

Application of livelihood vulnerability index in evaluating household's livelihood vulnerability to climate change in Can Gio district, Ho Chi Minh city, Vietnam

Nguyen Phuong Tan Le¹, Nguyen Khoi Dao^{2*}

¹Faculty of Environment and Natural Resources, Ho Chi Minh City - University of Technology, 3 Ly Tu Trong Street, Ben Nghe Ward, District 1, Ho Chi Minh City, Vietnam

²Faculty of Environment, University of Science, Vietnam National University - Ho Chi Minh City, 3 Ly Tu Trong Street, Ben Nghe Ward, District 1, Ho Chi Minh City, Vietnam

Received 12 November 2019; revised 6 December 2019; accepted 4 March 2020

Abstract:

Climate change is a global problem; however, its effects vary from region to region, country to country, district to district, and community to community. Climate change has profoundly impacted the livelihoods of households reliant on climatic conditions in Vietnam's coastal regions, both directly and indirectly. This research employs the livelihood vulnerability index (LVI) to gauge household vulnerability to climate change effects in one of Vietnam's most vulnerable regions - the Can Gio coastal district of Ho Chi Minh City. Through a survey encompassing 107 households across six communes and one town within Can Gio, LVI assessments were conducted at both district and commune levels. Findings indicate a moderate vulnerability level for Can Gio district (LVI=0.303), with Ly Nhon commune (LVI=0.334) emerging as the most vulnerable among the surveyed areas. Furthermore, livelihood strategies (0.516), socio-demographic profiles (0.391), and food security (0.385) significantly contribute to determining livelihood vulnerability across the seven surveyed communes. This study underscores the urgency of addressing climate change impacts on coastal livelihoods and highlights the nuanced vulnerabilities within specific communities, providing insights crucial for targeted adaptation and resilience-building efforts in vulnerable regions.

Keywords: Can Gio, climate change, livelihood vulnerability, LVI.

Classification number: 5.2

1. Introduction

Climate change is a global problem; however, its effects vary from region to region, country to country, district to district, and community to community [1]. The negative effects of climate change and climate variability has become an environmental and socio-economic problem that increasingly causes climate-related hazards to people around the world [2]. The poor and farming communities of developing countries are among the most influenced by climate change because they have a low adaptive capacity [3]. Therefore, the improvement of vulnerability assessment methodologies and the resulting adaption policies have become important.

In recent years, many studies using the LVI developed by M.B. Hahn, et al. (2009) [4] has been a popular approach to assess a household's vulnerability to climate change and variability. For example, G.M. Alam (2016) [5] used LVI to assess the vulnerability of riverbank erosion and its impact on the food security of rural households in Bangladesh. D.T. Adu, et al. (2018)

[2] applied LVI to assess the vulnerability of farming households to climate change in the Brong-Ahafo region of Ghana. Additionally, J. Panthi, et al. (2015) [3] assessed the livelihood vulnerability of 543 households living from mixed agro-livestock in Nepal using LVI. Therefore, LVI has been proven as powerful approach to assess household vulnerability to climate change in many regions around the world.

Ho Chi Minh city is regarded as one of the top 10 cities in the world to be severely affected by climate change due to its location in the intra-tropical delta zone and its low elevation [6]. The Can Gio district is a coastal area with mangrove forests, which is a biosphere reserve listed by UNESCO and is an essential part of Ho Chi Minh city. The main livelihoods of the local people are shrimp farming, aquaculture, near-shore fishing, and salt production for the coastal poverty, which attracts about 70% of the commune's workforce [7]. However, this area will become one of the most severely affected areas by climate change and sea level rise [6]. Additionally, the livelihood vulnerability of households to climate

*Corresponding author: Email: dnkhai@hcmus.edu.vn

change is not well documented in this area. Thus, the identification of the livelihood vulnerability of the local people and adaptation strategies must be investigated to respond to these natural hazards.

The objective of this study is to assess the livelihood vulnerability of the local people to climate change in the Can Gio district of Ho Chi Minh city. Seven communes, namely, Ly Nhon, Long Hoa, Tam Thon Hiep, An Thoi Dong, Thanh An, Binh Khanh, and Can Thanh town, were selected for the present study.

2. Study area

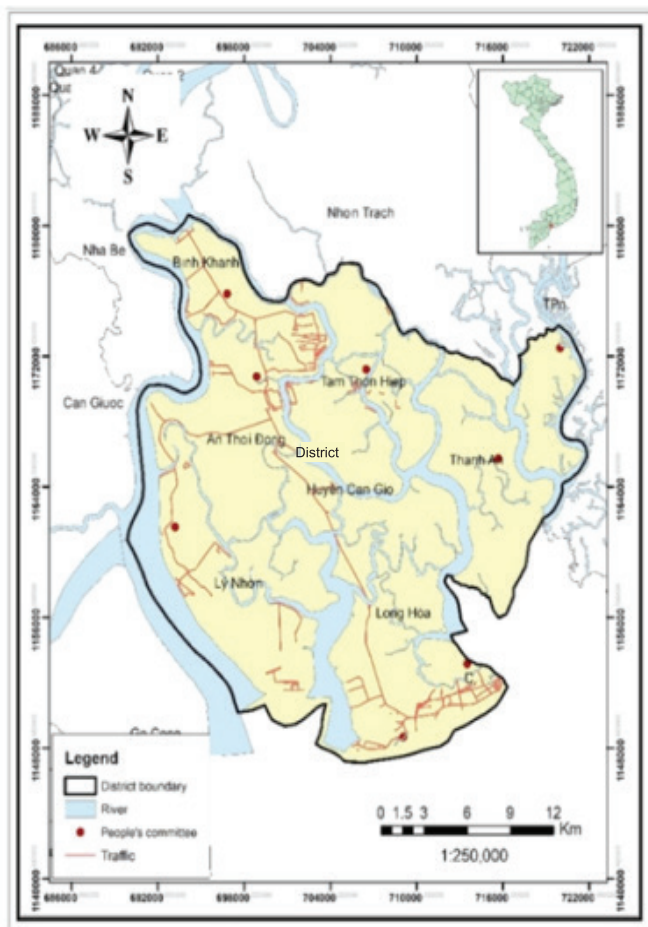


Fig. 1. Location of the study area.

Can Gio, located in the southeast of Ho Chi Minh city, is a suburban coastal district. The district is approximately 50 km away from the city centre. It has an area of 704 km² and it is located between latitudes 10°22'14" to 10°40'00" N and longitudes 106°16'12" to 107°00'50" E (Fig. 1). The Can Gio district has 20 km of coastline and a mangrove forest with a dense river and

canal system that creates a rich, biodiverse ecosystem with many special species. As a result, the local people mainly depend on aquaculture, near-shore fishing, salt production, forest management, and tourist services for their income. Besides, other livelihood activities include orchard and rice farming that are also important to the local people [7]. The weather conditions of the Can Gio district is typical for tropical monsoonal zones and has two distinct seasons: the rainy season and dry season. The annual average temperature is 25.8°C and monthly averages range between 25.5 and 29.0°C.

3. Methodology

3.1. LVI

The LVI developed by M.B. Hahn, et al. (2009) [4] includes seven major components, namely, the socio-demographic profile (SDP), livelihood strategies (LS), social networks (SN), health (H), food (F), water (W), and natural disaster and climate variability (ND). Each major component is made up of several sub-components or indicators. Table 1 presents the major components and sub-components used in this study. As the sub-components were assessed on a different scale, it is therefore necessary to standardize the sub-components as an index using the following equation:

$$\text{Index}S_c = \frac{S_c - S_{\min}}{S_{\max} - S_{\min}} \quad (1)$$

where S_c is the observed sub-component of an indicator for the household and $S_{\min}$ ($S_{\max}$) are the minimum (maximum) values.

After each sub-component is standardized, the major component is calculated by an average of the sub-components following the equation:

$$M_{jc} = \frac{\sum_{i=1}^n \text{index}S_c}{n} \quad (2)$$

where n is the number of sub-components in each major component and M_{jc} is the value of major component, j , for community, c .

The LVI for each commune can be calculated using the following equation:

$$LVI = \frac{\sum_{i=1}^n w_{Mi} M_{ic}}{\sum_{i=1}^n w_{Mi}} \quad (3)$$

where w_{Mi} is the weight of each sub-component that makes up each major component, and are included to ensure that all sub-components contribute equally to the overall LVI. The LVI was scaled to a range from 0 (least vulnerable) to 1 (most vulnerable) [8].

Table 1. Major components and sub-components comprising the LVI developed for the Can Gio district.

Major components	Sub-components	Unit	Explanation of sub-components in relationship with LVI
SDP	Dependency ratio (SDP1)	-	Higher value indicates less capacity to adapt
	Percentage of female-headed households (SDP2)	%	Women typically have less adaptive capacity. Higher value indicates less capacity to adapt
	Percentage of household heads who have not attended school (SDP3)	%	Education makes people more aware and able to adjust to changes in environmental condition. Higher value indicates less capacity to adapt
SN	Percentage of households having access to local governments for assistance in the past 12 months (SN1)	%	The assistance from local government strengthens adaptive capacity. Higher value indicates less vulnerable
	Percentage of households that can borrow money from friends, neighbors, or relatives (SN2)	%	Higher value indicates less vulnerable
	Percentage of households which can't access social networks (SN3)	%	Higher value indicates more vulnerable
LS	Percentage of households with family member working jobs outside their communes (LS1)	%	Income diversification increases adaptive capacity. Higher value reflects more capacity to adapt
	Percentage of households depending solely on one source of income (LS2)	%	Higher value reflects less capacity to adapt
	Livelihood diversification (LS3)	-	Higher value reflects more capacity to adapt
F	Percentage of households depending only on family farms for food (F1)	%	High sensitivity because limited source for food. Higher value indicates more vulnerable
	Crop Diversification Index (F2)	-	Higher value indicates less vulnerable
	Percentage of households struggling for food (F3)	months	Higher value indicates more vulnerable
W	Percentage of households using natural water sources (W1)	%	Higher value indicates more vulnerable
	Water source diversity index (W2)	-	Higher value indicates less vulnerable
	Percentage of households without a consistent water supply (W3)	%	Higher value indicates more vulnerable
	Average water storage volume (W4)	m ³	Higher value indicates less vulnerable
H	Average time to health facility (H1)	min	Higher value indicates more vulnerable
	Percentage of households with family member with chronic illness (H2)	%	Higher value indicates more vulnerable
	Medical expenses in the recent year (H3)	1000 VND/yr	Higher value indicates more vulnerable
ND	Percentage of households not having access to warning system of natural disasters in the past 6 years (ND1)	%	Higher value implies higher exposure
	Percentage of households having family member injured or death as a result of a severe natural disaster in the past 6 years (ND2)	%	Higher value implies higher exposure
	Percentage of households whose house is destroyed or heavily damaged by a natural disaster in the past 6 years (ND3)	%	Higher value implies higher exposure
	Average number of rainy days with extreme rainfall (rainfall amount >50 mm) (ND4)	days	Higher value implies higher exposure
	Mean standard deviation of monthly precipitation. (ND5)	-	Higher value implies higher exposure

Table 2. LVI's major components for six communes and one town in the Can Gio district.

	Binh Khanh	Can Thanh town	Ly Nhon	Thanh An	An Thoi Dong	Tam Thon Hiep	Long Hoa	Can Gio district
SDP	0.396	0.334	0.316	0.441	0.382	0.463	0.402	0.391
SN	0.286	0.256	0.156	0.330	0.222	0.284	0.237	0.254
LS	0.540	0.500	0.556	0.489	0.489	0.568	0.470	0.516
F	0.296	0.363	0.393	0.467	0.374	0.416	0.385	0.385
W	0.006	0.061	0.492	0.259	0.234	0.120	0.080	0.187
H	0.387	0.250	0.272	0.140	0.314	0.316	0.305	0.283
ND	0.168	0.208	0.188	0.198	0.208	0.202	0.228	0.208
LVI	0.286	0.269	0.334	0.318	0.307	0.319	0.288	0.303

3.2. Data collection and analysis

In this study, survey data and rainfall data were collected. The survey data was gathered from a household questionnaire survey developed by the authors. The structured questionnaire was designed based on the LVI's major components and sub-components mentioned in Table 1. The initial questionnaire was pre-tested by interviewing 10 random households in the study area and then the final version of questionnaire was developed to mirror the local realities of the household's livelihood vulnerability to climate change. Lastly, a household survey was conducted with 140 households who were randomly selected in six communes and one town of the Can Gio district in April 2019, where 20 households in each commune were surveyed. Household heads or other experienced members of the selected households were considered for the survey. However, there were 33 visited households who were not eligible or refused to be interviewed. The refusal rate was 24%. Finally, the survey results were analysed based on a total of 107 respondents from the surveyed areas. Rainfall data in the period of 1980-2017 at the Tam Thon Hiep and Can Gio stations were collected from Hydro-Meteorological Data Centre of Vietnam.

Data were inputted, checked, and analysed using Microsoft Excel (Version 2016). Households with missing data were rejected based on a simple deletion approach [9].

4. Results and discussion

Table 2 shows the results of seven of the LVI's major components and the LVI of the six communes and one town in the Can Gio district. The results indicate that the

vulnerability of the Can Gio district is moderate based on the LVI vulnerability scale of 0 to 0.5. In terms of the commune scale, the LVI values indicated that the most vulnerable commune is Ly Nhon (LVI=0.334), followed by Tam Thon Hiep (LVI=0.319), Thanh An (LVI=0.318), An Thoi Dong (LVI=0.307), Long Hoa (LVI=0.288), Binh Khanh (LVI=0.286), and Can Thanh town (LVI=0.269).

4.1. Livelihood's vulnerability in Can Gio district

Figure 2 illustrates a spider diagram for the seven major components of the LVI for the Can Gio district. There are three major components that increase the livelihood vulnerability of the district, namely, livelihood strategies (0.516), socio-demographic profile (0.391), and food (0.385). In addition, the major component of water (0.187) has the lowest vulnerability.

There were approximately 73.2% households of farmers in the Can Gio district that depend solely on their

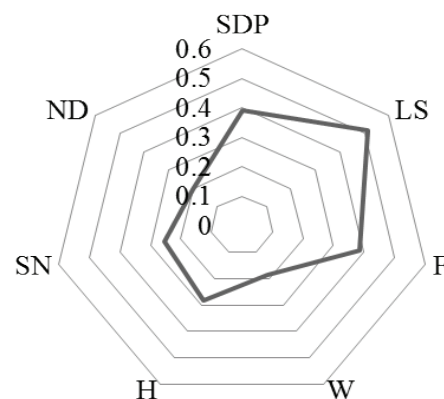


Fig. 2. Vulnerability spider diagram of LVI major components for Can Gio district.

farm and have a low diversification of income sources. Most of these families are supported by one main job, which is their farm of either fish, shrimp, mollusks, fruit trees, or salt. Therefore, they do not have any other source of income to replace losses due to climate change. The socio-demographic profile is also at an average vulnerability level when the head of household has not completed high school or attended any professional or technical institutions. According to R. Muttarak et al. (2014) [10], education plays an important role in the reduction of adverse effects of extreme climate events in direct and indirect ways. Formal education is considered as an essential method where a person can apprehend knowledge, skills, and abilities that can positively affect their adaptive capacity. Thus, when the head of household has a good education, their adaptive capacity improves, which mitigates their vulnerability in the Can Gio district. Lastly, food is an issue in this district because some households cannot guarantee a food source through a time period where a loss of income occurs due to extreme weather events, for example, due to lack of crop diversification and limitations in government policies for supporting food sources through the extreme weather conditions.

Livelihood vulnerability of 6 communes and 1 town

Figure 3 illustrates in detail the vulnerability of livelihoods in the 6 communes and 1 town. Through this figure, it is easy to recognize three contributing factors to LVI, namely, LS, SDP and F, which need special attention for all the surveyed areas.

Firstly, on livelihood strategies, this contributing factor shows the most vulnerability for all the communes and town surveyed, in which Tam Thon Hiep, Ly Nhon, and Binh Khanh communes are three most vulnerable with a levels of 0.568, 0.556, and 0.540, respectively (Table 2). Particularly, the aspect of livelihood strategies seems to be important in the Can Gio district. Most farmers in the area depend solely on one source of livelihood which makes all farmers vulnerable when climate directly affects their source of income. For example, ocean salinity, temperature changes, and the death of shrimp or fish heavily influence their source of income. Therefore, it is better to have a diverse source of income to ensure the stability of their earnings.

Secondly, on the socio-demographic profile, the figure also reveals that the two most vulnerable communes to this contributing factor are Tam Thon Hiep and Thanh An (0.463 and 0.441, respectively), however, other four communes and town still need attention because their

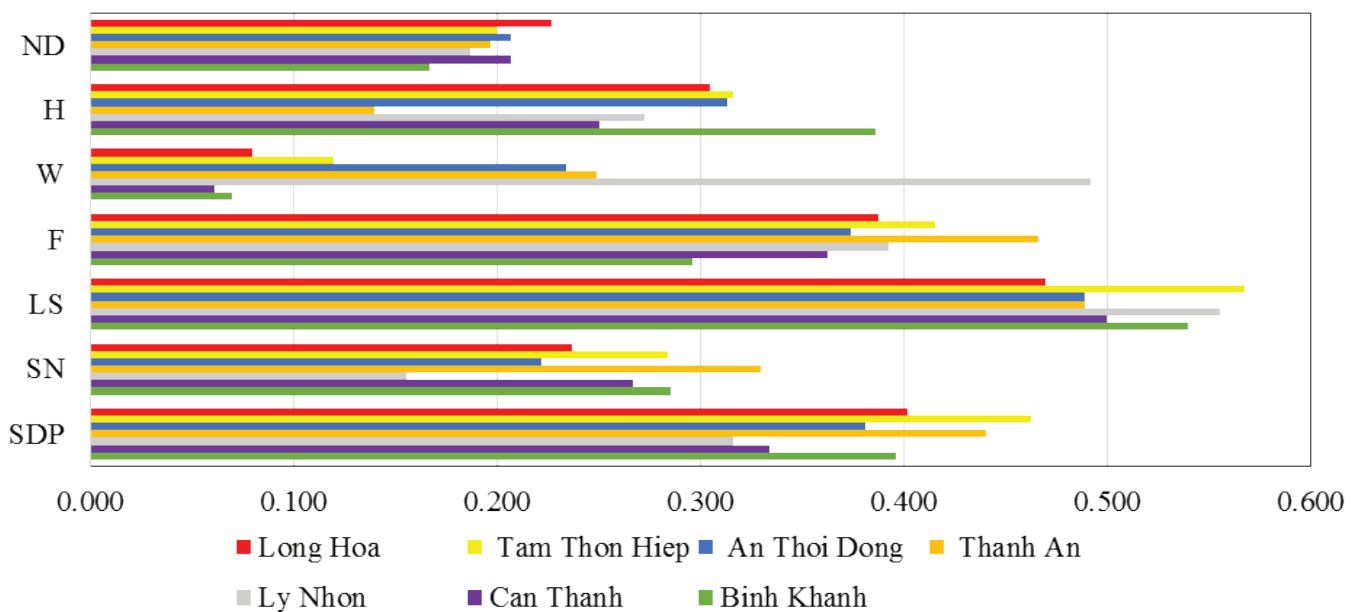


Fig. 3. Contributing factors of LVI for 6 communes and 1 town in Can Gio district.

vulnerability is relatively high. After the interviews, this study showed the key factor influencing socio-demographic profile is that most heads of household didn't finish high school or did not attend any professional institutions. Instead, the participants in the study believed their jobs require experience from the elders of the community that is passed down through generations, and that they need to spend time on their farm all day.

Thirdly, on the contributing factor of food, Fig. 3 shows that all surveyed regions need more attention in this area because their vulnerability reaches the average level, in which Thanh An is considered as the most vulnerable commune. Many households in Thanh An claimed that although they have diverse sources of income to fulfil their living requirements in recent years, their sources of income could not guarantee stability of their food sources. Thanh An is popular for oyster farming. However, oyster death due to high salinization or being a size too small for sale, will put farmers at risk of income loss.

Furthermore, the contributing factor of water seems to be extremely critical in Ly Nhon. In this commune, most households live far from the main street, where the water exists, which leads to a lack of water that severely affects the lives of the local people. Therefore, Ly Nhon is a commune that needs more water support than the others. Additionally, Thanh An and parts of An Thoi Dong commune share the same problems.

Finally, on health and natural disasters, this contributing component shows a low vulnerable level because the local people of all communes and town are well experienced in responding to natural disasters or extreme weather events. Besides, there are many hospitals nearby and good health insurance services. Although the precipitation extremes in terms of intensity and frequency are increasing trends [11], according to interviewed households, there were not many people suffering an injury, death, or severe damage as a result because they had adequate preparation plans by themselves or with help from the local government. Good preparation can help the local people react better to natural disasters.

In general, it is necessary to have appropriate policies

for these study areas. For Ly Nhon, the order of priority for support policies is as follows: livelihood strategies > water > food > socio-demographic profile > health > natural disaster > social networks. For Tam Thon Hiep, the priority is proposed as follows: livelihood strategies > socio-demographic profile > food > health > social networks > natural disasters > water. Likewise, for Thanh An: livelihood strategies > food > socio-demographic profile > social networks > water > natural disasters > health.

5. Conclusions

In conclusion, this study investigated the livelihood vulnerability of households to climate change in Can Gio district, Ho Chi Minh city by using the LVI. The main results can be summarized as follows: (1) the LVI estimates the vulnerability of the Can Gio district to be at a moderate level (0.303); (2) of the 6 communes and 1 town surveyed, Ly Nhon is the most vulnerable commune because of a lack of stable water sources, poor livelihood strategies, and problems with maintaining their food source through extreme weather events; (3) the factor of livelihood strategies is the most vulnerable component over all of the district. This study recommends replicating this research to investigate the change of climate effects in the area over time.

The limitation of the LVI approach is the challenge in the selection of appropriate sub-components used in vulnerability indices [12], and the local environment plays a significant role in forming and designing the indicators [3]. Thus, designing the sub-components of the vulnerability indices requires an extensive literature review, expert consultation, and stakeholder consultation [12]. The LVI approach indicates different sectors and aspects of vulnerability, so this approach can be used with other communities and also to assess the performance of programmatic interventions with goals to reduce vulnerability and highlight potential sectors requiring intervention.

CRedit author statement

Nguyen Phuong Tan Le: Data analysis and interpretation, Writing and manuscript revising; Nguyen Khoi Dao: Method, Data analysis and Writing.

ACKNOWLEDGEMENTS

This research is funded by Ho Chi Minh city's Department of Science and Technology (HCMC-DOST) under grant number '143/2017/HD-SKHCN'.

COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

REFERENCES

- [1] W.N. Adger, N. Brooks, G. Benthaml, et al. (2004), "New indicators of vulnerability and adaptive capacity", *Technical Report* 7, Tyndall Centre for Climate Change Research, Norwich, 128pp.
- [2] D.T. Adu, J.K.M. Kuwornu, H. Anim-Somuah, et al. (2018), "Application of livelihood vulnerability index in assessing smallholder maize farming households' vulnerability to climate change in Brong Ahafo region of Ghana", *Kasetsart Journal of Social Sciences*, **39(1)**, pp.22-32, DOI: 10.1016/j.kjss.2017.06.009.
- [3] J. Panthi, S. Aryal, P. Dahal, et al. (2015), "Livelihood vulnerability approach to assessing climate change impacts on mixed agro-livestock smallholders around the Gandaki river basin in Nepal", *Regional Environmental Change*, **16(4)**, pp.1121-1132, DOI: 10.1007/s10113-015-0833-y.
- [4] M.B. Hahn, A.M. Riederer, S.O. Foster (2009), "The livelihood vulnerability index: A pragmatic approach to assessing risks from climate variability and change: A case study in Mozambique", *Global Environmental Change*, **19(1)**, pp.74-88, DOI: 10.1016/j.gloenvcha.2008.11.002.
- [5] G.M. Alam (2016), *An Assessment of the Livelihood Vulnerability of the Riverbank Erosion Hazard and its impact on food security for rural households in Bangladesh*, University of Southern Queensland, Toowoomba, Queensland, Australia.
- [6] Asian Development Bank (2010), *Ho Chi Minh City Adaptation to Climate Change: Summary Report*, Asian Development Bank, Stock No. RPT101580.
- [7] International Union for Conservation of Nature (2013), *Building Resilience to Climate Change Impacts: Coastal Southeast Asia Can Gio District, Ho Chi Minh City, Vietnam*, International Union for Conservation of Nature.
- [8] A.T. Oo, G.V. Huylbroeck, S. Speelman (2018), "Assessment of climate change vulnerability of farm households in Pyapon district, a delta region in Myanmar", *International Journal of Disaster Risk Reduction*, **28**, pp.10-21, DOI: 10.1016/j.ijdrr.2018.02.012.
- [9] A.C. Acock (2005), "Working with missing values", *Journal of Marriage and Family*, **67(4)**, pp.1012-1028, DOI: 10.1111/j.1741-3737.2005.00191.x.
- [10] R. Muttarak, W. Lutz (2014), "Is education a key to reducing vulnerability to natural disasters and hence unavoidable climate change?", *Ecology and Science*, **19(1)**, p.42.
- [11] D.N. Khoi, H.T. Trang (2016), "Analysis of changes in precipitation and extreme events in Ho Chi Minh City, Viet Nam", *Procedia Engineering*, **142**, pp.228-234, DOI: 10.1016/j.proeng.2016.02.036.
- [12] N.T.T. Thao, D.N. Khoi, T.T Xuan, et al. (2019), "Assessment of livelihood vulnerability to drought: A case study in Dak Nong province, Viet Nam", *International Journal of Disaster Risk Science*, pp.1-12, DOI: 10.1007/s13753-019-00230-4.