

# Solutions of Apartment Building Groups Adapting to Climate Change in Thai Nguyen Province, Vietnam

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**Abstract**—The Global climate change is becoming more severe and tends to move in a negative direction, leading to the need for adaptive solutions for all sectors to mitigate and cope with extreme conditions of climate change. Among environmental solutions, the solutions of planning, designing architecture and building works play a huge role in contributing to mitigating the effects of climate change. This paper presents the climate change and its impacts on apartment building groups in Thai Nguyen province, Vietnam. After that, it is proposed to propose planning and architectural solutions to the apartment building group adapting to climate change in Thai Nguyen province, Vietnam

**Index Terms**— Climate change, Climate impacts, Apartment building groups, Adaptation solutions, Thai Nguyen, Viet Nam

## I. INTRODUCTION

Climate change is the concern of all countries in the world, of which Vietnam is one of the five countries most affected by natural disasters in the world. Natural disasters such as storms, floods, landslides, EL-Nino, and La-Nina are increasingly strongly affected. Climate change actually makes natural disasters, especially storms, floods, and droughts, increasingly fierce [2]. Research and assessment of the impacts of climate change on infrastructure, different socio-economic life to propose climate change adaptation and response measures are being implemented in many regions in Vietnam including Thai Nguyen province. In Thai Nguyen province, the trend of socio-economic development in general housing is thriving, including the form of Apartment [4]. Apartment building group according to QCVN 01: 2019/BXD includes: land acquisition area of the apartment blocks themselves, area of road and playground of the housing group, internal parking lots and garden in the housing group [6]. Studying to assess the impact of climate change on Apartment building group and proposing solutions to adapt to climate change is essential for housing in Thai Nguyen province under current conditions.

## II. RESEARCH METHOD

The paper studies climate change scenarios in Thai Nguyen province then assesses the impacts of climate change according to the effects of temperature, precipitation, flooding, drought and hail on the components of group of apartment buildings such as sound and vision, microclimate, outdoor landscape, yard, square, greenery, lawn, house structure, soundproof, heat insulation, indoor humidity, lighting, ventilation, furniture and engineering equipment [3].

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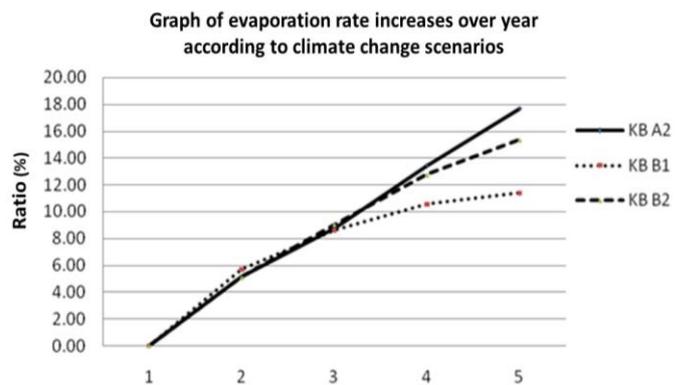
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After that, proposing solutions to adapt to climate change of apartment group in Thai Nguyen province, Vietnam.

## III. RESEARCH RESULTS

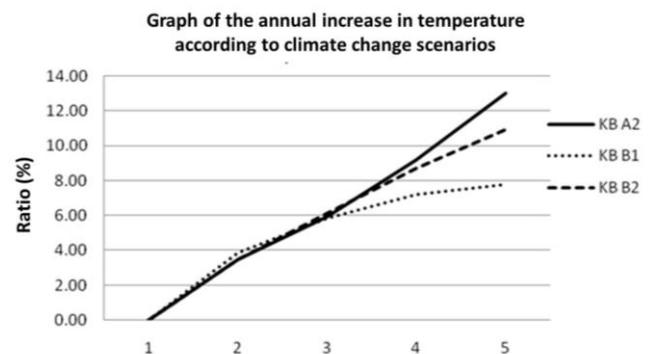
### 3.1. The Climate Change Scenario in Thai Nguyen province, Vietnam

According to the scenario of the Ministry of Natural Resources and Environment, a strong increase in temperature in Thai Nguyen leads to a gradual increase in evaporation in all scenarios: high emission scenario (KB A2), The low emission scenario (KB B1) and the medium emission scenario (KB B2) (Figure 1).



**Figure 1.** Evaporation rate increase with climate change scenarios in Thai Nguyen province [5]

According to scenario B2, for the temperature in Thai Nguyen in the period from 2020 to 2099, the annual average temperature will increase compared to the baseline period. The average temperature in the flood season and the average temperature in the dry season shows the increase respectively: 2.5 °C, 2.3 °C and 1.5 °C [1, 3] (Figure 2).



**Figure 2.** The rate of increase in temperature according to the climate change scenarios in Thai Nguyen province [5]

Annual average rainfall tends to increase in all 3 scenarios: A2, B1, and B2. However, the rainfall does not increase steadily in all months but tends to increase very strongly in the rainy season and decrease in the dry season [1, 3] (Figure 3).

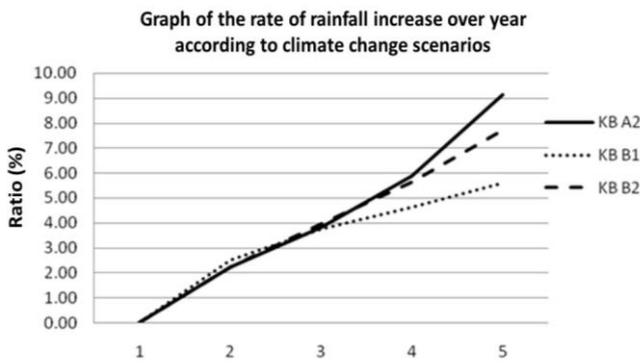


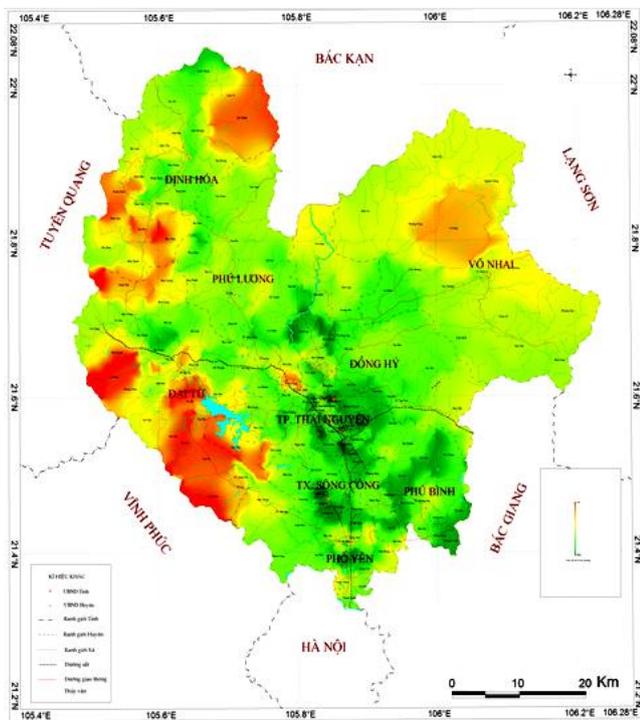
Figure 3. Increasing rainfall rate with climate change scenarios in Thai Nguyen [5]

3.2. Impacts of climate change on areas in Thai Nguyen province

In Thai Nguyen City, Song Cong City and Pho Yen District, housing groups are strongly affected by rain, storms and floods because they are located in the region with the highest rainfall distribution in the province. The phenomena of landslides, rocks, and tube floods, flash floods are not serious (Figure 4).

In the Dinh Hoa District, Vo Nhai District and Dai Tu District, Apartment building groups are severely affected by landslides and rocks, flash floods and droughts due to steep terrain and are located in low rainfall areas of Thai Nguyen province (Figure 4).

Phu Binh District is characterized by flat topography, few hills and in the average rain zone of Thai Nguyen province. Therefore, Apartment building groups in this area are less affected by extreme weather events than other areas in the province (Figure 4).



Note: The vulnerability caused by climate change decreases from red to green

Figure 4. Map of zoning vulnerability to climate change in Thai Nguyen [1]

3.3. Impact assessment of climate change on Apartment building groups in Thai Nguyen province

3.3.1. Affected by hot weather, drought

This phenomenon affects almost all components of the apartment building group, causing negative impacts on the user and the longevity of the construction. Increases cooling and water demands. In particular, the impact of increased temperature has the greatest impact on trees, flower beds, lawns, structural systems, soundproofing structures, heat insulation and humidity in the house (Table 1).

3.3.2. Affected by rain, storm, flood

The increase in temperature leads to increased evaporation, which leads to faster and larger rainfall cycles, increased storms and cyclones, and consequently landslides, rocks and trees. Affecting the daily life as well as the lives of residents and destroying buildings, trees, small landscapes ... Leading to the need to reinforce houses, raise the height of houses and floors. In particular, the impact of rain, storm, flood, and flood has the greatest impact on outdoor landscape components, yards, squares, trees and lawns (Table 1).

3.3.3. Affected by cold, damaging cold

Climate change leads to increasing hot and cold extremes of the climate, making it more extreme. Severe cold and damaging cold will last long in combination with the Northeast monsoon, affecting the lives of residents and affected animals and plants, leading to increased heating demand. In particular, the impact of cold has the greatest impact on the microclimate environment of the Apartment building groups (Table 1).

Table 1. Impact assessment, risk and vulnerability assessment of apartment building group in Thai Nguyen province

Hazards caused by climate change	Object										
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rising temperatures	Impact	*	***	**	*	****	****	****	****	****	**
	Risk / damages	*	****	***	*	****	****	****	****	****	*
	Adaptive capacity	**	*	**	**	*	*	*	**	*	*
	Vulnerability	**	***	***	**	*	***	***	**	**	***
Storm	Impact	****	****	****	****	****	****	****	****	****	**
	Risk / damages	*	*	****	*	****	****	****	****	****	****
	Adaptive capacity	**	*	**	*	**	**	**	*	**	*
	Vulnerability	**	*	***	**	***	***	**	**	**	**
Rainfall increase	Impact	****	***	**	**	****	***	***	***	***	**
	Risk / damages	*	**	***	**	****	***	***	***	**	*
	Adaptive capacity	***	**	**	**	*	**	**	**	**	*
	Vulnerability	*	**	***	**	****	**	**	**	***	***
Flood	Impact	**	***	***	***	***	***	**	**	**	***
	Risk / damages	*	**	***	***	****	**	*	*	**	**
	Adaptive capacity	***	***	**	**	**	*	**	***	**	*
	Vulnerability	*	*	***	**	***	**	**	*	**	***
Drought	Impact	*	****	**	**	****	**	***	***	***	**
	Risk / damages	*	****	**	**	**	*	**	***	***	**
	Adaptive capacity	***	*	**	**	**	**	*	*	**	**
	Vulnerability	*	***	**	**	**	*	**	***	**	**
Hail	Impact	****	****	***	***	**	**	*	**	*	*
	Risk / damages	*	*	**	**	**	**	*	*	*	**
	Adaptive capacity	*	*	**	**	**	**	**	**	**	**
	Vulnerability	*	*	**	**	**	**	**	*	*	**

Notes: (1) Sound and vision; (2) Microclimate; (3) Outdoor landscape; (4) Yard ; (5) Trees, flower beds, lawns; (6) Structure and structure of the house; (7) Indoor sound,

insulation, and humidity levels; (8) Lighting, ventilation; (9) Furniture and furniture; (10) Technical equipment; \*\*\*\*: Serious; \*\*\*: High; \*\*: Medium; \*: Short.

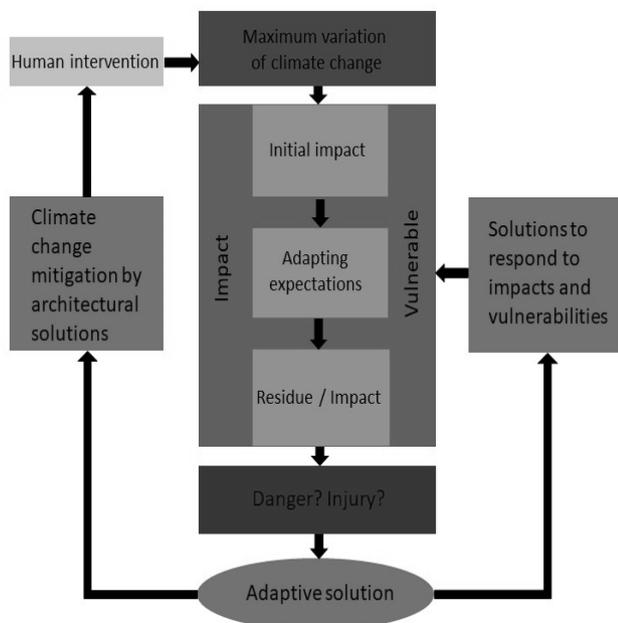
### 3.4. Proposing solutions to adapting climate change of apartment building groups in Thai Nguyen province, Vietnam

#### 3.4.1. Viewpoint

To solve the problems of the apartment group adapting to climate change, it is necessary to follow the following directions:

First, mitigate greenhouse gases by using eco-friendly architectural and planning solutions for apartment groups. Second, have plans to effectively respond to disasters caused by extreme climatic conditions.

Third, have effective solutions to cope with disasters caused by climate change with appropriate architectural solutions.



**Figure 5.** Organizational perspective of planning and architectural solutions for apartment building groups adapting to climate change

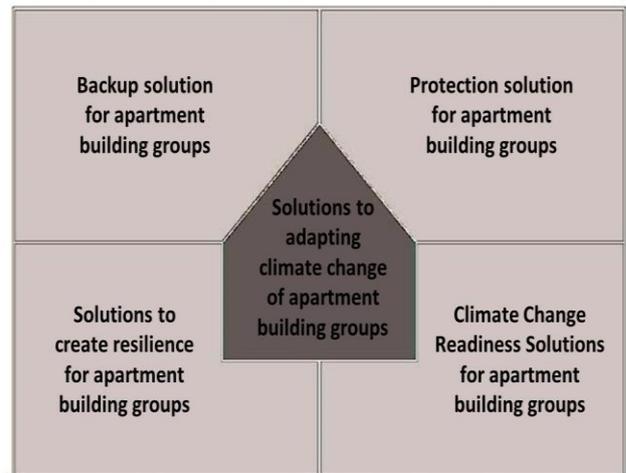
### 3.5. Backup solution for apartment building groups in Thai Nguyen province, Vietnam

Raising awareness about responding to climate change among staff in the management, planning and implementation of housing groups.

Propagating and educating about climate change adaptation and response for apartment building group residents in different forms, encouraging people to use clean energy.

In weak geological areas with frequent landslides such as Dinh Hoa District, Vo Nhai District, Dai Tu District, it is necessary to arrange relocation of the existing apartment building group and resettlement for people. And control the

foundation in apartment building group in the flooded areas to avoid flooding.



**Figure 6.** Solutions adapting to the climate change of the apartment group in Thai Nguyen province

### 3.4.3. Protection solution for apartment building groups in Thai Nguyen province, Vietnam

It is necessary to plan apartment building groups located in safe areas not affected by flood, flood, landslide, subsidence and soft ground areas. For areas of Dinh Hoa District, Vo Nhai District and Dai Tu District, avoid planning the apartment building groups on flood drainage streams and mountainous areas with slopes greater than 10%.

Increase greenery in all apartment groups to reduce urban heat island, reduce the load of heat resistance in buildings and create a healthy environment for public areas of the apartment building groups.

Enhance architectural solutions that make the most of natural light, natural ventilation and heat resistance for buildings to reduce the use of electricity to light and cool buildings.

### 3.4.4. Solutions to create resilience for apartment building groups in Thai Nguyen province, Vietnam

For flat terrain areas such as Thai Nguyen city, Song Cong city, Pho Yen district and Phu Binh district, design apartment building groups to adapt to high wind speeds and large earthquakes.

Apartment building groups need to be designed with good insulation to resist heat in the summer and keep heat in the winter in order to adapt to extreme changes in temperature during hot and cold seasons. There are solutions for storing energy, water and food in the apartment building groups to reduce the burden on public supplies. And the apartment building group has the ability to provide food and water for the residents in the event of extreme climate change.

In the apartment building group, it is necessary to arrange equipment to avoid extreme climatic phenomena of climate change such as emergency escape ladder. And arrange the space for living and playing inside the building when climatic phenomena are extremely sunny, hot and cold.

3.4.5. *Climate Change Readiness Solutions for apartment building groups in Thai Nguyen Province, Vietnam*

Establish and train response programs to extreme climatic events for all residents in the apartment building group.

Prepare preventive solutions to rescue and escape for the population when extreme climatic problems occur such as storms, earthquakes ... and establish policies to support resettlement and repair after being impacted by extreme climatic phenomena.

IV. CONCLUSION

Global climate change is becoming more and more serious and tends to go in a negative direction, leading all sectors to have appropriate and effective climate change response strategies and solutions.

Climate change has a major impact on the apartment building group in Thai Nguyen province because of changes in temperature, drought, heavy rain, storms, floods, landslides and damaging cold. Impacts particularly affect the indoor microclimate and structures of the building.

In order to adapt to the climate change apartment building groups in Thai Nguyen province needs to raise awareness for managers and residents. Identification of specific solutions suitable for prevention, protection, resilience and response to extreme climatic conditions.

ACKNOWLEDGMENT

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REFERENCES

- [1] Department of Natural Resources and Environment - Thai Nguyen (2011), *Action Plan to Respond to Climate Change in Thai Nguyen*, Thai Nguyen
- [2] Institute of Meteorology, Hydrology and Environment (2010), *Climate Change and Impacts in Vietnam*, Hanoi
- [3] Institute of Meteorology, Hydrology and Environment (2011), *Impact Assessment Guide and Identification of Adaptation Solutions*, Hanoi
- [4] National Institute of Urban and Rural Planning (VIUP) (2015), *Explanation on Adjustment of General Planning of Thai Nguyen City to 2035*, Hanoi
- [5] Ministry of Natural Resources and Environment (2016), *Climate change and sea level rise scenarios for Vietnam*, Hanoi
- [6] Ministry of Construction (2019), *QCXDVN 01: 2019 / BXD - National technical regulation on construction planning*, Hanoi

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