Science & Technology Development Journal – Science of The Earth & Environment 2024, 8(2):934-945

Research Article

Open Access Full Text Article

Assessment and zoning of economic damage risk due to the inundation in Thu Duc City on the period 2021-2022

Nguyen Ngoc Diep[1], Nguyen Tran An[2], Bui Viet Hung[2,*]

ABSTRACT

Thu Duc City directly under Ho Chi Minh City was established in 2020 on the basis of merging 3 districts (Thu Duc District, District 2 and District 9). Since its establishment, Thu Duc City has faced widespread urban flooding caused by both rain and tides. The impacts of urban flooding cause many adverse influences on people living and trading in the Thu Duc City. Inheriting the study on economic damage due to inundation in Ho Chi Minh City in the period 2016-2019, the project inherits the survey forms to conduct surveys and the flood's and damage's formulas to assess economic losses of people living there. The surveys of the inundation and the economic damages caused by floods are implemented in all wards of Thu Duc City in the period 2021-2022. The results of the study show that the distribution of inundation, economic damage level as well as the flood-damage risk level due to the inundation are concentrated in densely populated areas and riverside areas. It also shows that the level of economic damage in the period 2021-2022 is much reduced compared to the period 2016-2019 by about 25-30% and at the low level. The main reasonable of explanation about the reduction of risk level in the period 2021-2022 is the decrease of City's economic due to the serious disease Covide 19. The citizen's incomes reduced. Their works are delayed and the movement limitted. So that, the indirect economic damages also significantly being lower than the previous. Through establishing a flood and damage survey form, the study hopes to update more information and contribute a "way" to assess damage caused by floods directly to the urban management agencies of Thu Duc City.

Key words: Urban inundation, economic damage risk, tangible damage, intangible damage, Thu Duc City

[1]*University of Labor and Social Affair (Branch 2), Vietnam*

[2]*University of Science, VNU-HCM, Vietnam*

Correspondence

Bui Viet Hung, University of Science, VNU-HCM, Vietnam

Email: bvhung@hcmus.edu.vn

History

- Received: 15-4-2024
- Revised: 22-5-2024
- Accepted: 9-8-2024
- Published Online: 31-12-2024

DOI :

https://doi.org/10.32508/stdjsee.v8i2.764

INTRODUCTION

Urban flooding is a phenomenon where water overflows into urban areas, causing damage to property and human life. The main cause of urban flooding is due to a change in hydrological processes in urban areas, which in turn leads to an increase in the amount of water infiltrating roads, houses and infrastructure [1].

In Vietnam, the Ministry of Construction defined in Official Letter No. 338/BXD-KTQH dated March 10, 2003 on the development of the drainage framework program for urban areas: "*Local inundation points being within the allowable limits is the maximum inundation depth of 30 cm, the inundation time (withdrawal time) does not exceed 30 minutes…*". According to a study on flooding in Ho Chi Minh City by Le Sam (2011), urban flooding is an inundation situation, in which the inundation inner City's points are determined when satisfying some parameters such as the volume of water must be larger than 1000 m^3 (Corresponding to the flooded area with a length of 500 m, a width of 20 m and a depth of 0.1 m) and the inundation time being 30 minutes after rain. Flooding point after rain, water is flooded enough to obstruct traffic. Flooding points are classified into levels: heavy flooding, moderate flooding, light flooding and no flooding [2].

However, not all urban flooding can cause the damage to the people living and working there. According to a study in Vladivostok City, Russia [3], urban flooding causes a damage when satisfying the following levels: (1) *The first level* is the level of socio-economic development, i.e. total income. This means that, when a region is flooded, the flooding situation affects the income of people (decrease, lot); (2) *The second level* is the specific parameters of the flooding situation including a water depth, duration of inundation, extent of local damage and many other factors. The accurately determination of these parameters will make the damage calculation more accurate; and (3) *The third level is* concerned with the established disaster prevention and management solutions. Developing these solutions will help reduce damage and enhance recovery after a disaster.

Forwards the second level (2), a study on the flooding damage assessment in HCMC period 2016 – 2019 [4]

Cite this article : Diep N N, An N T, Hung B V. **Assessment and zoning of economic damage risk due to the inundation in Thu Duc City on the period 2021-2022** . *Sci. Tech. Dev. J. - Sci. Earth Environ.* 2024; 8(2):934-945.

and another analysis of household damage caused by flooding in Ho Chi Minh City[5] have conducted the surveys on the extent of flooding and corresponding economic damage. The results of these studies showed that the regionality in determining the extent of damage recorded due to urban flooding for HCMC are different with levels ranging from 15cm to 25cm with the same time over 30 minutes after rain and tide withdrew.

The flooding damage is usually divided into two main categories (1) Direct/tangible damage and (2) indirect/intangible damage[6]. For the direct/tangible damage, it is usually attributed to the cost of repairing/recovering lost property, vehicles or goods. Indirect/intangible damage is often more complex[6] as it often involves remedial damage, lost "opportunities" to increase income or sell more products, and health care…[5].

To serve the disaster prevention and environmental management, many studies propose to use the determination of the level of economic damage risk as a useful information for decision making of the relevant management levels[5,7–11]. The assessment of the economic damage risk caused by urban flooding is quite diverse [5]. However, most domestic and foreign studies focus on the following general formula:

$$R = f(H, E, V) \quad (1)$$

Where: H is the probability of occurrence of natural phenomena in the future. It usually calculated through the frequency of occurrence (%). E is an exposure to hazard and used to refer to the presence (by location) of people, livelihood activities, environmental services and natural resources, infrastructure, economic, social, cultural properties, etc., where they may be adversely affected by hazards leading to potential future harm, loss or damage[12,13]. V is a vulnerability, referring to the tendency of factors that are susceptible to the impact of hazards such as people (e.g. population structure, proportion of vulnerable population groups), society (Economic development).

Following the studies on flood damage assessment in Ho Chi Minh City in the period 2016 - 2019 and the formation of a new administrative unit of the City, Thu Duc City, in early 2020, the study assessment the economic damage level caused by an inundation in Thu Duc City on period 2021 - 2022 is carried out in order to initially provide relevant management agencies of the City with initial information about the urban flooding situation and the level of economic damage causing to people living in the City.

THE METHODOLOGIES

The study area is Thu Duc City (TDC) of Ho Chi Minh City (HCMC) as shown in Figure 1 above.

It surveys the extent of flooding and economic damage caused by inundation through the interviews with households. Based on the summary report of flood points in Ho Chi Minh City on period 2021-2022 of the Management Centre of Technical infrastructure, HCMC Department of Construction, the research team determined the frequent flooding points and severity of flooding (1 inundation point is a survey site). The number of survey points on the extent of flooding, the extent of economic damage was determined to be 12 survey locations. For each survey site, about 5 to 10 affected households will be interviewed, the total number of survey questionnaires of household is 242 votes (121 survey questionnaires for flooding situation and 121 survey questionnaires for economic damage) and the monitoring location flood signal is at 50 locations. Distribution of survey locations and locations of households interviewed see Figure 2 below.

The assessment of urban flooding

The assessment of urban flooding is determined by the frequency of mild, moderate and hard flooding occurrence[5] as follows:

$\mathbf{P}$ (%) = $\mathbf{N}_{flood\ occurrence}$ /$\mathbf{N}_{max}$ (%) (2)

There are:

- $\mathbf{P}$ (%) is the frequency of occurrence of flooding number causes the economic damage;
- $\mathbf{N}_{flood\ occurrence}$ is the number of occurrences of flooding causes the economic damage to the households.
- $\mathbf{N}_{max}$ is the maximum number of occurrences of flooding causing the economic damage in the area (According to the Hung (2021), $\mathbf{N}_{max}$ = 24).

The flooding level classification is by the frequency of occurrence[5] as shown in the Table 1.

The assessment of economic damage

The assessment of economic damage due to urban flooding is determined by the ratio between the total cost of overcoming consequences caused by inundation with the total annual income of households[5] as follows:

C = Total Economic Loss (TTH) / Total Income (TTN) (%) (3)

There are:

- TTN is the total annual income (VND).
- TTH is the total damage caused by urban flooding (VND).

The damage classification[5] is as the Table 2.

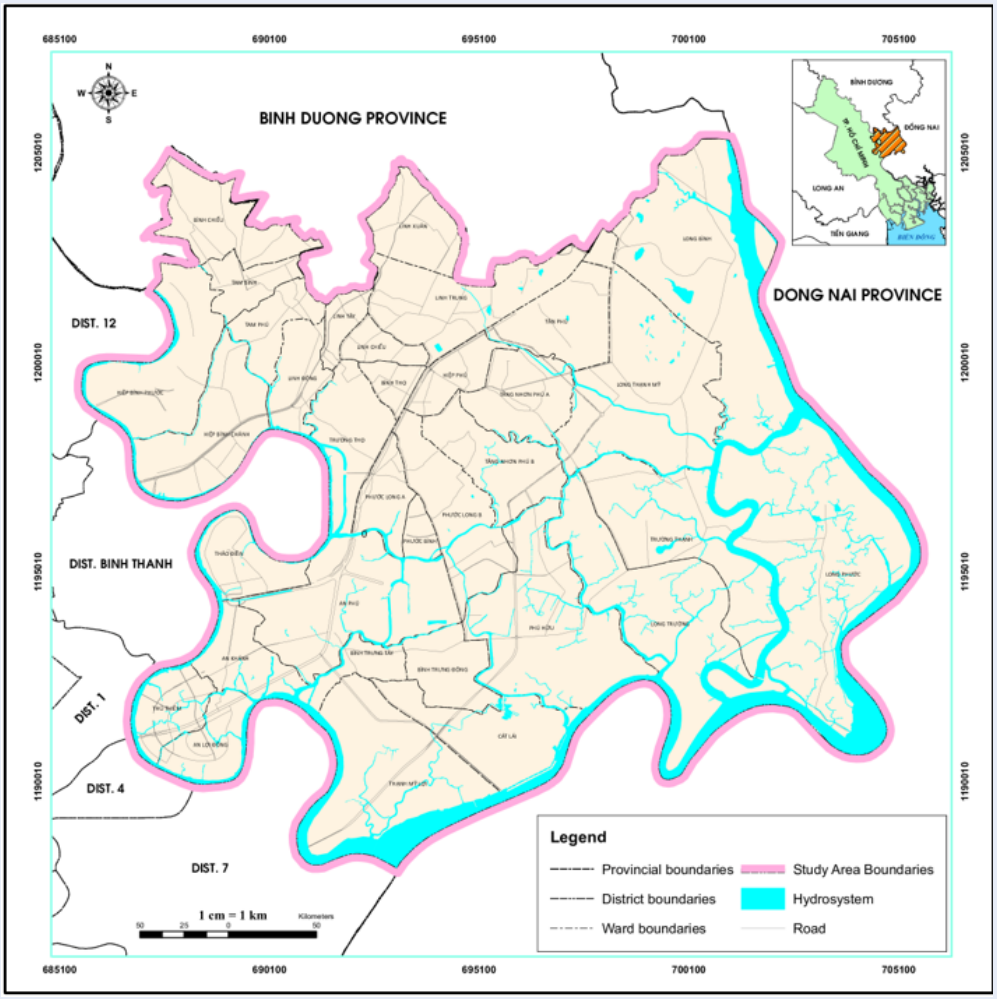

Figure 1: Thu Duc City, Ho Chi Minh City

Table 1: Frequency classification of damaging urban flooding

TT	Flooding level	Frequency	Meaning
1	Low	40%	Corresponding to the maximum number of occurrences (10 times of mild floods)
2	Moderate	40% < P 65%	Corresponding to 18 flooding occurrences (10 mild flooding and 8 moderate flooding).
3	High	65% < P 90%	Corresponding to 21 flooding occurrences (10 mild flooding, 8 moderate flooding and 3 hard flooding).
4	Very high	90% < P 100%	Corresponding to 24 occurrences of flooding (10 mild flooding, 8 moderate flooding and 6 severe flooding).

(Source: Hung, 2021)

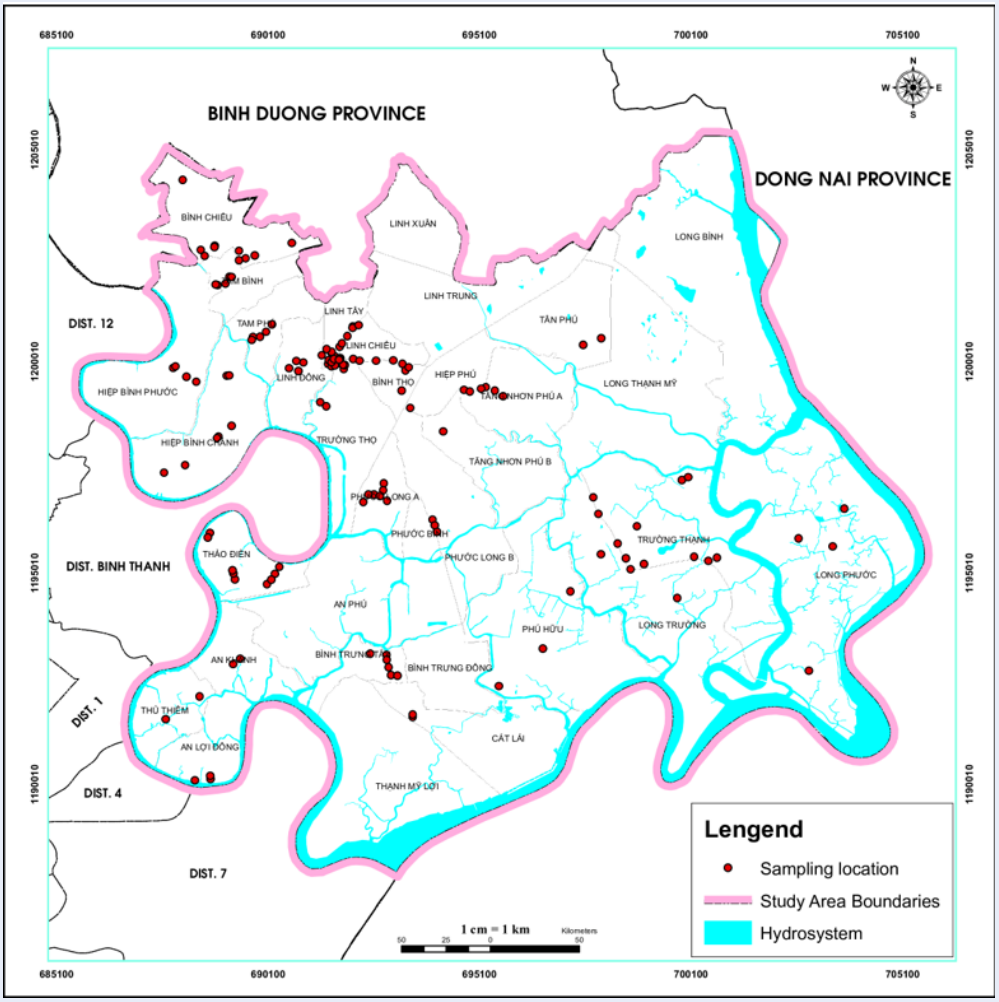

Figure 2: Location of households interviewed and observed signs of flooding in the city

Table 2: Table of extent of damage caused by flooding.

TT	Damage level	Rate	Meaning
1	Small	C 15%	The mild economic damage.
2	Moderate	15% < C 30%	The moderate economic damage
3	Hard	30% < C 50%	The hard economic damage
4	Very hard	50% < C 70%	The very hard economic damage
5	Serious	70% < C 100%	The serious economic damage (like completely)

(Source: Hung, 2021)

The assessment of economic damage risk

The assessment of economic damage risk due to urban flooding. The formula for assessing an economic damage risk caused by the urban flooding is described by the formula below[5].

$R = (w_P).P + (w_C).C$ (4)

There are:

- R is the risk value of economic damage caused by urban flooding.
- w_P and w_C are the weights of the two components of flooding level and damage's rate caused by flooding, respectively 0.473 and 0.527 applied to TDC.[5]

The classification of economic damage risk levels threshold is described in Table 3.

The threshold value of risk level is determined according to the Table 4[5].

Set up flood and damage zoning maps

Flood and damage zoning maps were created using GIS tools. Based on the results of synthesis and analysis of the level of flooding by depth, the level of economic damage and the level of economic damage risk at the survey locations, corresponding types of zoning maps are established.

The interpolation method used is Inverse Distance Weighting (IDW), which is the simplest interpolation method and the most commonly used method in GIS analysis functions. To determine the suitability of the IDW interpolation method with the flood and damage survey results, the project used 80% of the 121 survey locations (flooded and damaged) to interpolate for the remaining 20% of locations. again. Calculate the correlation level of direct and interpolated survey values of the above 20% locations. By calculating the correlation coefficient R2 of two sets of values (survey and interpolation) at 20% of survey locations, flooding reached 71% and damage reached 75%. The interpolation results are acceptable with a good level of correlation. Thus, the project can use the IDW interpolation method in GIS to map flood and damage zones appropriately.

THE RESULTS AND DISCUSSIONS

In recent years, the inundation has become a serious problem in the Thu Duc City. With the continuous development of urban areas, the drainage system has not been synchronized with the local urban development rate. According to a report from the project to reduce flooding in the area, Thu Duc City, when it rains heavily, has many main roads and residential areas often flooded, especially roads such as the old National Highway 13, quarters 1 and 3 of Hiep Binh Phuoc ward, road No. 10 of Linh Dong ward… affecting people's lives.

According to the research direction of the project to assess the economic damage caused by flooding in Ho Chi Minh City on period of 2016-2019[4], the total number of surveyed households in the Thu Duc City is 242 households, in which, there are 154 families (accounting for 63.63%), 88 trading households (accounting for 36.37%). During the survey, it found that trading households being also families with more goods. In general, the average income of households living in the old districts (Thu Duc, 2, 9) is quite high (34 million VND/month) on period 2016-2019. However, during the epidemic period of 2021 - 2022, the all surveyed households had a large decrease in income (about 18 million VND/month) according to the survey in the flood-affected area in the City.

Summary of flood survey results

Summary of flood survey results of 121 households on period of 2021 - 2022 in Thu Duc City showed that households suffered a total of 1149 floods, 121/121 households were affected by flooding before 2021 (See Table 5). Thus, it can be seen that the level of flooding has a prolonged flood situation and has a certain impact on the damage of households in Thu Duc City. Based on the formula number (2), calculate the frequency of light, moderate and severe flooding in Thu Duc City. The frequency of occurrence was determined by using the number of flooding occurrences corresponding to the levels compared to the total number (maximum) damaging floods recorded [5]. The frequency of flooding occurrence causing general damage is calculated according to the following formula:

$P(\%) = w_{light}P_{Light}(\%) + w_{Moderate}\ P_{Moderate}(\%) + w_{Severe}P_{Severe}(\%)$ (5)

There are: w_{Light}, $w_{Moderate}$, w_{Severe} are the weights respectively for each severe, light and moderate flooding level. They are determined through research on period 2016-2019[4] and summarized in Table 6.

At each flood survey position, the survey results include flooding factors (depth, time and dimensions). To determine relatively the flood area arounding the survey positions, the project maps the distribution flood by GIS tools. The urban flooding areas with depth in TDC in the period of 2021-2022, see the Figure 3.

The results show that, Thu Duc City has a frequency of flooding causing damage of 13.5%, equivalent to a mild frequency. It means the number of occurrences of flooding causing damage being less than 10

Table 3: Table of economic damage risk levels due to urban flooding.

TT	Risk level	Classification	Meaning
1	Low	R R1	The low economic damage
2	Moderate	R1 < R R2	The moderate economic damage
3	High	R2 < R R3	The high economic damage.
4	Very high	R3 < R R4	The very high economic damage.
5	Serious	R4 < R 1,0	The property is loted completely.

(Source: Hung, 2021)

Table 4: Thresholds values of economic damage risk due to urban flooding.

Location	Thresholds values of economic damage risk (%)				
	R1	R2	R3	R4	R5
Thu Duc City	25	43	65	81	100

(Source: Hung, 2021)

Table 5: General information on flooding status of surveyed households.

No	Contents	Characteristics	Survey's results
1	The number of flood (number).	Light (10 – 15 cm)	615
		Moderate (15 – 30 cm)	369
		Severe (>30cm)	165
2	The duration (number) .	< 30 Minutes	48
		30 – 120 Minutes	63
		> 120 Minutes	10
3	The flood causes.	Rain	107
		Tide	32
		Rain – Tide	37
4	The moderate depth (cm)		17,96
5	The length of flood area (m)		185,6
6	The width of flood area (m)		9,68

Table 6: Frequency of flooding causing the damage to the Thu Duc City.

Parameters/level	Light	Moderate	Severe
	0,535	0,321	0,144
w	0,075	0,122	0,388
P (%)	0,135		

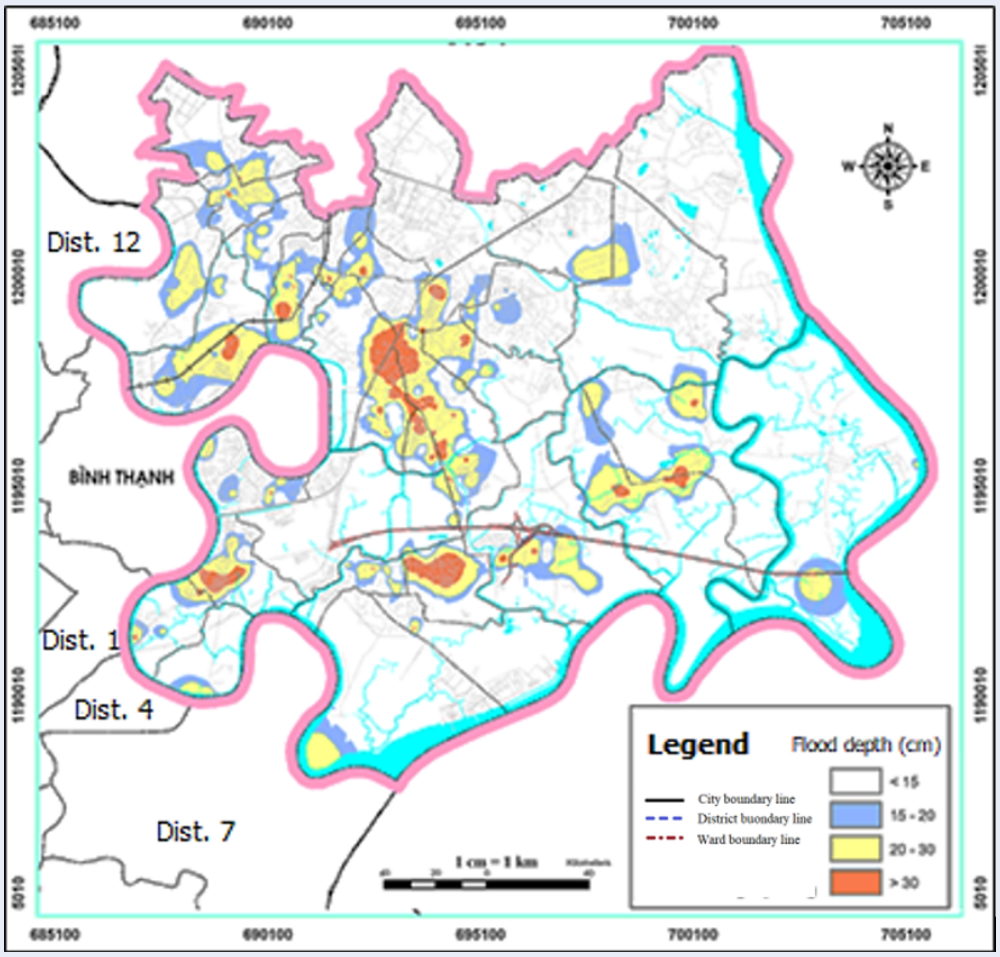

Figure 3: Flooded areas in TD City on period of 2021-2022

times/year. The areas flooded with severely level have a large population concentration (the old Thu Duc District area) and the areas flooded lightly – moderately have a large density of canals (the old Districts 2 and 9).

The assessment of economic damage

The assessment of economic damage due to urban flooding of 121 households surveyed in TD City.

According to the survey results of direct/tangible damages and indirect/intangible damages, the average damage level of each household corresponding to flood levels showed a significant reduction compared to the period 2016-2019 from 25% - 30%. The average indirective/directive economic damage of household due to the inundation situation in period 2021-2022 (two years) is summaried on Table 7. The average damage surveyed results according to the flood levels are determined as shown Figure 4.

The Table 7 shows that the majority of economic damage caused by flooding to households is the direct damage (accounting for 85.64% of total damage) and accounts for 14.19% of the total annual income. The comparing with the results of the project researching and surveying flood for Ho Chi Minh City in the period 2016-2019 (direct damage of districts 2, Thu Duc and district 9 fluctuated between 75-90% of the total economic damage due to flood[4]), the results of the economic damage assessment period 2021-2022 of the project are similar. With an average income (through a survey of 242 households) about 18 million VND/month, the average level of economic loss of households due to flooding in the area of TDC (corresponding to the average flood level) about 19.5%/year equivalent to the moderate damage level. The area with level of damage caused by flood see the Figure 5. Compared with the research results of Hung (2021), the average direct damage through the survey

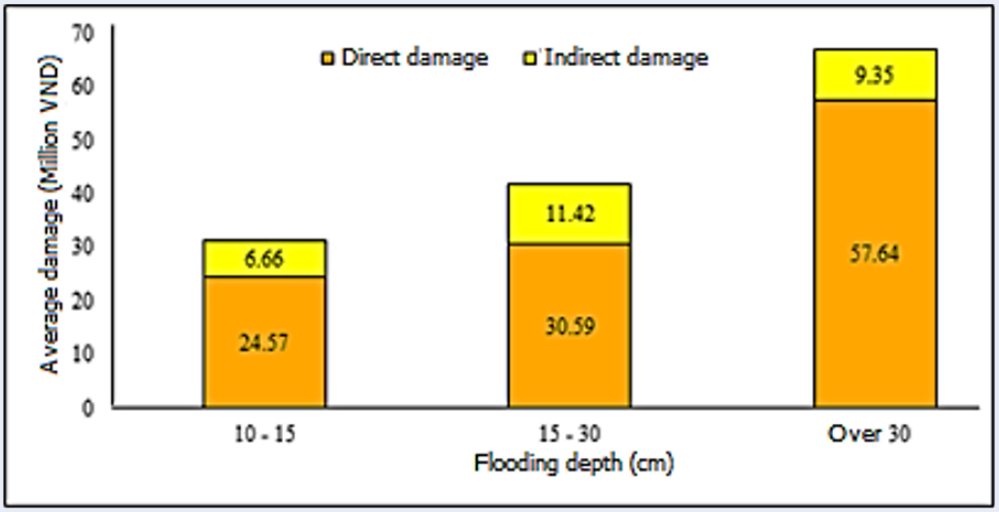

Figure 4: Economic damage (direct and indirect) caused by flooding

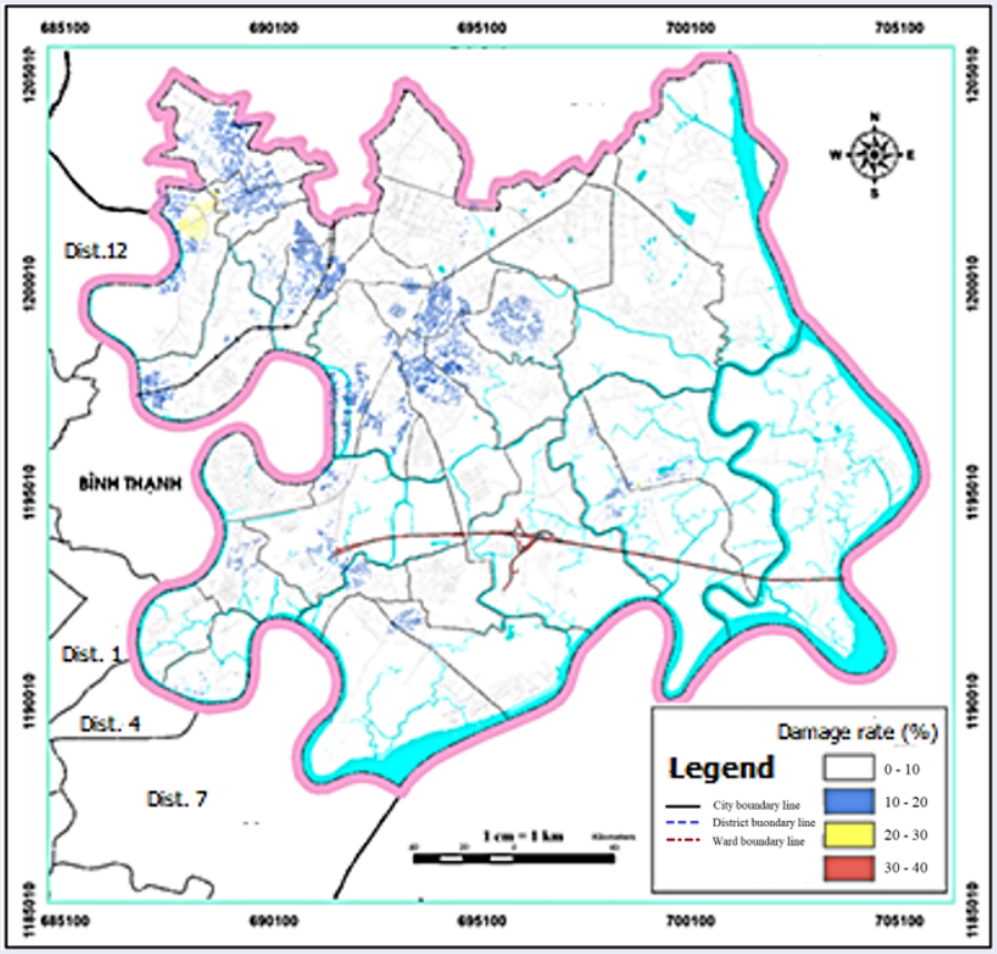

Figure 5: Economic damage caused by flooding on period of 2021-2022

Table 7: The directive/indirective economic damages of household living in TDC in period 2021-2022

Damage	Value (106 VND)	Rate (Damage/income) (%)
Directive damage	57,91 (85,64%)	14,19
Indiêctive damage	9,71 (14,36%)	2,38
Total	67,62 (100%)	16,57

decreased significantly compared to 45 million VND/year[4] on period 2016-2019 by about 30%. The main reason is that people spend a lot of time at home (the time is limited to move due to the epidemic), so the proactive level in limiting damage to furniture and means of transport.

The assessment of the level of economic damage risk

The assessment of the level of economic damage risk due to flooding in the area of TDC on period of 2021-2022. On the basis of the analysis about the flooding level, the occurrence frequency of floods causing the economic damage and the ratio between the economic damage and the annual income of households, the formula (4) is applied to calculate the economic damage risk due to flooding for administrative areas (wards) of the City. There are a total of 25/34 wards recorded in the summary reports on flood control and reduction work of the Technical Management Centre of infrastructure, HCMC Department of Construction in 2021 and 2022 have the damage of households. The total economic damage risk caused by flooding is shown in the Figure 6 and Figure 7. According to Table 4 – Threshold value of risk, the wards' risk levels of the economic damages are all less than $R_1 = 25$ corresponding to low risk level. The an Loi Dong, An Khanh, Tam Binh and Tang Nhon Phu A wards have higher risk values than other wards. The main reason is that the geographical location of these wards is flat and hollow. So that, these wards are easily affected and flooded by heavy rains, high tides.

CONCLUSION

The study calculated the economic damage risk caused by flooding through the economic damage level and the occurrence frequency of flood causing a damage in TDC. The economic damage level is about 19.5% of annual income of households. The occurrence frequency of floods causing damage is less than 10 times per year. The average level of economic damage risk due to urban flood is low at each ward of TDC. The study also classified the risk thresholds for the wards according to the number of survey questionnaires. As a result, there are 9 wards without risk, 25 wards have the same level of risk as low, but four wards (An Phu Dong, An Khanh, Tam Binh and Tang Nhon Phu A) have a higher numbers of risk than others.

The main reason for the low level of economic damage risk caused by urban flood in the TDC on period 2021-2022, the whole country experienced a serious pandemic that had a profound impact on social and economic life. This leads to a decrease in average income, the cost of repairing all kinds of damage also decreased significantly compared to the period 2016-2019. However, when the economy recovers, the increased flooding will affect people a lot, especially in the post-epidemic recovery period, so the management levels of the City need to have solutions to prevent and reduce the flood damage to people, support people to quickly recover their income and socio-economic activities.

ACKNOWLEDGMENTS.

The article is made from the research results of the graduate thesis majoring in Environmental Management, Faculty of Environment, University of Science, VNU-HCM in 2023 with the title "ASSESSMENT OF THE ECONOMIC RISK BELOW SURROUNDED SUPPLY THINK IN THU DUC CITY IN 2021 – 2022" by student Nguyen Tran An.

AUTHORS' CONTRIBUTION

Nguyen Ngoc Diep: The economic analysis (damages) Author 3*: Methodology, Funding acquisition. Author 2: Investigation, Formal analysis.

COMPETING INTEREST

We have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

1. Pramod Kumar S. Urban flood risk assessment [Internet]. EDUSAT IIRS Dehradun; 2019 [cited 2023 May 26];Available from: https://www.youtube.com/watch?v=fcUUclYTgtM.
2. Sam L, Vuong, et al. Research and propose solutions to prevent flooding for Ho Chi Minh City. Ho Chi Minh City: Ministry of Science and Technology & Ministry of Agriculture and Rural Development; 2011;.

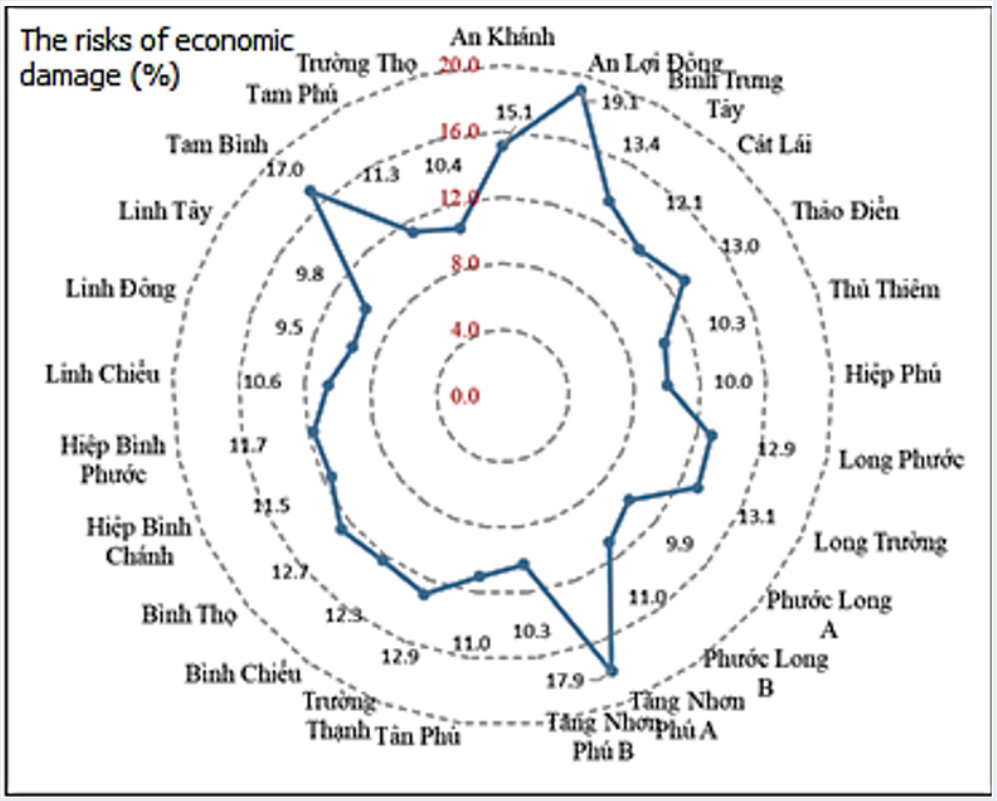

Figure 6: Level of economic damage risk due to flooding of wards of TDC on period of 2021-2022

3. Miroshnikova T. Economic assessment of flood damage. E3S Web of Conference. 2021;244:10055;Available from: https://doi.org/10.1051/e3sconf/202124410055.
4. Hung NV, et al. Investigation, survey and assessment of damage caused by flooding to the socio-economic; building a map of damage caused by inundation for flood control and urban planning in Ho Chi Minh City. Ho Chi Minh City: Department of Science and Technology; 2020;.
5. Hung BV, Diep NN. Assessment on the economic damage of trading households due to urban inundation. J Water Clim Change. 2021;Available from: https://doi.org/10.2166/wcc.2021.351.
6. Olesen L, Löwe R, Arnbjerg-Nielsen K. Flood damage assessment – Literature review and recommended procedure [Internet]. Cooperative Research Centre for Water Sensitive Cities; 2017;Available from: https://watersensitivecities.org.au/content/flood-damage-assessment-literature-review-recommended-procedure.
7. Wu Z, Shen Y, Wang H, Wu M. Assessing urban flood disaster risk using Bayesian network model and GIS applications. Geomatics Nat Hazards Risk. 2019;10(1):2163–2184;Available from: https://doi.org/10.1080/19475705.2019.1685010.
8. Xu Z, Chen H, Ren M, Cheng T. Research progress of urban flood disaster mechanism and risk assessment in China. Adv Water Sci. 2020;31:713–724;.
9. Zhang H, Zhang J, Han J. The assessment and regionalization of flood/waterlogging disaster risk in middle and lower reaches of Liao River of Northeast China. In: Proceedings of the Fifth Annual IIASA-DPRI Forum on Integrated Disaster Risk Management; 2005. p. 103–118;.
10. Zhou C, Wan Q, Huang S, Chen D. Flood risk zoning based on GIS. Acta Geogr Sin. 2000;55:15–24;.
11. Tomar P, Singh SK, Kanga S, Meraj G, Kranjčić N, Đurin B, Pattanaik A. GIS-based urban flood risk assessment and management—A case study of Delhi National Capital Territory (NCT), India. Sustainability. 2021;13(22):12850;Available from: https://doi.org/10.3390/su132212850.
12. Dimauro C. A methodological approach for the definition of multi-risk maps at regional level: First application. J Risk Res. 2009;12(3):513–534;.
13. Du X, Lin X. Conceptual model on regional natural disaster risk assessment. Procedia Eng. 2012;45:96–100;.

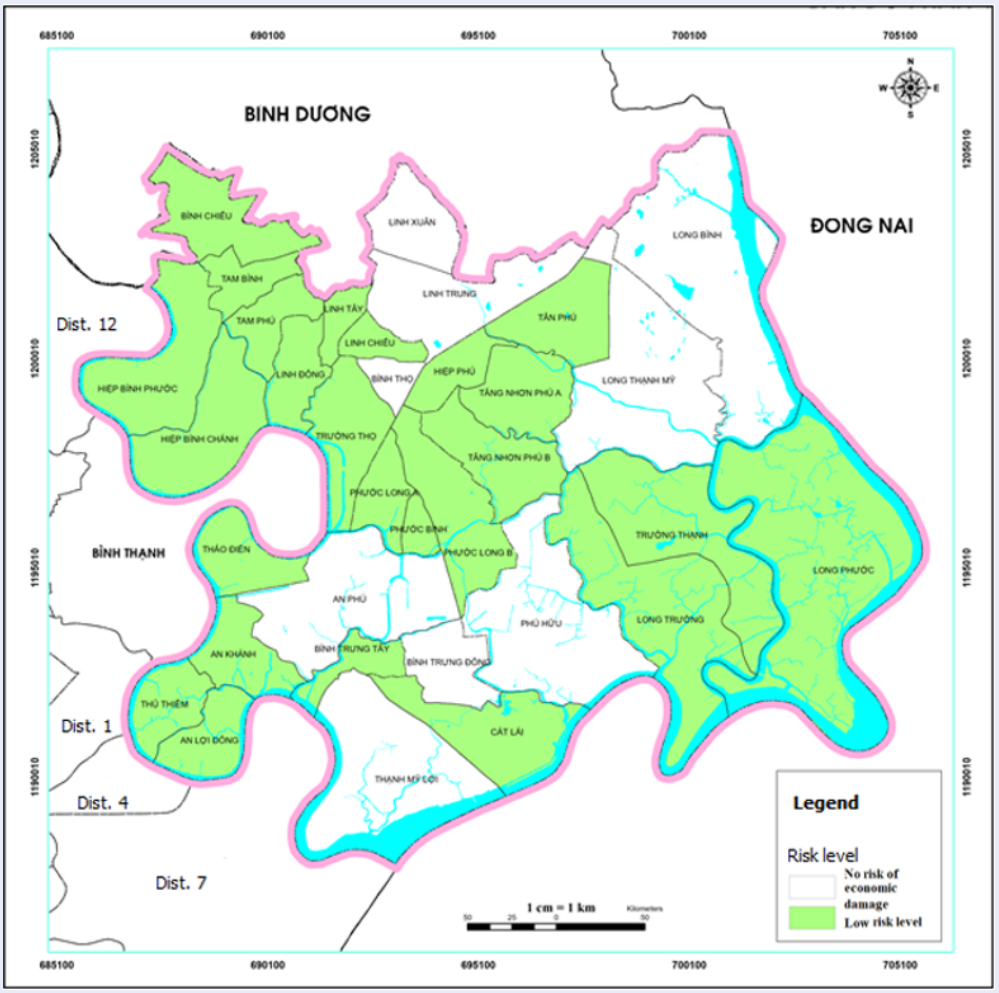

Figure 7: Economic damage risk map from flooding in TDC

Tạp chí Phát triển Khoa học và Công nghệ – Science of The Earth & Environment 2024, 8(2):934-945

Open Access Full Text Article

Bài nghiên cứu

Đánh giá, phân vùng rủi ro thiệt hại kinh tế do ngập úng tại TP Thủ Đức giai đoạn 2021-2022

Nguyễn Ngọc Diệp[1], Nguyễn Trần An[2], Bùi Việt Hưng[2,*]

TÓM TẮT

Thành phố Thủ Đức trực thuộc TP.HCM được thành lập năm 2020 trên cơ sở sáp nhập 3 quận (Quận Thủ Đức, Quận 2 và Quận 9). Từ khi thành lập đến nay, TP. Thủ Đức đã phải đối mặt với tình trạng ngập lụt đô thị trên diện rộng do cả mưa và triều cường. Tác động của ngập lụt đô thị gây ra nhiều ảnh hưởng tiêu cực đến người dân sinh sống và buôn bán tại TP. Thủ Đức. Kế thừa công trình nghiên cứu thiệt hại kinh tế do ngập lụt tại TP.HCM giai đoạn 2016-2019, dự án kế thừa các biểu mẫu điều tra để tiến hành khảo sát và công thức tính lũ, thiệt hại để đánh giá thiệt hại kinh tế của người dân tại đây. Các cuộc điều tra ngập lụt và thiệt hại kinh tế do ngập lụt được triển khai trên tất cả các phường của TP. Thủ Đức giai đoạn 2021-2022. Kết quả nghiên cứu cho thấy, sự phân bố ngập lụt, mức độ thiệt hại kinh tế cũng như mức độ rủi ro thiệt hại do ngập lụt tập trung ở các khu vực đông dân cư và ven sông. Cũng cho thấy mức độ thiệt hại kinh tế trong giai đoạn 2021-2022 giảm nhiều so với giai đoạn 2016-2019 khoảng 25-30% và ở mức thấp. Lý giải hợp lý chính về việc giảm mức độ rủi ro trong giai đoạn 2021-2022 là do kinh tế của Thành phố suy giảm do dịch bệnh nghiêm trọng Covide 19. Thu nhập của người dân giảm. Công việc của họ bị chậm trễ và việc đi lại bị hạn chế. Do đó, thiệt hại kinh tế gián tiếp cũng thấp hơn đáng kể so với trước đây. Thông qua việc lập biểu mẫu khảo sát lũ lụt và thiệt hại, nghiên cứu hy vọng sẽ cập nhật thêm thông tin và đóng góp một "cách" đánh giá thiệt hại kinh tế do lũ lụt gây ra trực tiếp cho các cơ quan quản lý đô thị của Thành phố Thủ Đức.

Từ khoá: Ngập đô thị, rủi ro thiệt hại, thiệt hại hữu hình, thiệt hại vô hình, TP Thủ Đức

[1]*Trường Đại học Lao Động và Xã Hội (Cơ sở 2), Việt Nam*

[2]*Trường Đại học Khoa học Tự nhiên, ĐHQG-HCM, Việt Nam*

Liên hệ

Bùi Việt Hưng, Trường Đại học Khoa học Tự nhiên, ĐHQG-HCM, Việt Nam

Email: bvhung@hcmus.edu.vn

Lịch sử

- Ngày nhận: 15-4-2024
- Ngày sửa đổi: 22-5-2024
- Ngày chấp nhận: 9-8-2024
- Ngày đăng: 31-12-2024

DOI : https://doi.org/10.32508/stdjsee.v8i2.764

Trích dẫn bài báo này: Diệp N N, An N T, Hưng B V. **Đánh giá, phân vùng rủi ro thiệt hại kinh tế do ngập úng tại TP Thủ Đức giai đoạn 2021-2022**. *Sci. Tech. Dev. J. - Sci. Earth Environ.* 2024, 8(2):934-945