

論文 / 著書情報
Article / Book Information

論題	Investigation of Awareness of Typhoon and Storm Surge in the Mekong Delta – Recollection of 1997 Typhoon Linda
Title	Investigation of Awareness of Typhoon and Storm Surge in the Mekong Delta – Recollection of 1997 Typhoon Linda
著者	Anh L. T., Takagi H., Thao N. D., Esteban M.
Authors	Le Tuan ANH, Hiroshi TAKAGI, Nguyen Danh THAO, Miguel ESTEBAN
出典	土木学会論文集B3 (海洋開発) , Vol. 73, No. 2, p. I 168-I 173
Citation	Journal of Japan Society of Civil Engineers, Ser. B3 (Ocean Engineering), Vol. 73, No. 2, p. I 168-I 173
発行日 / Pub. date	2017,
権利情報 / Copyright	本著作物の著作権は土木学会に帰属します。 (c) 2017 Japan Society of Civil Engineers.

Investigation of Awareness of Typhoon and Storm Surge in the Mekong Delta – Recollection of 1997 Typhoon Linda

Le Tuan ANH¹, Hiroshi TAKAGI², Nguyen Danh THAO³, Miguel ESTEBAN⁴

¹School of Environment and Society, Tokyo Institute of Technology
(2-12-1 Ookayama, Meguro-ku, Tokyo 152-8550, Japan)
E-mail: letuananh.aa@m.titech.ac.jp

²Member of JSCE, Associate Professor, School of Environment and Society, Tokyo Institute of Technology
(2-12-1 Ookayama, Meguro-ku, Tokyo 152-8550, Japan)
E-mail: takagi@ide.titech.ac.jp

³Associate Professor, Department of Port and Coastal Engineering, Ho Chi Minh City University of Technology
(268 Ly Thuong Kiet St., Dist.10, Ho Chi Minh City, Vietnam)
E-mail: ndthao@hcmut.edu.vn

⁴Associate Professor, Graduate School of Frontier Sciences, The University of Tokyo
(5-1-5 Kashiwanoha, Kashiwa City, Chiba 277-8563, Japan)
E-mail: esteban.fagan@gmail.com

Typhoon and storm surge are considered the biggest hazards that threaten coastal communities in Vietnam. The possibility of a large typhoon taking place in Southern Vietnam is considerably smaller than in the northern and central parts of the country. However, this does not necessarily mean that Southern Vietnam is less vulnerable against typhoons. In this paper the authors tried to analyze typhoon track data during the last six decades to analyze how frequently typhoons made landfall on southern coast, particularly focusing on the Mekong Delta. The analysis reveals that the chance of typhoons making landfall is not negligible, although the frequency is substantially lower than that in Northern or Central Vietnam. A questionnaire survey was also carried out to investigate disaster awareness amongst local inhabitants in the Mekong Delta. To do this, the authors visited many small coastal towns and the regional capital, Can Tho city, whose population is well over 1.2 million. The events of the worst storm in recent times, severe tropical storm Linda in late October 1997, which claimed more than 3,000 lives and caused severe damage in the delta and the remote islands, were also investigated by conducting interviews with local people who directly experienced the typhoon. The key objective of this paper is thus to understand the awareness and concern about typhoons and storm surges in the delta. The results show that the local population tend to have a high degree of awareness about the dangers posed by those events, contrary to the authors' original hypothesis. However, it is also noticeable that it is necessary to improve preparedness against coastal disasters in Vietnam, especially in term of the education of the younger generation, and the elaboration of a mitigation plan.

Key Words : Vietnam, typhoon, storm surge, Mekong Delta, awareness, 1997 Typhoon Linda

1. INTRODUCTION

The climate in Vietnam is characterized by the tropical monsoons, dividing the country into 3 geographical areas, namely the northern, central and southern regions. The white sandy beaches are found in Nha Trang and Phan Thiet, while muddy coastlines are predominant in the Southern part of Vietnam, around the Mekong Delta. The delta is very flat and low with an average elevation of only about 1 m above mean sea level¹⁾. The region is extremely

vulnerable to the influence of sea-level rise, flood, and typhoon storm surges²⁾.

The maximum storm surge offshore the Red River Delta that located in the Northern part can be 1 to 1.5 m above mean sea level, but as the surge progresses towards the coast it typically grows higher³⁾. The possibility of a large typhoon taking place in Southern Vietnam is considerably smaller than in the northern and central parts of the country, though this does not necessarily mean that Southern Vietnam is less vulnerable against typhoons.

In fact storm surges can be considered to pose the

greatest risk to low-lying coastal areas of the Mekong Delta, whereas fluvial and pluvial flood events appear to be more predominant in the upper part of the delta, close to the Cambodian border⁴⁾.

For example, Typhoon Linda (meteorologically, categorized as severe tropical storm) formed in late October 1997 in the East Sea of Vietnam, eventually causing extensive damage to coastal areas in the south end of Vietnam, as many fishermen and sailors were caught at sea in the path of the storm and were unable to escape it⁵⁾. Linda is considered to be the worst storm to have hit the Southern part of Vietnam in the past several decades, and resulted in 3,111 people being killed, and the total damage was estimated at \$385 million (USD). The flooding caused by Linda damaged or destroyed about 200,000 houses and left about 383,000 people homeless. Though the storm surge during the passage of Linda has not been sufficiently investigated, it could have reached about 0.7m, excluding wave-setup, near the mouth of Hau River (Bassac River), one of the distributaries of Mekong River (**Table 1**)⁶⁾.

In the present paper the authors tried to make an assessment of the state of awareness and preparedness of the population of the delta against typhoon and storm surges. In order to attempt such an analysis, the authors analyzed typhoon tracks in the last six decades and also conducted field surveys and interviewed a variety of local residents and officials in the Mekong Delta. The extent of storm surge caused by Typhoon Linda was also investigated by interviewing those who had direct experience of it. The results show that it is important to improve disaster awareness education and also put in place feasible prevention measures to mitigate the damage caused by future typhoon storm surges.

Table 1 Estimated storm surges at the river mouth of the Mekong River

Station	Tilda 1954	Lucy 1962	Thelma 1973	Linda 1997	Muifa 2004
Mekong River Mouth	0.05m	0.30m	0.09m	0.70m	0.39m

2. TYPHOON TRACK ANALYSIS

The authors used the so-called Typhoon Best Track Data, obtained from Joint Typhoon Warning Center (JTWC) to analyze the typhoon tracks between 1951 and 2010 around the East Sea of Vietnam. The data consists of time, geographical position of the storm center, minimum sea level pressure at the storm center and the maximum sustained wind speed in knots. To explore the occurrence of tropical cyclones approaching the

coasts of Vietnam in more detail, the authors used a numerical code for detecting the point of landfalls, defined as the place where a tropical cyclone track intersects with the coastline⁷⁾. **Fig. 1** was created to try to analyze in detail both the temporal and spatial patterns of tropical cyclone landfall along the entire Vietnamese coastline. **Table 2** shows the number of typhoons that passed through Vietnam's coasts in the last six decades. Each tropical cyclone was categorized into three latitude zones (North: N21.5°-18°, Center: N18°-14° and South: N14°-9.5°) according to the point when it made landfall in order to attempt to identify any trends over time.

It appears that tropical cyclones have made landfall even in the southernmost part of Vietnam, Mekong Delta, although the chance of landfall is substantially smaller than in the northern or central coasts. Based on these analyses, it is obvious that tropical cyclones in the Mekong Delta is not negligible when planning future disaster management strategies.

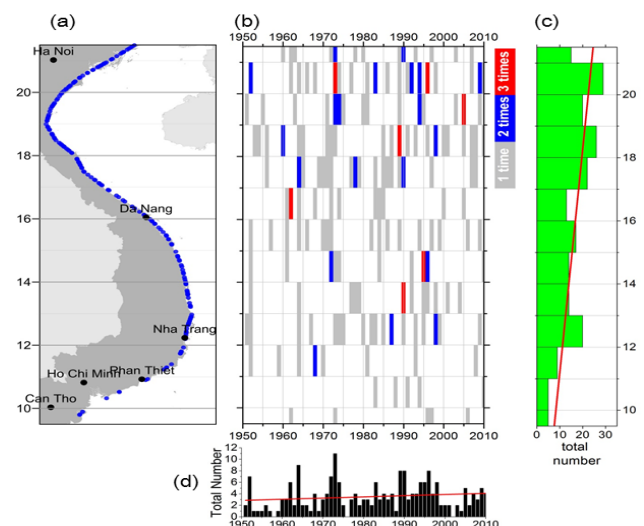


Fig.1 (a) Landfall points along Vietnamese coast between 1951 and 2010, (b) Annual frequency of landfalls for each one degree segment of the coastline, (c) Total number of landfalls for each one degree segment of the coastline between 1951 and 2010, and (d) Annual total number of tropical cyclones making landfall Vietnam between 1951 and 2010

Table 2 Number of tropical cyclones that made landfall along the coasts of Vietnam, categorized into 3 latitude zones, for the 6 decades between 1951 and 2010

Zone	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	Total
North (21.5°-18°)	10 (53%)	9 (27%)	20 (48%)	15 (36%)	20 (45%)	16 (57%)	90 (43%)
Center (18°-14°)	4 (21%)	16 (49%)	14 (33%)	15 (36%)	11 (24%)	6 (22%)	66 (32%)
South (14°-9.5°)	5 (26%)	8 (24%)	8 (19%)	12 (28%)	14 (31%)	6 (21%)	53 (25%)
Total Number	19	33	42	42	45	28	209

3. INTERVIEW SURVEY

A series of field surveys were conducted over the last 3 years along the small coastal towns of the Mekong Delta and its regional capital, Can Tho city, located along the bank of Hau river (**Fig. 2**). The purpose of the survey was twofold: (1) identifying the damage caused by past typhoons and (2) understanding disaster awareness of the inhabitants. To do so, a structured questionnaire survey was distributed to individuals encountered on an opportunistic basis (**Fig. 3**), focusing on awareness and past damage during typhoon and storm surges.

As a result, a total of 172 valid questionnaire responses were obtained ($n=172$). The majority of respondents were over the age of 40, which could be considered to be part of the generation that have more experience and memory about previous disasters, as opposed to the younger groups (**Fig. 4**). Fishermen and farmers, who have directly suffered damage by disasters, occupied 6% and 18% of the sample, respectively. **Fig. 5** also shows how self-employed, housewives and laborer constituted other major occupational groups (12%, 9%, and 9%, respectively).

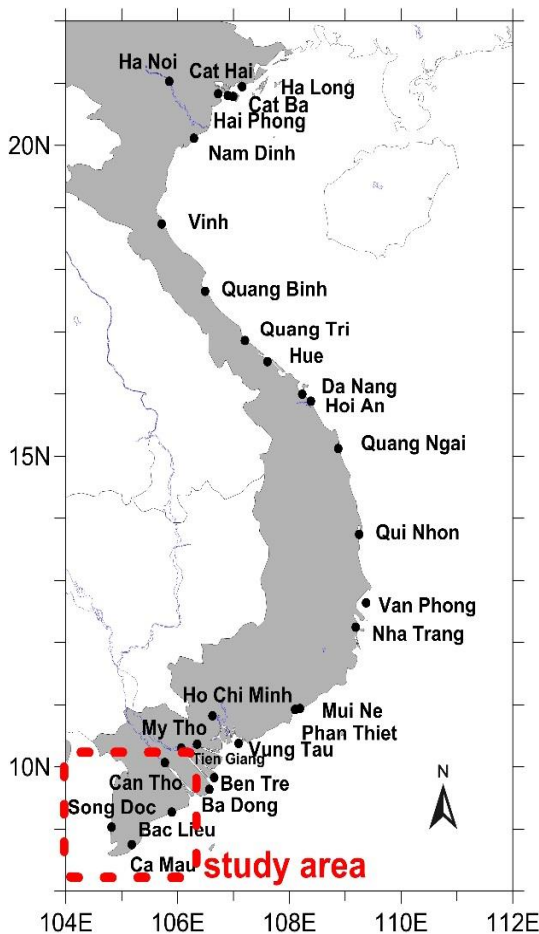


Fig. 2 Location of surveyed areas in Vietnam



Fig. 3 Interview with local people in Can Tho city

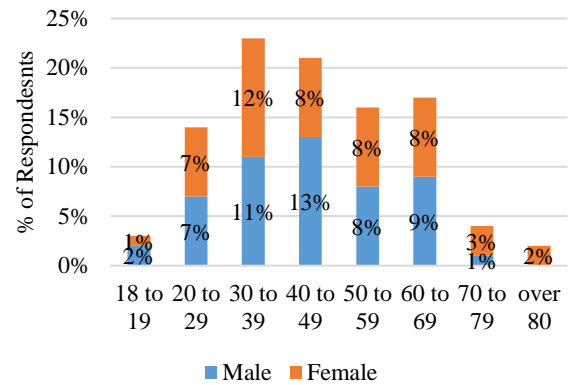


Fig. 4 Age distribution of respondents ($n=172$)

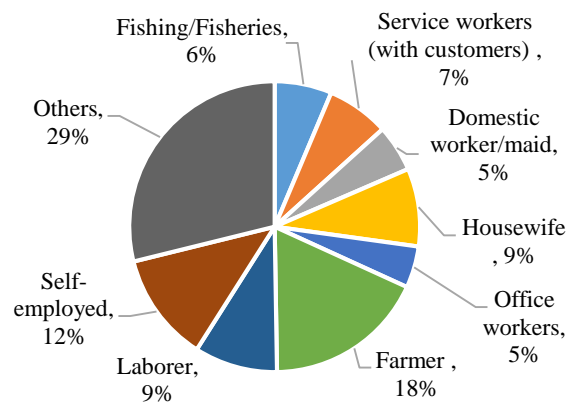


Fig. 5 Occupation of respondents ($n=172$)

4. TYPHOON LINDA IN 1997

Regarding the damage suffered from previous disasters, 63% of respondents reported that they had experienced some sort of damage (**Fig. 6**). Furthermore, respondents typically indicated that the disaster which caused the most damage was Typhoon Linda, which made landfall in the area at the beginning of November 1997. A moderate storm surge, approximately 1 m high, was generated by this typhoon in Ca Mau, according to a local resident (**Fig. 7**). This agrees well with the results of numerical simulations, which indicate a storm surge

height of around 0.7 m at the mouth of the Mekong River⁶⁾ (**Table 1**).

Aside from the questionnaire on disaster awareness, the authors also conducted a separate more limited survey on the damage caused by Typhoon Linda, amongst 102 residents in Can Tho city (n=102). **Fig. 8** shows that Linda caused strong winds (classified as either of moderate or stronger by 86% of respondents, who indicated that it could knock trees down) in Can Tho city, even though it is located about 170 km away from the place where the typhoon made landfall. It was also clearly recognized that places near the river bank suffered stronger winds than that inland parts of the city. The insufficient structural strength of the houses meant that many roofs were blown away, which was the most common type of damage in Can Tho (50%) (**Fig. 9**). Strong wind in combination with heavy rain also caused flooding in places adjacent to the river bank, while there were no noticeable damage recorded in the higher areas and further inland.

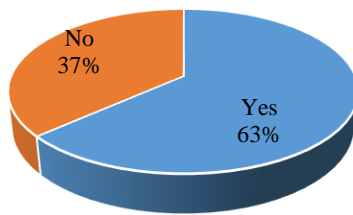


Fig. 6 Distribution of people have experienced damage from previous disasters (n= 172)



Fig. 7 Surge height, as indicated by a local resident who remembered Typhoon Linda

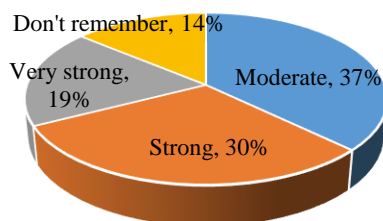


Fig. 8 Wind speed during typhoon Linda in Can Tho city (n=102)

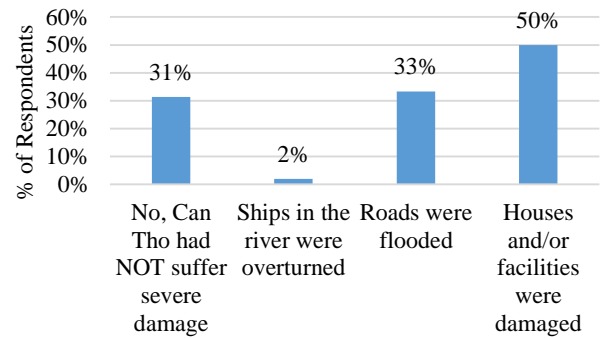


Fig. 9 Damage in Can Tho city during Typhoon Linda 1997 (n=102)

5. PEOPLE'S AWARENESS

In terms of awareness, over half of respondents (55%) understood the nature of storm surges (**Fig. 10**), with the great majority (59%) believing that they represented a moderate or high danger to them (**Fig. 11**). This result shows that local people has a high degree of knowledge regarding storm surges, this contrasts to their less experience about such event due to low frequency. The reason for this could explained by the fact that the low elevation and flat nature which characterizes coastal areas can substantially increase the vulnerability of local communities to storm surge, even if surge heights are relatively small. Thus, a given storm surge height that would not cause great inundation in Central or Northern parts of the country could devastate coastal settlement in the Mekong Delta⁶⁾.

Furthermore, Category 5 super typhoon Haiyan in 2013 could be considered as a defining event in raising awareness about storm surges, not only in the Philippines but within the entire world including Vietnam⁸⁾. On the other hand, this 59% appears similar to the 63% of people who have experienced damage from previous disasters. This means that in the Mekong Delta local resident tend to know about the disasters only when they have observed or suffered damage from those events. That explains for the fact that most interviewee with higher awareness are at the age over 40 (**Fig. 11**).

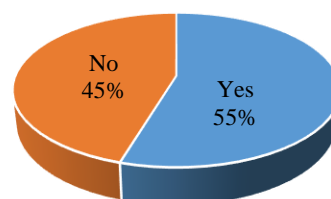


Fig. 10 Distribution of respondents who were aware of the nature of storm surges in Mekong Delta (n= 172)

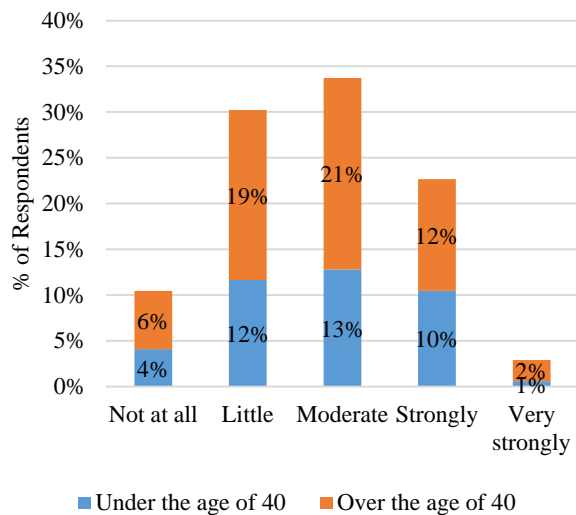


Fig. 11 Distribution of respondents who think that a storm surge constitutes a real danger for them in Mekong Delta ($n=172$)

Despite the relatively high awareness about storm surge, the preparedness in Mekong Delta seems to be not adequate with the potential risk posed by such an event. Just over one-fifth of people (21%) said that they had taken part in evacuation drills in the last 5 years (**Fig. 12**), thus the majority of respondents (62%) indicated that they do not know how to evacuate when a typhoon disaster event happens (**Fig. 13**). Furthermore, when asking local people in Can Tho city what they did during typhoon Linda, many answered that they were working and keep working. Essentially, it appears that they underestimated the danger from the typhoon. In addition, there are still a number of people living by the coastline or along the river bank, who would directly face the storm surge and little time for evacuation unless an effective early warning system is put in place (**Fig. 14**).

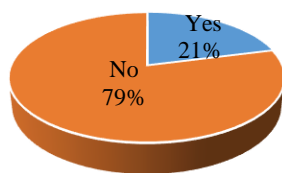


Fig. 12 Distribution of respondents regarding whether they have taken part in evacuation drills in the last 5 years ($n=172$)

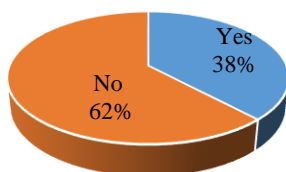


Fig. 13 Distribution of people who know how to evacuate in the event of a typhoon / storm surge ($n=172$)



Fig. 14 Houses near water in Ca Mau (left) and Can Tho (right)

6. DISCUSSION ON DISASTER RISK AWARENESS IMPROVEMENT

Many researchers have shown how typhoons can be considered a great threat to Vietnam^{6,9}. The authors also found out through their field surveys that sometimes local people even ignored the threats posed by natural hazards (10% of respondents, according to **Fig. 11**). Those who do not know how to evacuate when disasters happen (62%) (**Fig. 13**) could drown due to the storm surge as a result of placing themselves in high-risk situations. The high population density and low-lying estuarine nature of the delta is also considered a disadvantage for people to try to find safe places to evacuate, especially those who have not ever taken part in evacuation drills. The number of people exposed to storm surges is also increasing due to the rapid growth of population around hazardous areas in the coastal zone of Mekong Delta. Thus, raising awareness among local inhabitants is the most urgent thing that needs to be considered in the disaster management plan.

Fig. 15 shows that only 19% of respondents assumed disaster issues were taught at school, while around 26% of people did not know and 55% said that this was not taught. This can offer some insight into why the younger generation might be less aware about disasters, given that many were probably not taught about them in school, and were too young to have experienced this during their lives. Typically, the level of disaster awareness in a country changes throughout time, with awareness being reinforced by recent events. However, after a given event awareness gradually fades in time unless appropriate educational efforts are made¹⁰. In order to raise awareness of children, it is necessary to enhance education and training about coastal disasters in school and maintain this kind of knowledge by organizing activities.

One possible solutions would be to add a compulsory subject on coastal and other life-threatening disasters into the school curriculum. Student should be taught the basic information of *Do's and Don'ts* during the disasters. Besides, it is advisable to organize a school events to visit a places that suffered damage by past disasters and talk with those who experienced the disasters. Being able to

observe these areas can help students understand the potential consequences of disasters and the risks they pose to human life, hopefully increasing their awareness. For adults, evacuation drills are considered as a key component of disaster risk management, and should be conducted as a part of a disaster mitigation programme.

Regarding the sources of information about disasters, most respondents indicated that they used TV or radio (84%), internet (51%), or got it from authorities (including village elders, firefighters or police) or public address systems (Fixed Loudspeakers, Mobile Loudspeakers, etc.) during flooding events (**Fig. 16**). This shows that television is also an efficient way to inform people in Vietnam about disasters, and disaster education tied up with a TV programme could be effective due to the fact that information for TV programme can reach millions of people – but only for a few minutes at a time and especially it is free for people to access. Furthermore, there is also a need to develop warning stations.

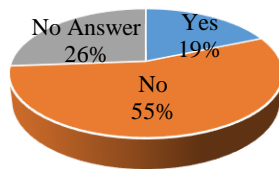


Fig. 15 Do children learn about storm surge/flooding in school, and how to evacuate? (n= 172)

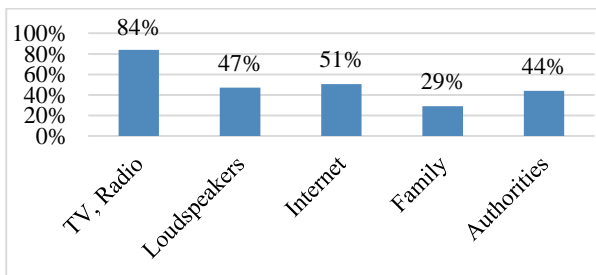


Fig. 16 Source of information on storm surge and typhoons in Southern Vietnam (n= 172)

7. CONCLUSION

It appears that coastal hazards in the Mekong Delta, particularly storm surges and typhoons, have not received as much attention by academics and disaster risk managers as they probably deserve. However, the analysis of past typhoon track clearly reveals that the threat of tropical cyclones in the Mekong Delta is not negligible, although the frequency is substantially lower than that in Northern or Central Vietnam. The results of the questionnaire

surveys show that local population have a relatively high degree of awareness about the dangers posed by typhoons. However, residents are not well prepared to face these natural disasters, and the present study highlights the necessity to enhance the education about natural hazards of the younger generation in the Mekong Delta and the rest of Vietnam.

ACKNOWLEDGMENT: Funding for this research was supported by grants to Tokyo Institute of Technology and Ho Chi Minh City University of Technology from JSPS KAKENHI (26702009, 16KK0121), Heiwa Nakajima Foundation, Sumitomo Foundation, Obayashi Foundation, and AUN/SEED-Net (Project No. HCMUT CRC 1601).

REFERENCES

- 1) Toan, T.Q. : Flood and tidal inundation change in the Mekong Delta in sea water level rise scenarios, *The Fifth Mekong Annual Flood Forum*, Vientiane, Lao PDR, 2010.
- 2) Takagi, H., Thao, N. D., Anh, L. T. : Sea-Level Rise and Land Subsidence: Impacts on Flood Projections for the Mekong Delta's Largest City, *Sustainability*, 8(9), 2016.
- 3) Larson, M., Nguyen, M.H., Hanson, H., Sundström, A., Södervall, E. : Impacts of Typhoons on the Vietnamese Coastline: A Case Study of Hai Hau Beach and Ly Hoa Beach, *Coastal Disasters and Climate Change in Vietnam: Engineering and Planning Perspectives Elsevier*, pp. 17-42, 2014.
- 4) Takagi, H., Tran, T.V., Nguyen, D.T., Esteban, M. : Ocean Tides and the Influence of Sea-Level Rise on Floods in Urban Areas of the Mekong Delta, *J. Flood Risk Management*, 8(4), pp. 292-300., 2014.
- 5) UNDP: Summing-up report on disaster situations in recent years and preparedness and mitigation measures in Vietnam, 2003.
- 6) Takagi, H., Thao, N. D. and Esteban, M. : Tropical Cyclones and Storm Surges in Southern Vietnam, *Coastal disasters and climate change in Vietnam, Engineering and planning perspectives*, Elsevier, pp.3-16., 2014.
- 7) Takagi, H., Esteban, M. : Statistics of Tropical Cyclone Landfalls in the Philippines -Unusual Characteristics of 2013 Typhoon Haiyan, *Natural Hazards*, Vol. 80, Issue 1, pp. 211–222, 2015.
- 8) Esteban, M., Thao, N.D., Takagi, H., Valenzuela, P., Tam, T.T, Trang, D.D.T, Anh, L.T. : Storm Surge and Tsunami Awareness and Preparedness in Central Vietnam, *Coastal Disasters and Climate Change in Vietnam: Engineering and Planning Perspectives*, Elsevier, pp. 321-336., 2014.
- 9) Esteban, M., Takagi, H., Thao, N.D., Tam, T.T., *et al.* : Assessment of potential increased damage to Vietnamese coasts due to increases in typhoon intensity, *Proceedings of the Fourth International Conference on Estuary and Coasts*, Hanoi, Vietnam, vol. 2, pp. 411-419., 2012.
- 10) Esteban, M., Thao, N. D., Takagi, H., Tsimopoulou, V., *et al.*: The Emergence of Global Tsunami Awareness: Analysis of Disaster Preparedness in Chile, Indonesia, Japan, and Vietnam, *Handbook of Coastal Disaster Mitigation for Engineers and Planners*, Elsevier, pp.205-233, 2015.

(Received February 2, 2017)