utilized to analyze the urban expansion process. During 20 years, Da Nang city experienced a high rate of urbanization, the approximate rate of increased built-up in the area was 220%. The main directions of urbanization are seen in the West, Northwest, South and Southeast and long the coastal line. By overlaying expanded urban/settlement expansion during 20 years (from 1990 to 2010) with those extracted flood risk areas, the rate of settlement exposure to flood risk was clarified. The result shows that some of urbanization has clearly invaded into the higher risk areas of flood. The potential risk revealed by such urban/settlement expansion into the relatively high flood risk areas increased from 1.9 to 3.5% (nearly twofold) in the urbanization periods of 1990-2001 and 2007-2010, respectively.

My analysis of *chapter 5* is to assess the resilience of the rural communities to flood disaster. The community resilience assessment was conducted based on typology

technique and questionnaire surveys. Flood affected villages typology was constructed by using two multivariate statistical techniques, respectively Principle Component Analysis (PCA) and Cluster Analysis (CA). The use of typology in zoning flood affected villages as a background for community resilience assessment is an effective and novel approach to flood disaster related in Vietnam. Household questionnaires were carried out by the authors with the assistance of Hoa Vang Statistical Office's staffs including face to face interview with the respondent's household and capturing the location and image of household by GPS camera/handheld GPS device. A total of 300 households were administered in four plot site villages of Hoa Vang rural district, Da Nang city by using simplified sample formula of Yamane (1967). The application of the 47 indicators of community resilience to the case study of Tay An, Cam Ne, Tuy Loan Dong 2, Hoi Phuoc villages showed that those indicators are applicable, duplicable, and effective for better describe how resilience of community to flood disaster in the study area sites. The linking typology potential vulnerability flood affected villages and capital-based approach in community resilience measurement (including economic capital, socio capital and environmental capital) has showed an effective and unique methodology/conceptual framework for representing and assessment community resilience to flood disaster. The findings of this study showed that various types of resilience community were found for each target village. Based on those differences, some solutions, recommendations can provide for the authorities to base their policy decisions for the enhancement of community resilience as well as meet the objectives of the new rural development program in the face of flood disaster and other climate related disasters.

In *the final chapter*, some main research findings are given: (i) The integrating of ALOS PALSAR and ASTER GDEM in mapping potential flood hazards shows effective contributing to flood risk assessment (ii) urban expansion in Da Nang city has been increasing in the present study area into regions where settlements are subject to significant flood risk during past 20 years (iii) the use of regional typology technique in zoning flood affected villages has demonstrated the interaction between differential socio-economic conditions and spatial distribution of flood affected villages in term of potential vulnerability that have providing background for community resilience assessment (iv) linking typology potential vulnerability flood affected villages and capital-based approach in community resilience measurement (including economic capital, socio capital and environmental capital) has showed an effective and unique methodology/conceptual framework for representing and assessing community resilience to flood disaster.

Key words: Flood Risk, Urban Expansion, Community Resilience, Vulnerability, Regional Typology, Da Nang city, Vietnam