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Original Article

Community Responsiveness on Climate Change and Natural Hazards Towards Sustainable Cities: An Empirical Study of Da Nang, Vietnam

Nguyen Duc Toan*

The Vietnam Agency of Seas and Islands, Ministry of Natural Resources and Environment, 83 Nguyen Chi Thanh, Dong Da, Hanoi, Vietnam

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Abstract: Understanding of community responsiveness on climate change and the natural hazards is an essential component of urban planning and adaptation strategies. The coastal cities are seriously affected by the impact of rising sea levels and climate change-induced hazards. In this paper, we investigate the urbanization level on climate change and natural hazards awareness of local communities at the households' level in Da Nang city, the largest municipality in Central Vietnam using 1903 surveyed households. The results showed that the urbanization level significantly influenced the local communities' responsiveness to climate change. Communities with robust infrastructure and strong economic status demonstrate greater resilience and awareness of climate change and natural hazards compared to others. Therefore, it is recommended to prioritize enhancing local people's responsiveness to develop bottom-up climate change response strategies and policies, instead of enforcing top-down decisions.

Keywords: Communities; Natural hazards; Climate change; Sustainable cities; Da Nang city.

1. Introduction

Climate change is a global issue, causing numerous environmental, social and economic problems worldwide such as extreme weather, temperature increase, sea level rise, famine, land-use change, etc. Vietnam is recognized as one of the most vulnerable countries under the impacts of climate change, particularly in the coastal zone of Vietnam [1-3]. The climate change scenarios of Vietnam expected that the mean temperature would increase by 1.3 to 1.7

* Corresponding author.
E-mail address: toantnmt@gmail.com

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degrees Celsius in the mid-century. The annual rainfall will likely increase up to 20% and the sea level will rise approximately 22-24 cm in mid-century [2, 3]. The coastal zone of Vietnam is a high population density, concentrated in some coastal municipalities such as Hai Phong, Da Nang and Ho Chi Minh city. However, the coastal area is also highly influenced by climate change and natural hazards such as typhoons, floods, rising sea levels, and erosion. Consequently, the livelihoods and assets of people in coastal municipalities will be severely damaged or lost, causing a decrease in sustainability and human security [4, 5]. To reduce the impacts of climate change and sustainable development of coastal areas, the central and local governments, communities, and local people are challenged to find the best solutions for mitigation and adaptation.

People awareness of climate change and natural hazards plays an essential role in developing mitigation and adaptation solutions [6-8]. Climate change awareness was recognized as a significant factor that influenced climate change on adaptive capacity at the household level [9]. The previous research showed that the inherent capacity contributed significantly to the total adaptive capacity of individual households [10, 11]. Therefore, the determining key factors of climate change and natural hazards awareness play critical roles in developing mitigation and adaptation strategies and policies in the context of climate change.

However, there is a relative lack of studies on spatial variability of climate change awareness among rural, urban, and transition areas [10]. Research on critical factors of climate change awareness and its spatial differences was also rare, particularly in developing countries [7]. Thus, the research on the above issues will contribute significantly to understanding patterns of climate change awareness and adaptive capacity of urban and rural areas and providing effective solutions for enhancing climate change responsiveness of local people based on empirical data.

In the present study, the household survey was conducted to test the hypothesis that the urbanization level will influence people's awareness in responding to climate change impacts in the coastal city. The objectives of the present research are i) To determine the patterns of climate change awareness at the household level; and ii) To develop the solutions for enhancing the local people's responsiveness to climate change in coastal cities. The research was conducted in Da Nang city, the largest urban area in the Central Vietnam. Results from the present study will contribute significantly to climate change adaptation in coastal regions at the household level, particularly in Vietnam and Da Nang city.

2. Material and Methods

2.1. Study Area

Da Nang city is the most modern city in the coastal zone of the Central Key Economic Zone of Vietnam (Fig. 1). This city plays an important role in socio-economic development and international trade in the Central Vietnam, which is also a connecting corridor between South East Asia countries and others. The total area of Da Nang city is approximately 1283.42 km^2 with eight districts of Cam Le, Hai Chau, Thanh Khe, Lien Chieu, Ngu Hanh Son, Son Tra, Hoa Vang and Hoang Sa islands [12]. The urban zone covered 18,9% total area of Da Nang city, which concentrated 88% total population with a population density was approximately 3709 people /km^2 [13].

The total area of Da Nang city can be divided into four regions with differences in urbanization level, infrastructure, and characteristics of natural hazards (Table 1 and Fig. 1). The Old city zone is the center of Da Nang, with sound infrastructure, high population density, and income. In contrast, the rural area is characterized by low-income people, low population density, weak infrastructure and frequently serve impacted by natural hazards and climate change. In recent years, the economy of

Da Nang has rapid growth, causing the rapid development of the urban areas and tourist sites along the coastal line of Da Nang Bay. The high urbanization area is situated in the Lien Chieu, Hai Chau, and Ngu Hanh Son districts, where there is rapid development of new urban spaces and infrastructure. The coastal region of Da Nang has a high density of residential areas, tourism services, and good infrastructure but is frequently impacted by climate change-induced natural hazards.

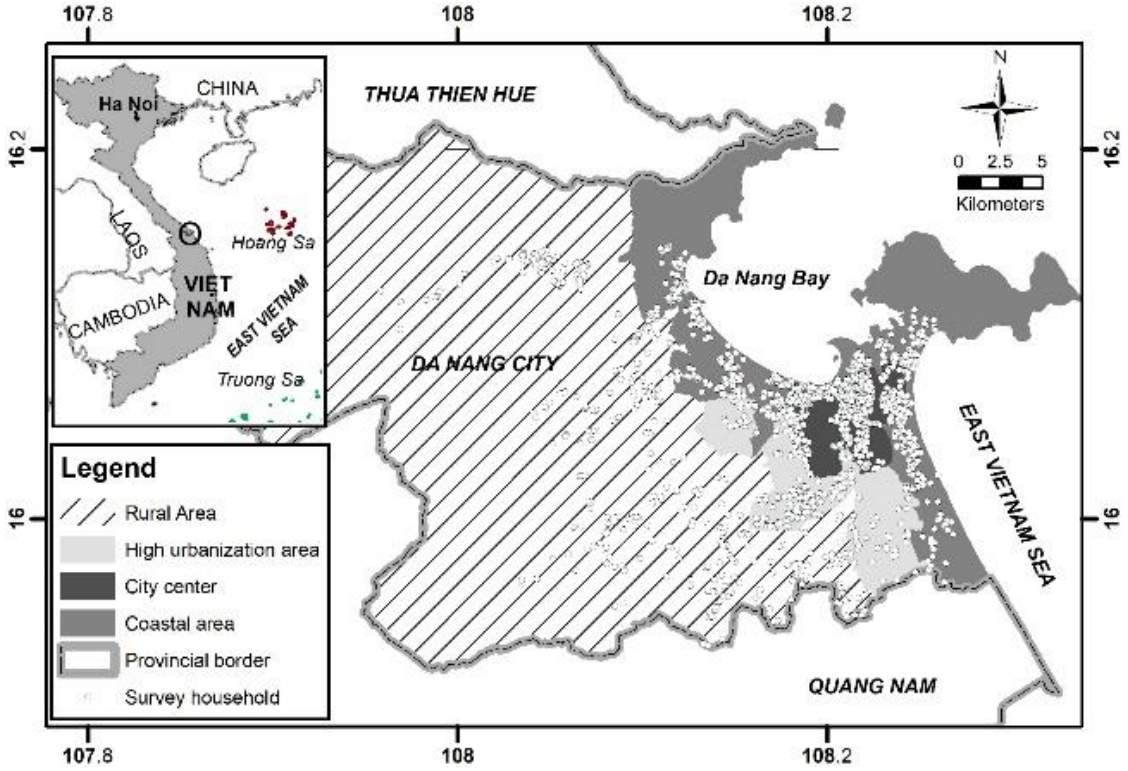

Figure 1. Map of Da Nang city and household survey points.

Table 1. Number of interviewed households in Da Nang city

No	Zone	Description	n
1	Coastal	Coastal communes/quarters or adjacent to river estuaries highly vulnerable to natural hazards and climate change impacts, good infrastructure.	619
2	Old City	The old city center of Danang, high population density, and sound infrastructure.	506
3	High urbanization	The new urban zone of Danang city, rapid urbanization, and development of industrial and commercial services.	392
4	Rural	Rural and mountainous areas of Hoa Vang District, except coastal area. Low population density, weak infrastructure and frequently impacted by typhoons and floods.	386

The climate of Da Nang city is typically tropical monsoon with a dry season from February to August and a rainy season from September to December, and the total rainfall

was 2500 mm.year^{-1}. The precipitation in Da Nang city showed a markedly different trend between dry and rainy seasons, with more than 70% rainfall concentrated in 4 months of the rainy season. The monthly average temperature of Da Nang city ranged from 18 to 30 ^{o}C, with an average of 25.9 ^{o}C.

Typhoons and post-typhoon floods are the most dangerous natural hazards, which have increased in frequency and intensity recently due to the impacts of climate change in Da Nang city [12]. The consequences of typhoon impacts included damage to human lives, livelihoods, infrastructure [14], and posttraumatic disorder [15]. The areas with the highest vulnerability to climate change-induced disasters is in coastal, lowland, and adjacent river areas, which are characterized by poor residents, weak infrastructure, and a low-level climate change awareness. Rapid urbanization in these areas has increased the impacts of typhoons and post-typhoon floods in Da Nang [14].

Table 2. Questions for surveyed households in Da Nang city

Code	Question	Answer
Q1	Have you heard climate change information in recent years?	Yes/No/No answer
Q2	What is the most dangerous disaster that impacted your family in the last ten years?	Typhoon/Flood/Erosion/Drought/ Salt intrusion/Others
Q3	Do you feel the typhoon's intensity change in the last ten years?	Decrease/Stable/Increase/No answer
Q4	Have you observed the impacts of the typhoon on your house and assets in the last ten years?	Yes/No
Q5	Have you applied engineering methods to respond typhoon?	Yes/No
Q6	Do you think engineering methods are effective ways to respond typhoon?	Efficient/Relatively efficient/No efficient/ No answer
Q7	Are you donating to local funds for disaster prevention?	Yes/No/No answer
Q8	Are you received help from the local fund of disaster prevention?	Yes/No/No answer
Q9	Are you participating in disaster prevention training class.	Yes/No/No answer
Q10	Are you getting disaster prevention information from electronic devices (Radio, television, smartphone, etc.).	Yes/No/No answer

2.2. Data Collection

The questionnaire survey was conducted in Da Nang city. Before the field survey, researchers were provided general information about the natural and socio-economic conditions of the research areas and contents of the questionnaire table in a short training course. During the field survey, researchers and local official staffs of quarters/communes were briefly introduced to the present study's objectives. Then, researchers independently interviewed local inhabitants and surveyed socioeconomic conditions of each household. Each household's GPS position was recorded for correcting uncertain information during survey time. The interview questionnaire consists of 10 questions with two parts: i) People's awareness of natural hazards and climate change (hearing about climate change and relevant terms (Q1), receiving information about climate change (Q10); change the intensity of typhoons in past ten years (Q3); the most dangerous natural hazards (Q2) and damage assets by typhoons (Q4)); and ii) Climate change responses (applying engineering prevention methods (Q5); effective of engineering prevention methods (Q6); donate for disasters prevention community funds (Q7), received notes from disasters prevention community funds (Q8) and training disaster prevention class (Q9)). In each household, the patriarch has selected for an interview the responding household in each question. In the case of the patriarch's absence, the

oldest or rich-experienced person was selected for the interview. Approximately 30 households participated in the survey from every commune and ward of Da Nang city. These households were randomly selected from the list provided by the local government, which included 56 communes and wards in Da Nang City. A total of 1,903 households were interviewed, ensuring a 99% confidence interval with a margin of error less than 5% (Table 2).

2.3. Data Analysis

Data from the household interview was imported to Microsoft Excel and IBM SPSS v.20.0 for further statistical analysis. The descriptive statistics and chi-square test of independence were applied to explore the spatial differences in survey results among city zones. The possibility of differences by chi-square test can be assessed the relationship between urbanization level (city zones) and variables of people awareness and climate change response in interview data. Results from the chi-square test of independence will explain the pattern of natural hazards and climate change awareness at the household level, which play essential roles in developing climate change response strategies and sustainable development. All statistical analyses were performed by IBM SPPS software v.20, with the statistical difference being accepted if the p-value was less than 0.05.

3. Results

3.1. The Awareness of People About Climate Change and Natural Hazards

In Da Nang city, the proportion of people who heard information about climate change and relevant terms (Q1) was 50.78%, 54.44%, 52.55%, and 57.71% for rural, coastal, high urbanization, and old city zones, respectively (Fig. 2). However, the difference among city zones was not observed this variable ($\chi2$=8.5, p=0.2, Table 3). Similar to Q1, the pattern of Receiving information on climate change and natural hazards (Q10) was insignificant in city areas ($\chi2$=6.6, p=0.359, Table 3). The highest proportion of people who received climate change information from local people was observed in the coastal zone (69.14%), whereas the lowest was in a rural area (62.95%) (Fig. 3).

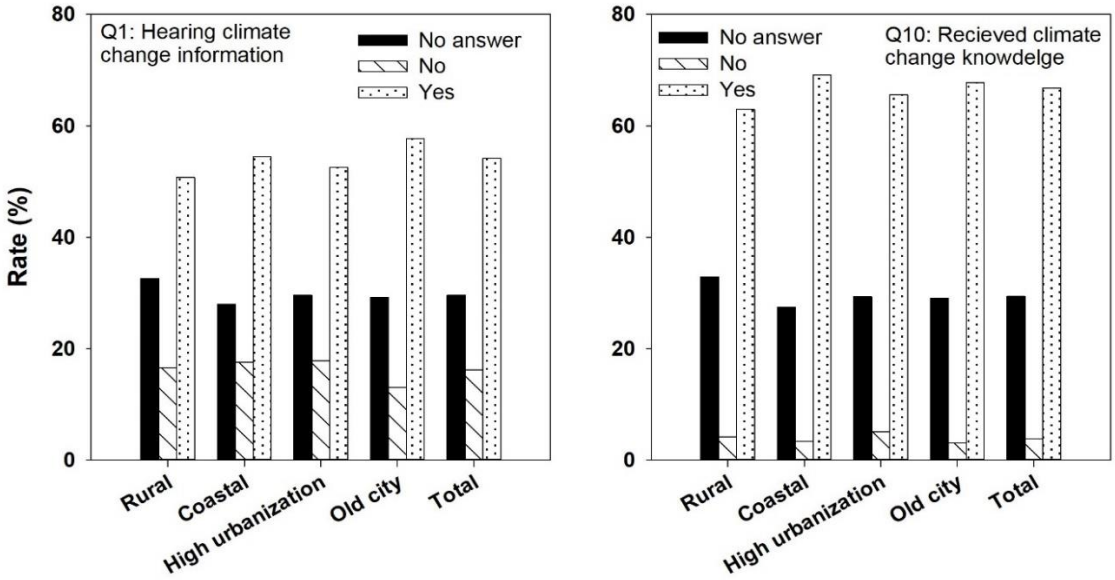

Figure 2. The understanding of climate change and relevant terms in Da Nang city.

The most dangerous hazard in Da Nang city is typhoons, which is clearly described in the Q2 question of questionnaire ($\chi2=50.3$, $p<0.001$, Fig. 3, Table 3). The 69.10 percent of interviewed households in Da Nang ranked typhoons as the top dangerous hazards, with the highest values observed in high urbanization and coastal areas. The second hazardous hazard identified was flooding, impacting 11.1 percent of the households surveyed. Salt intrusion, erosion, and drought also had minor effects on most households in Da Nang, as revealed by the survey results. Flooding, salt intrusion, and erosion concentrated near riverbanks in rural and high-urbanization areas. The Q4 questionnaire results showed that more than 90% of interviewed households in Da Nang had damaged assets by typhoons with various levels. The spatial difference was also observed in the Q4 question, with 98.9 percent of households in rural areas answering that their properties were damaged by typhoons. In contrast, this variable was 91.7 percent in the Old city. Consistent with the above variable, the spatial differences were observed in the Q3 (Change intensity of typhoon in last ten years) question ($\chi2=29.7$, $p=0.003$, Table 3).

Table 3. The differences among city zones in the questionnaire

Questions	χ^2 value	df	p	n
Q1	8.544	6	0.2	1903
Q2	50.327	18	<0.001	1903
Q3	29.678	12	0.003	1903
Q4	28.654	3	<0.001	1903
Q5	81.8	15	<0.001	1903
Q6	73.742	9	<0.001	1903
Q7	37.315	6	<0.001	1903
Q8	28.085	6	<0.001	1903
Q9	48.458	6	<0.001	1903
Q10	6.601	6	0.359	1903

Most people in Da Nang city judged that the power of typhoon has been increased in the last 10 years with the highest rates observed in high urbanization and the lowest rates in the Old city zone. Overall, Results showed that the people in the coastal and rural areas showed an elevated level of awareness about climate change and natural hazards of local people. In contrast, the lowest was the high urbanization area. The spatial variation of questionnaire results was observed in the present study, which supported our hypothesis about the influences of city location on people's awareness.

3.2. Responsiveness of the Local Community to Climate Change and Natural Hazards

Applying the engineering method is an effective way to face climate change-induced hazards in the coastal area. The study results showed that 97.2 percent of interviewed households used more than one engineering method to prevent impacts from natural hazards. The standard engineering methods include fastening the house with solid wire, raising the house floor, building typhoon rescue tunnels, upgrading house grade, and rebuilding typhoon-resistant houses. In the old city, the rate of interviewed households with unassigned engineering prevention methods was highest. In contrast, the lowest is a rural area (Fig. 4). The spatial variation among city zone was also observed in questionnaire results ($\chi2=81.8$, $p<0.0001$, Table 3). Following the above question, the results for assessing the effectiveness of engineering methods showed that most people considered these methods relatively efficient in Da Nang city. In the Old city, 37.8 percent of interviewed households ranked "efficient" for these engineering prevention methods. In contrast, it drops down to 23.8 percent in the rural area ($\chi2=73.7$, $p<0.0001$, Table 3, Fig. 3). The patterns of interviewed results about engineering methods showed that these methods play essential roles in responding to impacts of climate change-induced natural hazards in Da Nang. The spatial variation in results also reflected the differences in awareness of local people about climate change and natural hazards.

The training course in disaster prevention was also an important solution to respond to

climate change. But, approximately 83.7 percent of local people did not care about these classes in Da Nang city. The statistical difference among city zone was observed in households participating in disaster prevention class ($\chi2$=48.5, p<0.0001, Table 3, Fig. 4). The highest rate was observed in a rural area with a value of 26.4 percent, whereas the lowest was 11.5 percent in the Old City.

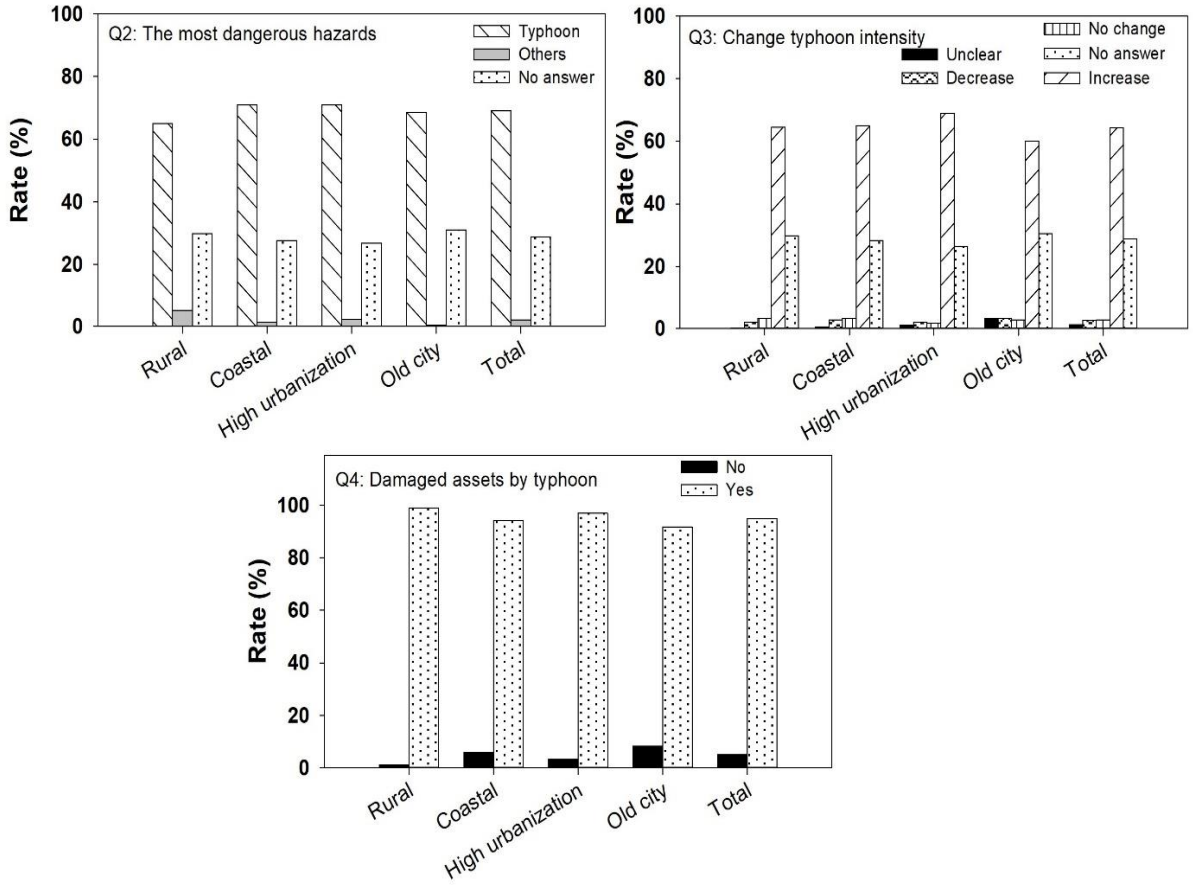

Figure 3. The spatial differences in questionnaire results about the impacts of typhoons in Da Nang city.

In response to climate change and natural hazards, the community established a local fund in Da Nang City, and local committees managed the donation and usage of this fund. The interview results showed that more than 91.5 percent of households donated to local disaster prevention funds, with the highest rate observed in the coastal area. Although the donation rate for the local fund is relatively high in Da Nang City, there was a statistical difference among city zones based on the interviewed data ($\chi2$=37.3, p<0.0001, Table 3, Fig. 5). The percentage of households receiving local funds was significantly lower compared to donations, with an average of 14 percent in Da Nang city (Fig. 5). The highest rate of households receiving local funds was 19.2 percent in a rural area, while the lowest was 11.9 percent in the Old City. The proportion of households receiving local disaster prevention funds varied significantly across different city zones in Da Nang ($\chi2$=28.2, p<0.0001, Table 3, Fig. 6). These findings suggest that residents in the Old City area are less proactive in responding to climate change and natural hazards compared to those in other areas.

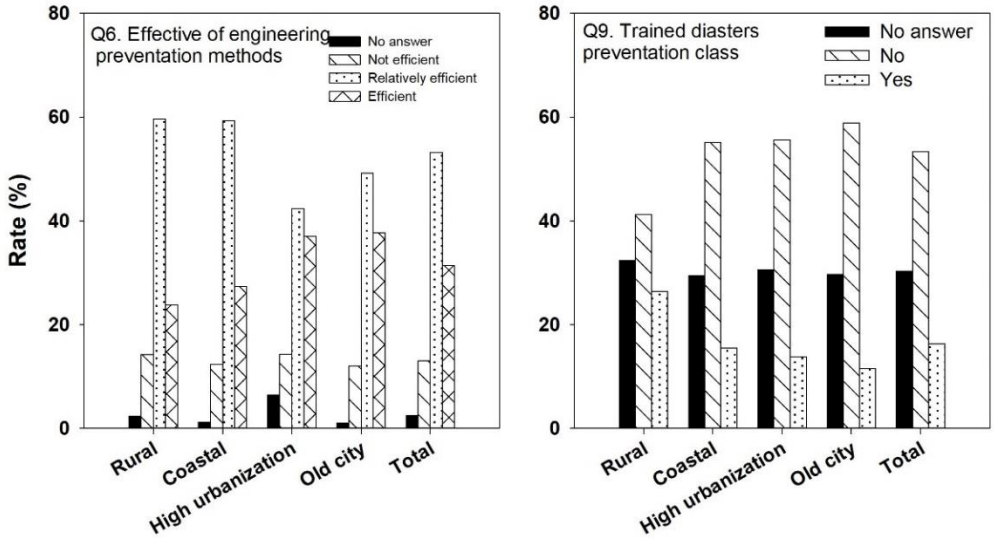

Figure 4. The effectiveness of engineering disaster prevention methods (Q6) and proactive training disasters prevention class (Q9) in Da Nang city.

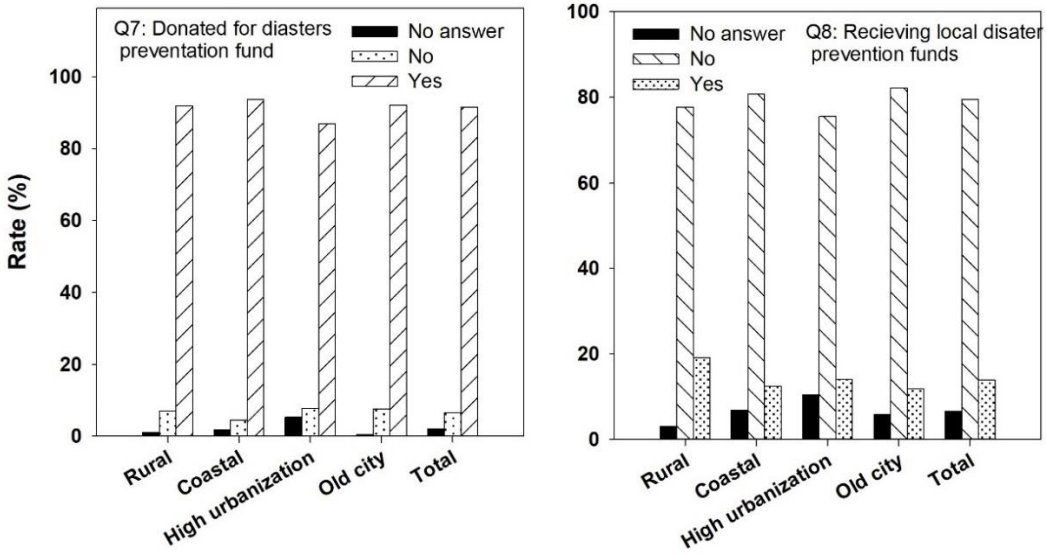

Figure 5. The spatial differences in Donation and Receiving rates of local disaster prevention funds in Da Nang city.

4. Discussion

4.1. Pattern of Climate Change and Hazard Response at the Household Level

The results of the present study showed clear patterns of local people's awareness of climate change and natural hazards. Individuals living in the Old city and coastal areas demonstrated a greater awareness and were more likely to receive information about climate change compared to those in rural and highly urbanized areas. These differences can be attributed to variations in wealth, housing conditions, durable assets, and insurance coverage between urban and rural areas in Da Nang [12]. The present

results are consistent with a previous study's suggestion that the economic level is a major influenced factor in climate change response [16]. Thus, low-income households are highly vulnerable to the impacts of climate change and natural hazards [1, 17]. The low-income households covered less than 20% of total households in Da Nang [12], nevertheless they are relatively highly vulnerable and have low resistance and recovery to climate change and natural hazards impacts [17, 18]. Even though Da Nang city is the most developed city in Central Vietnam with many priority projects for enhancing infrastructure, healthcare, and sustainability, the solutions for the above issues are challenged in future development and planning in the context of climate change.

Engineering disaster prevention methods such as enhancing house structures, building typhoon shelters, developing irrigation and drainage systems, and constructing dykes and dams were ranked as the most effective ways to respond to climate change and natural hazards impacts in Da Nang city. The findings showed that addressing climate change in this area required improvements to infrastructure, hazard prevention systems, and residents' quality of life. However, the challenges posed by variations in housing design features, the impacts of natural hazards, and uncertain climate change scenarios in Da Nang have made it difficult to implement effective response strategies, which has affected the outcomes at the household level [19, 20]. In developing countries, the other lenient climate change and natural hazards responding method was training local people for proactive response to disasters [9, 21]. The current findings indicate that while most households in Da Nang exhibit a relatively high capacity for responding to and adapting to disasters, there is a lower participation rate in disaster prevention classes. The low participation rate in classes in Da Nang city may be attributed to three main reasons. Firstly, the high awareness and education level of local residents may lead to decreased interest in these classes. Secondly, the quality of the classes may be lacking, providing little information for local people. Lastly, the low participation rate may be due to weak promotion by the local government. The study does not identify the primary cause of the issue, but it suggests that low participation in disaster prevention classes could hinder households' capacity to adapt to climate change in Da Nang city [22].

The local community's disaster prevention fund is an innovative solution to adapt to natural hazards and climate change in Da Nang City. Although all areas in Da Nang City demonstrated relatively high donation rates, the higher rates of donation in the Coastal and Old City areas may be linked to the economic circumstances of households. However, the utilization rates of using disaster presentation funds were highest in areas with high levels of urbanization rather than in rural areas. This trend could be attributed to increasing urbanization in Da Nang city, leading to unequal income and response capacities among households [20]. The other reason is the high construction rate in this area, which led to numerous environmental and accident issues under the impacts of typhoons and natural hazards such as flooding, erosion, and environmental pollution. Consequently, poor households in this area receive more support from the local fund than the others. Poor households are high vulnerability to the impacts of natural, social, and economic changes due to a lack of livelihood and dependency on natural resources [12, 23-25].

The patterns of the above results showed the roles of local institutions and households in responding to climate change in coastal areas. The climate change adaptation and mitigation strategies should be varied by groups, focusing on enhancing each individual's adaptive capacity, human security, and local institutions [4, 24]. Thus, the adaptive policies should address the differentials of climate change response among urban and rural zone to improve their efficiency [26]. The other reason for these differences was the influencing of residents' local cultural dynamics and ethics [27]. Da Nang

city is recognized as one of the most high-quality living conditions in Vietnam, with friendly people and sound governance systems [12, 13]. Therefore, the local people may easily share and assist the others, represented through a local community fund. The variations in responding to climate change in Da Nang are consistent with the previous study in Indonesia [10], which suggested that each local group will require differentials of support for enhancing their capacity to respond to climate change impacts.

4.2. Enhancing the People's Awareness of Responding to Climate Change in the Coastal City

People's awareness is important in enhancing climate change adaptation activities at community and country levels [5, 9, 28]. In the present study, household awareness about climate change and natural hazards is relatively high, indicating the potential high engagement and perceptions at the household level. At the community level, the vulnerability and risks from climate change can be assessed and recognized by various parameters [25, 29]. However, there are still significant gaps in addressing the impacts at household levels, particularly in ranking the local people's awareness of climate change. Most of the surveyed households in Da Nang showed a decent understanding of climate change, natural hazards, and their relevant impacts, indicating the efficiency of the local government propagation system for transferring climate change information to a person [19]. Additionally, the living conditions of each household may have played a role in their awareness levels. Residents of the Old city zone and Coastal areas tend to have more information compared to those in rural and highly urbanized areas. Coastal areas, known for tourism, are particularly susceptible to climate change and natural hazards [14, 19], leading to a higher climate change awareness among local residents. Furthermore, differences in household income among city zones may also contribute to varying levels of awareness, with the high-income zone demonstrating the high level of awareness regarding climate change and natural hazards.

Even though the previous study showed that typhoons and floods are the most impacted hazards in Da Nang city [12], the surveyed results reflected the different patterns at the household level. More than 60% of local households considered typhoons the most dangerous natural hazard. The households ranked floods as the most dangerous hazard, especially in areas near rivers that are highly vulnerable to flooding. A smaller number of households considered drought and erosion to be significant hazards. This pattern suggests that local awareness of climate change and natural hazards is influenced by the environment and infrastructure characteristics of the surrounding area. The climate change scenarios of Vietnam showed that the intensity and frequency of typhoons and heavy rain would increase in Da Nang city in the future [2]. It means that the loss and damage caused by natural hazards will increase significantly by climate change effects. The frequency of severe typhoons in Da Nang was approximately stable for 25 years, seriously damaging household assets [19]. However, the local people noticed that they had been severely impacted by typhoons, with more than 90% answering that they were losing assets. Interestingly, the climate change awareness of local people in Da Nang was relatively high, with over 80% of people acknowledging the recent increase levels of typhoon occurrences. These patterns suggest that the local people are relatively vulnerable to climate change impacts, and indigenous knowledge of local people will be crucial for climate change adaptation. Thus, the adaptation strategies in Da Nang must be developed from the household to community level rather than top-down policing control.

The finding from the present study suggested that to enhance people's awareness and responsiveness to climate change in Da Nang city, the future city planning and development strategies in Da Nang should be integrated below solutions: i) Enhancing the effectiveness of the

local community's disaster prevention fund and improving the housing structure of low-income households; ii) Improving the quality and propagating of proactive disaster prevention classes to increase household participation; iii) Applying the engineering disaster prevention methods or resettling vulnerable households in high-risk areas, such as those near rivers and estuary islands in the northern part of Da Nang; and iv) Developing and strengthening climate change mitigation and adaptation policies and strategies at the household and community levels, focusing on spatial variability among natural, social, and human systems.

5. Conclusions

The study has demonstrated that the urbanization level are major influencing factors of people's awareness and responsiveness to climate change impacts and natural hazards in Da Nang city, Vietnam. The results showed that community living in areas with robust infrastructure and high economic status demonstrate greater awareness of climate change and natural disasters compared to others. Analysis of household survey data revealed that there is statistically significant difference in the responsiveness of local residents from various areas of Da Nang city. These differences could potentially influence climate change awareness at both household and community levels. The results also suggested that integrating climate change adaptation solutions, enhancing the use of local community funds, and sharing knowledge are effective ways to respond to climate change and natural hazards impacts in Da Nang city. The patterns are essential in developing future climate change adaptation and mitigation strategies in Da Nang city. It is recommended that the government formulates strategies and policies grounded in bottom-up planning at the household and local community levels, as opposed to top-down authoritarian decisions.

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