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Using the Socioeconomic Indicator Analysis to assess the Urban Vulnerability for Building Urban Resilience: A Case Study in Siem Reap City, Siem Reap Province

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សង្ខិត្តន័យ

ភាពធន់នឹងអាកាសធាតុនៅទីក្រុងពឹងផ្អែកលើកត្តាជាច្រើន ប៉ុន្តែកត្តាសេដ្ឋកិច្ចសង្គមទីក្រុងត្រូវបានចាត់ទុកថា ជាចន្លោះឈាមស្នូលមួយសម្រាប់ការអភិវឌ្ឍទីក្រុង និងការកសាងសមត្ថភាពបន្សាំខ្លួនដើម្បីឆ្លើយតបនឹងភាពងាយរងគ្រោះ និងផលប៉ះពាល់នៃការប្រែប្រួលអាកាសធាតុនៅទីក្រុង។ សូចនាករសេដ្ឋកិច្ចសង្គមគឺជាប៉ារ៉ាម៉ែត្រសំខាន់ក្នុងការវាយតម្លៃកម្រិតភាពធន់នៃទីក្រុងលើគ្រោះមហន្តរាយ ដែលបង្កឡើងដោយកត្តាអាកាសធាតុ និងមនុស្ស។ ការសិក្សានេះមានគោលដៅវិភាគ និងវាយតម្លៃកម្រិតនៃភាពងាយរងគ្រោះ និងភាពធន់នៅក្នុងក្រុងសៀមរាបនៃប្រទេសកម្ពុជា ដោយប្រើអថេរនៃសូចនាករសេដ្ឋកិច្ចសង្គម។ វិធីសាស្ត្រស្រាវជ្រាវនេះត្រូវបានធ្វើឡើងដោយការអនុលោមតាមក្របខ័ណ្ឌ HIGS (Hazard-Infrastructure-Governance-Socio-economics) លើការវាយតម្លៃភាពងាយរងគ្រោះក្នុងទីក្រុង។ ក្នុងចំណោមធាតុផ្សំសំខាន់ៗទាំងបួននៃសូចនាកររនេះ ការស្រាវជ្រាវនេះផ្តោតតែលើសូចនាករសេដ្ឋកិច្ចសង្គមចំនួនដប់ពីរប៉ុណ្ណោះ ដោយបែងចែកជាសមាសភាគសំខាន់ៗចំនួនបីគឺ៖ ទម្រង់ប្រជាសាស្ត្រ ការអភិវឌ្ឍ និងការអប់រំ-ភាពក្រីក្រ-មុខរបរ សម្រាប់វាយតម្លៃភាពងាយរងគ្រោះ និងស្វែងយល់ពីរបៀបកសាងភាពធន់នឹងអាកាសធាតុក្នុងទីក្រុង។ ការប្រមូលទិន្នន័យនៃការស្រាវជ្រាវបានធ្វើឡើងដោយប្រើប្រាស់ទិន្នន័យឃុំ សង្កាត់ ការសម្ភាសអ្នកផ្តល់ព័ត៌មានសំខាន់ៗ និងការពិភាក្សាជាក្រុម ជាមួយក្រុមប្រឹក្សាសង្កាត់ និងមន្ត្រីរដ្ឋបាលពាក់ព័ន្ធក្នុងក្រុងសៀមរាប។ សរុបមក ទីក្រុងសៀមរាបងាយរងគ្រោះខ្លាំងដោយឥទ្ធិពលនៃការប្រែប្រួលអាកាសធាតុ ហើយភាពធន់នឹងការប្រែប្រួលអាកាសធាតុក្នុងទីក្រុងនៅមានកម្រិតទាប។ ក្រុងសៀមរាបនៅតែមានអត្រាក្រីក្រខ្ពស់ និងមានប្រជាជនច្រើន (ជាពិសេសកុមារ និងមនុស្សចាស់ដែលមានអាយុលើសពី ៦០ឆ្នាំ) ដែលងាយរងគ្រោះដោយសារ

ការប្រែប្រួលអាកាសធាតុ។ លើសពីនេះ មុខរបរសំខាន់នៅក្នុងទីក្រុងនេះគឺនៅតែជាកសិកម្ម ដែលត្រូវរងផលប៉ះពាល់ដោយការប្រែប្រួលអាកាសធាតុ។ ការអភិវឌ្ឍប្រកបដោយតុល្យភាពគួរតែធ្វើឡើងសម្រាប់សង្កាត់ណា ដែលងាយរងផលប៉ះពាល់ពីការប្រែប្រួលអាកាសធាតុ ជាពិសេស ហេដ្ឋារចនាសម្ព័ន្ធបៃតង សេវាសង្គម ការបង្កើតការងារ និងការធ្វើពិពិធកម្មជីវភាពសម្រាប់ក្រុមប្រជាជនងាយរងគ្រោះ ដែលជួយកាត់បន្ថយភាពងាយរងគ្រោះដោយគ្រោះថ្នាក់អាកាសធាតុ។ ការអភិវឌ្ឍដោយសមធម៌នេះក៏ជាកត្តាសំខាន់ៗផងដែរសម្រាប់ការបង្កើនសមត្ថភាពឆ្លើយតប និងការបន្សាំខ្លួននៃទីក្រុង ឬបង្កើនសកម្មភាពខ្នាតតូចៗឆ្លើយតបនឹងការប្រែប្រួលអាកាសធាតុក្នុងកម្រិតទីក្រុង។

Abstract

Urban climate resilience relies on several factors, but urban socioeconomics are considered as a core bloodstream for urban development and building adaptive capability to overcome urban vulnerability and climate change impacts. The socioeconomic indicators are important parameters in assessing urban resilience level on climate-related natural and man-made disasters. This study aims to explore and address the levels of urban vulnerability and resilience in Siem Reap City, Cambodia by using variables of socioeconomic indicators. The research design of this study was made by adopting the HIGS framework (Hazard-Infrastructure-Governance-Socio-economics) on urban vulnerability assessment. Of these four key components of indicators, this study focuses only on twelve socioeconomic indicators by dividing them into three main components (demographic profile, development, and education-poverty-occupation) for assessing vulnerability and exploring how to build urban climate resilience. Data collection and research conducted using commune database data, key informant interviews and focused group discussion with Sangkats (communes) and relevant government agencies in Siem Reap City. The Siem Reap City is highly vulnerable to climate change impacts and has fair resilience toward urban climate change. Siem Reap City remains high ID Poor people. It has a relatively high number of population (especially children and 60 years old) vulnerable to climate change. In addition, the main occupation in this city retains a high attribution of agricultural production, and it has been impacted by climate change. The balanced development should also be made for the communes (Sangkats) that are vulnerable to climate change impacts, especially the green infrastructure, social services, and job creation and livelihood diversification for vulnerable groups, which help reduce the vulnerability of urban areas to climate threats and also key factors for the enhancing response capacity and adaptation of the city, or scalling up small, more local and city-based climate actions.

1. Introduction

More than 55% of the global population live in urban areas by 2018 and this number will grow to about the two-thirds by 2050 (World Bank, 2020; Wahba-Tadros et al., 2020). In developed nations like Europe and the United States, the urban landscape has taken place up to 80% of the total population (Haase et al., 2014). In addition, the urban population in Asia is some 50% while Latin America urban population takes more than 90% of their population (Wahba-Tadros et al., 2020; Haase et al., 2014). The urban population contributes to the world economy by up to 80% of goods and services. The urban area is an agglomeration of trade, education, civilization, technology, and politics. The growth of urban area consumes space, resources, and energy, leading to changes in urban ecosystem function and provision of goods and services to urban dwellers (Middleton and Krawanchid, 2014; Qiandong and Xin, 2022). Socioeconomics is a core structure for cities and urban development (Accius and Joo, 2019). Socioeconomics has influenced the so-called urban socio-ecology, which composes of the natural environment, society, and the important roles of cities in fostering human well-being (Roggema, 2020; Haase et al., 2014).

Because climate change has advanced from year to year, significant impacts have been seriously spelled out in urban areas of the world, and these caused great losses and damages to urban socioeconomics and related sectors (Wahba-Tadros et al., 2020; Sa, 2017). However, the economic activities of each nation have contributed to varied levels of carbon and other greenhouse gas emissions (IPCC, 2019). In response to these impacts, climate adaptation and mitigation have become crucial in urban basic policy and planning as an effort to reduce urban challenges, including mortality, morbidity, asset loss, and increase of greenhouse gas, and promote urban resilience for socioeconomic development and human well-being (Barton, 2013; Satterthwaite et al., 2007). Furthermore, (Horton et al. 2022 and Sa 2017) claimed that climate change-related disasters have caused significant adverse impacts on the disruption of urban services, damage to residential assets, and negative effects on citizens. For instance, floods in Lower Mekong Cities and Phnom Penh had a wide impact, ranging from infrastructure to livelihood and environmental losses (Pal et al., 2023; Nop and Thornton, 2019). Urban socioeconomics play an important role in social and environmental resilience, and they greatly influence the functions of investment in vital and

primary sectors of policymakers and public services in the sense of responsibility (Roggema, 2020). But limited research in Cambodia was carried out to assess the urban vulnerability for building urban climate resilience using socioeconomic indicators.

This paper aims to assess the level of vulnerability in Siem Reap City socioeconomic indicators, largely based on the hazards, Infrastructures, governance, and socio-economic (HIGS) framework developed by (Parikh et al. 2014). Based on the socio-economic indicators regarding vulnerability to climate change impacts and building urban climate resilience in Siem Reap City, this paper presents the results of analysis based on three key components: 1) Vulnerability and resilience by population profile indicators; 2) Vulnerability and resilience by development indicators; and 3) Vulnerability and resilience by education, poverty, and occupation indicators. This study also provided a basic concept and data for further urban resilience building through the HIGS framework, which is understandable, and simple approach to and visualizing big data and communicating to policymakers, urban planners, and decision-makers for urban development to ensure the context of sustainability and smart city.

1.1 Conceptualization of Urban Vulnerability

IPCC (2022, p. 52) defines that "vulnerability significantly determines how climate change impacts are being experienced by societies and communities, and vulnerability to climate change is a multi-dimensional, dynamic phenomenon shaped by intersecting historical and contemporary political, economic and cultural processes of marginalization". Urban vulnerability is defined as "a lack of resilience of individuals, households, and communities to climate change and hazards that threaten their welfare and well-being in the urban ecosystem" (Moser and Satterthwaite, 2008 p. 1). Taylor and Lassa (2017) conducted an urban vulnerability assessment in cities of Indonesia. They found that urban vulnerability is a function of exposure, sensitivity, consequences, and adaptative ability of human systems interacting with nature systems that respond to climate change.

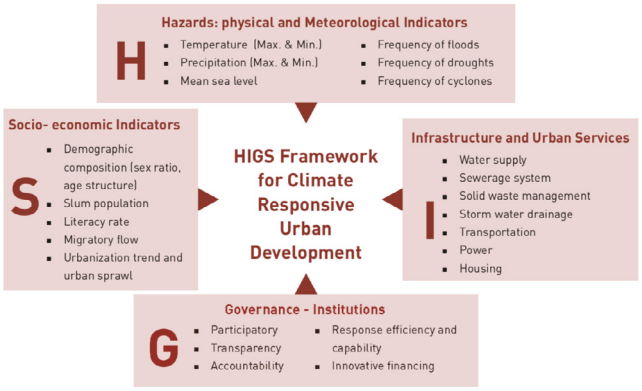
Other authors (Jha et al., 2013; Huedo et al., 2021; Nyahuma-Mukwashi et al., 2021; IPCC, 2022; UNEP, 2007; etc.) who have researched urban vulnerability and resilience building have defined urban vulnerability is a process produced by the combination of many disadvantaged dimensions in which any possibility of upward social mobility and overcoming social condition exclusions is extremely hard to achieve (Jha et al., 2013). Very often, the more vulnerable urban areas lack basic services and have a higher number of crowded and obsolete buildings, unfavorable social characteristics, vulnerable people, and more prominent gender and age class differences (Huedo et al., 2021; Nyahuma-Mukwashi et al., 2021; IPCC, 2022). UNEP 2007 has described that the urban areas provided several socio-economic opportunities with jobs and income creation simultaneously becoming increasingly risky places for low-income families, especially in developing countries. Exposure to environmental risk and hazard results from physical processes creating these hazards and human processes that lead to vulnerabilities (Lankao and Qin, 2011). These issues have cumulatively different impacts in different city areas, depending on its socio-spatial structure. Notwithstanding, there were several studies examining the geographical characteristics of urban settlements that make city residents (particularly people with low incomes) vulnerable to the impacts of climate change and disasters, as reported by Bhattarai and Conway (2010) and McGranahan et al. (2007). In addition, a recent study by Lankao and Qin (2011) noted that much research has highlighted urban areas in middle-income and low-income countries, which are suffered more by the impacts of climate hazards as a result of both development and the failures of governance. However, there is less research focused on socio-economic indicators.

Parikh et al. (2014) assessed urban vulnerability in 20 Indian cities by using the framework HIGS, which is a key framework used in this assignment. HIGS: the framework comprises four sets of variables, which 'H' denotes Hazards and extreme climate change events, 'I' is for the infrastructure status, 'G' for Governance, and 'S' for socio-economic characteristics. For this paper, we used the socioeconomic characteristics as the prime indicators for analyzing the urban vulnerability and resilience in Siem Reap City of Cambodia.

The framework helps to understand the current scenario of cities and urban settlements that features many impacts of climate change, such as increased weather events, variation in temperatures and precipitation, increase in vector-borne diseases, and introduces new hazards like intensive rainfall, heat wave, sea level rise, etc. To implement the framework, a vulnerability template was developed, which helps gather the datasets and identify their linkages with natural causes, sustainable practices, and strengths of the concerned authorities. The framework as shown in Fig. 1 in this research, was used and analyzed for the socio-economic indicators.

1.2 Study Area and Methodology

This research has been conducted in twelve Sangkats (communes) of Siem Reap city to determine socioeconomic attribution for vulnerability and resilience building in Siem Reap city. Siem Reap is a cultural heritage city in Cambodia where world heritage temples and cultural tourist sites are supporting the GDP growth of Cambodia's



Source: Parikh et al. (2014)

Fig. 1: The research framework of HIGS.

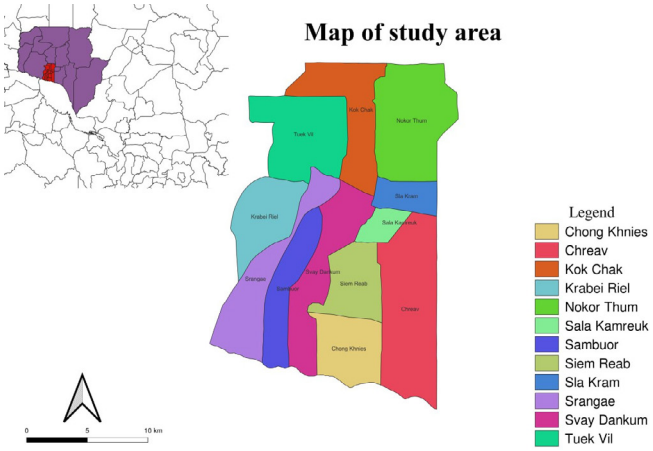


Fig. 2: Map of Siem Reap town.

economic development. As of 2022, Siem Reap City comprises 268,710 persons (144,230 females), and about 15.3% are female-headed households. The major occupation of the population in Siem Reap City is service providers at 71% (tourism, vendor, and related sectors) followed by agriculture at 27%, remaining involved in the government and private sector.

Siem Reap town lies on the northern shoreline of the Tonle Sap Lake. Fig. 2 shows the map of the study area, briefly describing the study sites in Siem Reap City. It has a great diversity of geographic descriptions from the Southern to the Northern part of the city. The Southern part lies on the lowland of Tonle Sap Lake, which is flooded for six months yearly by receiving rainwater from the Mekong river and its tributaries during the wet season. However, the middle and the Northern parts are fairly impacted during the rainy seasons, which receive water and flash floods originating from Kunlen mountain and surrounding catchment areas through Siem Reap river, which runs through Siem Reap town. There are streams and reservoirs that were constructed in the middle and the Northern part of Siem Reap City since ancient times. These infrastructures fairly absorb and retain the floods when there is heavy rainfall in the wet season. Because of rapid development and natural processes, these water infrastructures have been damaged and have been converted to agricultural and settlement purposes. The damages and losses of these water infrastructure systems have tremendously reduced their physical functions and capacity for retention and pooling, leading to urban floods.

Like other districts of Siem Reap province, Siem Reap town has similar weather and climate patterns. It has six months of dry and rainy seasons. The city receives an average annual precipitation of about 1,406 mm, an average yearly temperature of some 28°C, and an average annual relative humidity of 66% (Merkel, 2022). Regarding climate change impacts caused by climate hazards like floods, drought, and wind storm, Siem Reap province was assessed to be quite vulnerable to overflow of riverine flood, and drought (MOE, 2006). Siem Reap town has been impacted by floods almost every year since 2010 (Gupta et al., 2015), especially Sangkats close to Siem Reap River and in the floodplain of Tonle Sap Lake (WFP, 2021; Pal et al., 2023).

This study adopted the HIGS framework to thoroughly analyze urban resilience and climate change adaptation (Parikh et al., 2014). HIGS framework encompasses four main vulnerability assessment components for urban resilience to climate change. However, for this paper, the socioeconomic component was considered as the core indicator for vulnerability assessment and resilience building (including adaptation capacity of people) in Siem Reap City. In addition, variables of the indicators were consulted with experts from the Asian Institute of Technology for their validity and suitability. The socio-economic component of the analysis includes the key indicators presented in Table 1.

Fig. 3 below indicates the HIGS framework for urban climate resilience based on the socio-economic indicators, as this framework is highly relevant for Cambodia's studied cities under this research. We use twelve indicators for our study, i. e. to assess the vulnerability of Siem Reap city to climate change and its adaptive capacity. This conceptual framework indicates how the variables of urban socioeconomic indicators such as demography, population by age groups, sex ratio, and other variables are being used to measure the level of urban climate-related vulnerability. After vulnerability assessment, it will help urban planners, development practitioners, and decision-makers to build the city's adaptation capacity through a full set of improving public investment plans to help the city improve social security nets (ID poor), education, and occupation that enhance the annual GDP per capita. Thus, improving public investment programs will help Siem Reap City build sustainable and resilient development.

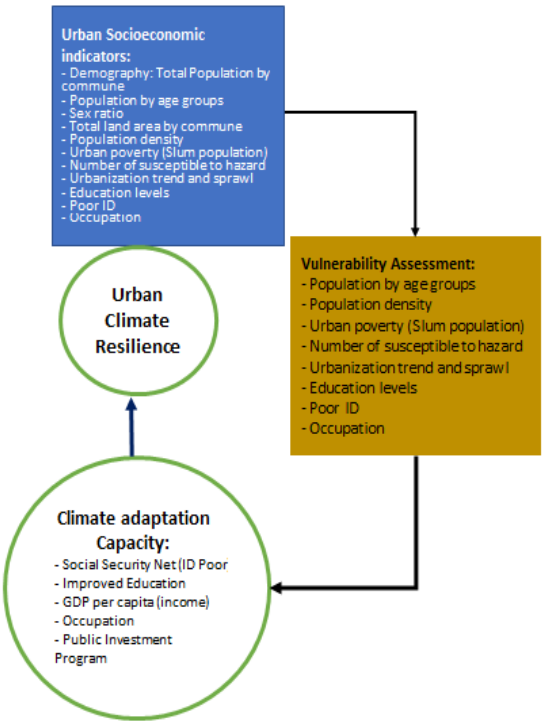
This study has utilized data from two sources: secondary data and primary data. The secondary data were

Table 1: List of socio-economic indicators of urban vulnerability and resilience building.

No.	Indicators	Description
1	Total population by communes	The different number of total populations by communes (Sangkat) is used to assess each commune's vulnerability level. The larger the population in each commune, the more vulnerable it will be to the changing climate it will be exposed, as it is so crowded for city mobility and green space.
2	Population by age group (children, elderly, adults)	Younger and older age groups are most vulnerable to climate change impacts. Adult groups are less vulnerable to climate change impacts. It is divided into five age groups: 1) 0–6 years old (Highest Vulnerability; 2) 7–12 years old (Medium Vulnerability; 3) 13–17 years old (Low Vulnerability); 4) 18–60 years (Lowest Vulnerability); and 5) 60 years old and above (High Vulnerability) (Cutter and Finch, 2008).
3	Sex ratio	It is used to differentiate the male and female populations. The communes having more female persons with younger and older age groups are more vulnerable to climate change impacts.
4	Total land areas (by communes)	They are used to compare the population density among the communes in Siem Reap city. It links to indicator no. 5 below. The communes with large land areas and high elevation are less vulnerable to climate change impacts and have higher adaptation capacity than those with small and low land areas.
5	Population density (persons/ Km^2)	It indicates the vulnerability and adaptive capacity of the people in the communes. The more populated of population in the commune, the more vulnerable to climate change that commune faces.
6	Urban poverty (Slum population and population below the poverty line)	It is visibly aware that people residing in the slum areas are most vulnerable to climate change impacts because they are so poor and have limited access to hygiene and other urban services. It is also linked to poverty indicators showing that poor people most live in the slum area.
7	Percentage of urban areas susceptible to hazards (report of hazard communes)	Some communes are located in flood-prone areas and have limited infrastructure to support their population.
8	Urbanization trends and urban sprawl	As Cambodia had good economic growth of about 7% annually before the COVID-19 pandemic, urban areas have experienced rapid development by expanding the urban area into suburban and outskirt surrounding areas. This has resulted in housing and supported infrastructure development like hotels, restaurants, recreation, and business centers. Urbanization trends and urban sprawl can be assessed by urban development by years, and annual land use change in the communes.
9	Education level	It is used to assess the ability of the population in each commune who can cope with climate change. People with higher education have more diverse choices of livelihood opportunities than those with little education. The unit of analysis is based on the percentage of literacy and illiteracy in the commune.
10	Poverty (ID Poor I and II)	It indicated the living conditions of inhabitants in the commune, and this can be interpreted the level of vulnerability and adaptive capacity of the people within the communes. The ID poor I and II are defined as those who live below the national poverty line. ID poor I households are very poor and homeless, while ID Poor II households are poor, but they still have poor settlement buildings and some jobs. These two categories are used for this assessment as data are available from communes.
11	Per capita GDP (per communes)	Similarly, with the above poverty indicator, GDP is good for measuring the adaptive capacity of people for communes, but data on GDP is homogenous among the communes.
12	Occupation	It can be used to assess the vulnerability and adaptive capacity of people in communes. As commonly perceived, people engaged in agriculture-related and daily services are more vulnerable to climate change impacts than those with business and government services. Non-agriculture occupation means working in the service, government, business, and small enterprise.

Souce: Modified from Parikh et al. (2014) and Cutter and Finch (2008).

collected from commune development and investment plans and the Provincial Department of Planning. While the preliminary data like informal settlement, investment planning, disaster reduction, urban planning, social support system, etc. were gathered based on interactive meetings and discussions with relevant stakeholders, including local communities, provincial departments, civil societies, and private sectors. We constructed the tables of vulnerability and resilience matrices based on indicators from the secondary sources before



Source: adopted from Parikh et al. (2014) of HIGS conceptual framework of urban climate resilience).

Fig. 3: The socioeconomic indicator framework for building urban climate resilience.

field validation was carried out to confirm the data on vulnerability and resilience with local communities and commune councilors. This exercise was conducted with twelve Sangkats (communes); each focused group discussion was held with between 6 to 10 persons from the communes of Siem Reap city to elaborate on each indicator with real situations happening in the Sangkats.

These socio-economic indicators are analyzed using the MS Excel functions like mainly tabular forms to assess the level of vulnerability and resilience building. First, the relevant data were extracted from the commune database and entered into Excel formats for cleaning, review, and validation against other sources. Then the data were analysed by comparing the variables of each socio-economic indicator between the communes. The data in tabular forms were consulted with commune authorities to explore their validity and accuracy so that analysis could be statistically comprehensive and acceptable. The preliminary result of this paper was presented to researchers and students sponsored by the Higher Education Improvement project (HEIP) during the workshop in the 3rd and 4th quarters of 2022 in Siem Reap and Kampot provinces. Constructive comments and suggestions from the participants were considered for improvement of the paper so that its quality has been improved to reduce the gap between data interpretation and the reality of urban climate vulnerability and resilience.

2. Findings and Results

2.1 Vulnerability and Resilience by Population Profile Indicators

The population profile indicators are the most important variables to assess the vulnerability and resilience measurement as they visualize the level of specific impacts of natural hazards and climate change impacts on the spatial scale of the population and economy. Particularly, the indicators help researchers clearly define population by age groups (including infants, teenagers, adults, and old people) and genders impacted by different urban climate hazard patterns. Table 1 presents the population profile indicators of Siem Reap city for twelve Sangkats (communes), which include the total population, age groups and sex ratios. These form the basis for assessing vulnerability and resilience building in the studied area.

As of 2022, the city has a total population of 268,710 people (144,230 females) with an annual birth rate of 3.2% with a total number of 53,574 households. In terms of the most vulnerable groups to climate change impacts (mainly by floods) for the population age groups of 0-5 years old as infants and above 60 years old, Sangkat Sla Kram has the highest percentage of the population with ages of 0 to 5 years old at 17.12%, followed by Krabei Riel at 14.69% and Chong Khnies at 13.70%. At the same time, Teuk Vil and Kok Chak have a similar percentage of infants at 12.70%. For age groups above 60 years old population, Sla Kram has the highest rate (12.4%) of the older population, followed by Sala Kamreuk at 10.6% and Svay Dangkum at 10.2%. For the population with medium vulnerability (7–12 years old as older infants), Chong Khnies is considered to have a high percentage of the population (22.65%) falling within this category, followed by Sala Kamreuk at 20.86%, Sambuor at 20.44%, and Teuk Vil at 20.30%. Similarly, in terms of vulnerability by gender groups, Sangkat Siem Reap has the highest number of female population (121.8 females/100 males), followed by Krabei Riel (105.4 females) and Norkor Thom (104.4 females).

For urban resilience building by the adult population with strong power and labor forces to combat climate change impacts and movability, Sangkat Siem Reap possesses the highest percentage of the adult population at the rate of 63.7%, followed by Chhreav at 60.1%, Srangae at 59.90%, and Svay Dangkum at 55.7%, which represent more than half of total population within the commune. In terms of sex ratios, Sangkat Chong Khnies is seen to have more male population than female (100 men/90.5 women), followed by Svay Dangkum (100 men/98.2 women).

The demographic data for the total population in each commune can help distinguish the chance of exposure to climate change impacts in overall view it distinguishes the opportunity of exposure to climate change impacts.

As in Table 2, the total population in Sangkat Sla Kram is the highest compared to other Sangkats (communes) in Siem Reap city, which indicates that this Sangkat is located in the central business area of the city, composed of the center of the local commerce, education, and administration makes it attractive to immigration from other communes in Siem Reap city. This Sangkat is most vulnerable to climate change impacts when extreme climate events occur. In comparison to the finding of (Hasan et al. 2017) in an Indian city, which defines town-level population and density as an explanatory agglomeration regression to population as a result of employment, infrastructure provisioning, amenities, expenditure, and social and educational services.

The population with age groups ranging from 0-5 years old, 6-11 years old, and over 60 years old are considered more vulnerable to climate change impacts due to their physical body challenges and low experiences (younger ages) and low power (for elder ages) in combating the climate change impacts because these age groups have less experience and knowledge to help themselves in the difficult situations of climate-related hazards, including floods, and droughts. The sex ratio provides a clear image of the gender perspective on socioeconomic vulnerability and building urban resilience. The high percentage of the female population in the city is considered the most susceptible to shocks caused by climate change impacts because they have relatively low inter-movability during climate extreme events, and they have triple household roles for society in terms of productive, reproductive, and community activities.

These age groups have a high risk of climate change-related disasters due to their incapability of mobility and wealth to deal with the loss and damage in the aftermath. The vulnerable people were classified into main categories, such as elderly people who cannot generate income and have limited scale of critical nutrition requirements. They rely on the support of their relatives or neighbors to make their daily living. When their relatives encounter climate change impacts, the older people face similar problems. Normally, they have lost support from their family due to migration or death. Furthermore, poor households (especially ID Poor I and II) are susceptive to climate change disasters due to the decay of their housing materials or their settlement buildings being damaged. The observation shows that they cannot maintain their settlement due to their ages and poor financial conditions. Whether there is partial assistance from the local authority will not ensure they maintain the settlement. Another category of vulnerable people is homeless individuals who reside in slums or informal settlements. Their houses were normally built from straw or tin, less than 20 pieces. These houses were normally built on the edge of the roads or on private vacant land, which is not eventually favorable for undeclared residence. There is simultaneously maintenance as people have no sense of security in their living settlements. Most homeless people migrated from other provinces to find a job in Siem Reap city. Some of them asked for temporary settlement on old villagers' land or grappling land in protected areas where they are risked being caught by APSARA authority and local authorities. The third category of vulnerable people is orphan children who do not own any property in the area. Most of them live with local people with low income, while some are unemployed and impoverished.

These groups (0–5 years and 6–11 years old) require high attention and support in the context of climate-related disaster occurrence. It is important to generate a social working group to assist this group of people. In response to these issues, the Ministry of Women's Affairs has created neary rattanak strategy phases: 1, 2, 3, 4, and 5 (MOWA, 2020) to address the number of people in poverty in the local community and support them during natural disasters. However, this strategy does not seem to practically work with older adults who are not under poverty circumstances. Still, they are highly vulnerable to climate change disasters in urban areas due to their limited mobility and accessibility. To deal with this problem, the local government must create an additional team to address older people with limited mobility and accessibility to provide support on time during climate disasters such as flooding, drought, or windstorms.

However, teenagers and the young population aged at 12 to 17 years old are moderately vulnerable to climate-related hazards, as they have acceptably strong physical health, and they can understand the message of common sense in early warning systems. The percentage of the population by age group helps understand the levels of vulnerability in each commune. Considering the age groups, Sangkat Chong khnies consists of a high percentage of young population (infants) in Siem Reap city, indicating that this Sangkat is highly vulnerable to climate change impact. While, Sangkat Sla Kram has a high percentage of older people who are most vulnerable to the impacts of climate change. According to Table 2, the sex ratio in communes of Siem Reap city varies from 90.5 persons to 121.8 over a hundred men. The result in the table indicates that the communes located in the outskirt area of the city have a high ratio of women working in the agricultural and tourism sectors. The highest sex ratio of the female population in Siem Reap commune, which consists of 121.8 women in hundred men, makes this commune more vulnerable to climate change.

2.2 Vulnerability and resilience by development indicators

The commune with a small land area located in low elevation is more vulnerable to climate change impacts than those with larger land areas and higher height because they are easily flooded during rainy season.

Table 2: Vulnerability and resilience by population profile indicators.

Names of Sangkat (Commune)	Teuk Vil	Krabei Riel	Sragnae	Siem Reap	Sambuor	Chong Khnies	Chhreav	Norkor Thom	Sala Kamreuk	Kok Chak	Svay Dangkum	Sla Kram
Total population (persons)	15,014	9,886	9,002	23,943**	7,888	8,484	22,529**	13,756	26,440**	38,374***	40,438***	52,956***
Population by age groups (%)												
0–6 Years old	12.07**	14.16***	9.86	7.62	10.83	13.70**	8.33	10.91	11.50	12.70**	10.57	17.12***
7–12 Years old	20.30**	19.39	15.82	14.84	20.44**	22.65***	15.24	19.92*	20.86**	19.8*	17.25	13.1
13–17 Years old	6.77	7.52	7.14	5.39	7.93	8.05	6.93	6.2	6.64	7	6.28	6.28
18–60 years old	53.00	51.80	59.9**	63.7***	53.5	48	60.1**	58.10	50.40	53.1	55.7*	51.1
Over 60 years old	7.2	6.6	7.5	8.8	7.3	7.6	9.4*	5.60	10.6**	7.4	10.2**	12.4***
Sex ratio (women by 100 men)	99.7	105.4**	102.8**	121.8***	102.3**	90.5	101	104.4**	99.8	101.2	98.2	99.3

Source: Department of Planning of Siem Reap Province (2022), and Field Survey in 2021-2022
Notes: ***0–6 years old - Highest Vulnerability, **7–12 years old - Medium Vulnerability, 13–17 years old - Low Vulnerability, 18–60 years - Lowest Vulnerability, 60 years old and above - High Vulnerability

The urban development is seen quickly expanding to the outskirts of the city, especially Sangkats located in the east, west, and north of the Siem Reap city center. And five Sangkats situated in the flood plain of Tonle Sap Great Lake. Fig. 1 shows map of Siem Reap city. These are considered directly vulnerable to floods in the wet season when the lake receives water from surrounding rivers of its catchment and Mekong mainstream. The rapid expansion of urban areas to floodplain areas have the most increased risks of climate change impacts because there is an insufficient number of supporting infrastructures to absorb flash flood and hygiene conditions. Some parts of Siem Reap city still consist of slum dwellers with a low capacity to cope with climate change impacts when extreme events occur.

The Sangkats in the city center has more population density than those in the outskirts areas. For instance, Sangkat Sla Kram has the highest population density at the rate of 4,263.3 persons per square Kilometer, followed by Sala Kamreuk at 1,802.9 persons/Km^2 and Svay Dangkum at 1,191.3 persons/Km^2. But these Sangkats have relatively small areas of land, ranging from 1,200 ha for Sla Kram, 1,398 ha for Sala Kamreuk, 3,380 ha for Svay Dangkum, and 2,694 ha for Sambuor with a population density of 267.7 persons/Km^2 (Table 3).

In terms of slum areas in Siem Reap City, Sangkat Sla Kram has the highest rate of households residing in slums at 19.86%, followed by Norkor Thom with, as low as 3.18% that are located in the city center. Sangkat Sragnae has the biggest number of households (132 households) susceptible to climate hazards, followed by Krabei Riel (130 households), Sala Kamreuk with 120 households, and Svay Dangkum with 118 households. Concerning urbanization trends, as high as 98.9% of the total land area of Sangkat Sala Kamreuk is an urban settlement area with housing, a business center, and supported infrastructure, followed by Svay Dangkum at about 88%, Krabei Riel at 65%. These Sangkats have little space for recreation and green space to cope with events of climate change, meaning that they are more vulnerable to climate change impacts than those with large green areas.

For the urban climate resilience regarding the total land area of the Sangkats (communes) in the Siem Reap municipality, Krabei Riel has the largest land area of about 190 Km^2, followed by Kok Chak at 135 Km^2. At the same time, Chong Khnies and Chhreav have a total land area of less than half of Sangkat Kok Chak at about 73 and 57 Km^2, respectively. The large land areas are considered to be more resilient than other Sangkats in terms of green space, wetlands for water pooling, and high mobility when there are extreme climate events. Regarding population density, Krabei Riel is seen to be the least populated (49.4 persons/Km^2) compared with other Sangkats within Siem Reap town. While Sangkat Chong Khnies and Norkor Thom still have relatively low

population density at 103.5 and 180 persons/Km^2, they still have many opportunities and resources to develop themselves by integrating climate resilience measures. There is no slum community in Sangat Sambuor and Chong Khnies, meaning that no households live within the public land, while Sangkat Sala Kamreuk has a slightly smaller number of households residing in slum areas. However, it has a higher population density than Sla Kram. Sangkat Siem Reap has little number of urban poor families (37 HH) susceptible to climate hazards. However, it has a high population density (832 persons/Km^2), among the highest of Sla Kram and 46 poor households most vulnerable to climate hazards. Chong Khnies has the lowest urban settlement area at 0.3%, with a large land area third after Sangkat Krabei Riel and Kok Chak, followed by Teuk Vil at 0.9%, which indicates that these Sangkats are more resilience to climate change impacts. It is a fact that Sangkat Chong Khnies is located in the floodplain area of Tonle Sap Lake, where infrastructure, housing, and business center development are hard to achieve. The largest part of Sangkat Teuk Vil is located in the Angkor Wat heritage site and in West Baray, where urban development is not allowed. These Sangkats are excellent for applying nature-based solutions in Siem Reap town.

The level of vulnerability and resilience here is reflected by land-use indicators and the trend of development. The analysis of exposure by development is explained by the surface area of urban expansion trends, including population density and urban poverty which is measured by the number of households living on the public land. According to (Parikh et al., 2014), the urban poor have a highly vulnerable chance to climate-related disasters in both direct and indirect ways. They are vulnerable to macro scale economic shocks due to their low capacity in income generation, with consequent impacts on access to food, housing, services, and health care. These people live in informal settlements on public land and often have no choice but to live in areas that are particularly exposed to climate hazards and lack of resilience infrastructure such as drainage and sanitation. They also have poorly constructed housing with low tenure security, making them easily suffer and become desperate after disaster events. Economically, they may not be able to get recover in a short time which keeps them in a cycle where they cannot build their adaptation to cope with the shocks of climate change. Lack of safety nets and social and institutional support systems, including health insurance, property rights, and tenure, increases the potential for the vulnerability of the urban poor.

The analysis displays total land areas and population density by each commune in Siem Reap City can point out the grid of vulnerable impacts and possible shocks that are caused by climate hazards on the urban poor. In addition, the number of households living on public land, and the number of people who live on public land and the number of people susceptible to climate change are closely associated with climate change vulnerability and resilient capacity. Table 3 of the population density and total land area help visualize the expansion of Siem Reap City and urbanization trend that help urban planners and policymakers build a sustainable plan to respond to the needs of urban sustainability and resilience in this city. The size of the land surface in each commune varies in hectares the largest commune is Sangkat Krabei Riel, covering a land surface of 19,014 hectares, and the smallest commune is Sangkat Sla Kram, having a land surface area of 1,200 hectares. The land size can indicate the socioeconomic data for climate resilience assessment. Population density in Siem Reap city varies from 40 persons/km^2 to 4,500 persons/km^2 (Table 3). For instance, the Sla Kram commune has the highest population density, up to 4,263.3 persons/km^2, which has a high vulnerability rate toward climate change regarding movability and accessibility. In contrast, Krabei Riel commune has the lowest population density at 49 persons/km^2 and is less vulnerable to climate change impacts.

The number of urban slums is the percentage of households living on public or private-conflicting land plots. In each commune of Siem Reap City, this number of slums varies by levels of income generation activity and location. It is ranking from 0.94% in Teuk Vil commune to 19.80% in Sangkat Sla Kram. Sangkat Sla Kram is located in the main part of Siem Reap city. It is the most happening place with diverse economic activities and income generation opportunities, attracting many poor urban individuals to reside. However, Teuk Vil commune has the least urban poor due to the location and income generation opportunities. This commune is located in the remote area of Siem Reap City the heritage site, namely Angkor Wat, so there are fewer. It is close to heritage site, namely Angkor Wat, so there are fewer economic and income generation opportunities. Most economic activities in Teuk Vil commune are agricultural, so there are little slum households in this commune. It is visibly aware that people residing in the slum area are most vulnerable to climate change impacts because they are so poor and have limited access to hygiene and other urban services. It is also linked to the poverty indicator, showing that poor people mostly live in the slum area. The number of urban poverty is different in communes of Siem Reap city.

As Cambodia had a good economic growth of about 7% annually before the COVID-19 pandemic, urban areas in the country in particular Siem Reap City, have experienced rapid development by expanding the urban area further into suburban and surrounding outskirt areas that used to be rice field and wetlands. This has resulted in booming housing, and supported infrastructure development like hotels, restaurants, recreation, and

Table 3: Vulnerability and resilience by development indicators.

Names of Sangkat (Commune)	Teuk Vil	Krabei Riel	Srangae	Siem Reap	Sambuor	Chong Khnies	Chhreav	Norkor Thom	Sala Kamreuk	Kok Chak	Svay Dangkum	Sla Kram
Total land areas (Km^2 and ha. in bracket)	29.00 (2,900)	190.14+++ (19,014)	28.41 (2,841)	27.83 (2,783)	26.94 (2,694)	73.38++ (7,338)	57.63 (5,763)	65.00 (6,500)	13.98 (1,398)	135+++ (13,500)	33.80 (3,380)	12.00 (1,200)
Population density (persons/ Km^2)	504.7	49.4+++	302.2	832*	267.7	103.5++	360.2	180++	1,802.9**	274.2	1,191.3**	4,263.3***
Urban Slum (Percentage of the households living on public land)	0.94	0.6	1.71	0.21	0+++	0+++	1.66	3.18**	0.2++	0.6	0.36	19.86***
Number of urban poor households susceptible to climate hazards	88	130***	132***	37+++	82	87	53	45+++	120**	99	118**	46+++
Urbanization trends - urban settlement and land use) (%)	0.9+++	65.8**	4.8	23.8	13.5	0.3+++	17.5	17.7	98.9***	60.8**	87.8***	58.3**

Source: Department of Planning of Siem Reap Province (2022), and Field Survey in 2021-2022
Note: *** significant in terms of vulnerability
+++ important in terms of resilience

business centers. Urbanization trends and urban sprawl can be evaluated by yearly urban accumulation and annual change of land use in the communes, pinpointing that the areas are more vulnerable to climate change.

2.3 Vulnerability and resilience by education, poverty and occupation indicators

This is the third part of the results for the study of urban climate resilience building in Siem Reap City using the HIGS framework's socioeconomic indicators. It focuses on analyzing vulnerability variables such as education, poverty and occupation in relation to the assessment of vulnerability and resilience creation. Education data is presented by the percentage of illiteracy and number of students at the university level, which are so important to understand the level of vulnerability reduction and resilience building. In addition, ID poor, GDP per capita, and Occupation data analysis provides clear information for identifying the level and location of adaptation capacity and vulnerability reduction in communes of Siem Reap City. The occupations in Siem Reap city are classified into three main categories: 1) the agricultural sector encompassing on-farm income generation activities including crop production, animal husbandry, and aquaculture; 2) non-farm activities including construction and garment workers, individual business people such as sellers of consumable commodities in the city markets; and 3) the service sector which includes tourism, transportation, and other services (Table 4).

Among those variables, education in Siem Reap city is classified into primary, secondary, and high school for general education and higher education (university level). After educational reform in Cambodia, the Royal Government of Cambodia has encouraged students to complete at least grade 9 by providing free public education services. However, there is the high rate of dropout in 1st to 5th grades (primary school) due to many reasons, including poverty, migration, and other issues. In this context, the analysis of education has included the percentage of illiteracy in the vulnerability and resilience-building assessment. It is perceived that people with higher education have more diverse choices of livelihood opportunities than those with little education. Most communes in Siem Reap city have high rates of literacy. As a result, Sangkat Chong Khnies has high percentage of illiteracy rate at 23.3%, followed by Krabei Riel at 2.2% (Table 4), which indicates low capacity in receiving training on climate vulnerability reduction and resilience building for these two Sangkats, particularly Sangkat Chong Khnies.

The total number of students who managed to get into university education in Chong Khnies commune is only 24, for which many people (total population of 8,484 persons) are vulnerable to climate change impacts. The number of university students in this Sangkat is the smallest

compared to other Sangkats in Siem Reap City. In Chong Khnies, (Ntenda, 2019) conducted a study of livelihood assessment, which showed that most of the population in Chong Khnies has extreme illiteracy, explaining that most of the participants could not evaluate their income and expenditure in their own household. In the same way, this research found a high number of illiteracy people in Chong Khnies commune, which proves that people in this commune are highly vulnerable to climate change impacts due to their low capacity in planning and receiving training on climate change adaptation. In contrast, Sangkat Kok Chak has the highest number of university students (2,433 persons), followed by Sangkat Svay Dangkum and Sala Kamreuk, which shows that these Sangkats have more resilience ability than other Sangkats in Siem Reap city.

In terms of poverty rates (ID Poor I and ID Poor II) for Siem Reap city the vulnerability dimension, Sangkat Sla Kram has the highest rate of ID Poor I people at 5,095 persons, followed by Sangkat Kok Chak and Svay Dangkum at 4,933 and 2,024 persons, respectively. Additionally, Sangkat Kok Chak commune has the highest number of ID Poor II people at 6,450 persons, followed by Sangkat Chong Khnies at 4,650 persons and Sangkat Siem Reap at 2,761 persons. To sum up, ID Poor I and II, Sangkat Kok Chak, has the highest number of poor people as this commune is located in the Angkor Wat heritage site in West Baray reservoir and is vulnerable to flood impacts. They lack income generation skills and capacity in the area to cope with climate change. Practically, ID poor I refers to poor households living in the downtown area, and ID poor II refers to poor people inhabiting the outskirts of Siem Reap city center where they have basic shelters for living, but their daily incomes are below the national poverty line. Generally speaking, poor people are always vulnerable to the shocks of climate change hazards. With high poverty rates and low education may put local people with a low ability to build strong climate resilience (Parikh et al., 2014).

Given our consideration of vulnerability and resilience, GDP per capita is another criterion of its measurement. GDP in Siem Reap city is ranked from USD 1,577.9 per year to USD 1,625.24. People in Sangkat Kok Chak, Svay Dangkum, and Sla Kram have more income than those in other Sangkats, and in terms of climate resilience, these three Sangkats are less vulnerable to climate change as they have more finance to cope with climate change. This figure can reflect the obvious capacity of local assessment the source of climate-related disasters, such as flooding from rivers, streams or rainfall so that they can invest in structural urban flood defenses (GFDRR, 2022).

As commonly perceived, people engaged with agriculture-related and daily services are more vulnerable to climate change impacts than those with business and government services. Table 4 presents the key occupations of people in Siem Reap city. Sangkat Krabei Riel possesses the highest number of people engaged in agriculture activities at 72% among the communes in Siem Reap City, followed by Sangkat Chhreav at 53.4% and Sambuor at 52.9%. These communes are more vulnerable to climate change impacts, especially those caused by floods and droughts. Geographically, the communes are located in the floodplain area of Tonle Sap Great Lake, where people have engaged in farming activities for generations, and in recent decades the housing and commercial center development has just expanded into the communes because the city center has become crowded and expensive land price. For the services, Sangkat Norkor Thom composes the lowest number of people engaged in income generation by the services sector at about 14.7 persons per thousand people of the commune. In contrast, about 63.2% of its people have been involved in non-agriculture activities, followed by Chong Khnies at 20.4%. In contrast, Sangkat Sragnae has the highest number of people (312.3 persons/thousand) in the services sector. Sangkat Sla Kram encompasses as high as 96.7% of its people engaged in non-agriculture, followed by Sala Kamreuk and Svay Dangkum at 93.8 and 89.5%, respectively. This can be interpreted that the people in these Sangkat have a high capacity to cope with climate change impacts, meaning that they are more resilient to climate change impacts within the city of Siem Reap.

The vulnerability assessment on main jobs shows a relatively high percentage of the agricultural sector (about 36%) contributing towards the income source of Siem Reap city. The agricultural sector normally relies on rainfed and irrigation systems that are highly vulnerable to climate change. To respond to this vulnerability, smart climate agricultural practices must be applied to increase efficiency and reduce climate change risk in the agricultural sector. Smart agricultural practices include crops and animal genetic selection, smart climate application for monitoring the requirement of water, fertilizer, and application of pesticides in a sustainable way. With the new technology approach and resilient practices such as smart climate agricultural practices, farmers can increase both the quality and quantity of agricultural production to support the needs of Siem Reap city citizens.

3. Conclusion and Policy Implication

This study systematically undertaken to assess the dimensions of vulnerability and resilience capacity of Siem Reap City by using the three sets of socio-economic indicators, namely population profiles or demographic profiles (total population, age groups, and sex ratio); development indicators (total land area, population density, percentage of urban slum, urban households

Table 4: Vulnerability and resilience by education, poverty, and occupation indicators.

Names of Sangkat (Commune)	Teuk Vil	Krabei Riel	Sragnae	Siem Reap	Sambuor	Chong Khnies	Chhreav	Norkor Thom	Sala Kamreuk	Kok Chak	Svay Dangkum	Sla Kram
Education												
Percentage of illiteracy	0.5++	2.2**	1.1	0.2+++	0.8	23.3***	1	0.8	0.2+++	1.5	0.9	0.1+++
University students	328	272	122	1,255++	278	24	1,504++	211	2,220+++	2,433+++	2,370+++	328
Poverty												
ID Poor I (HH)	747	568++	526+++	2,222	313+++	2,343**	1,040	916	1,134	4,933***	2,024**	5,095***
ID Poor II (HH)	1,603	1,436	1,141	2,761**	1,986	4,650***	1,238	2,711	1,512	6,450***	1,708	2,362**
Per capita GDP (USD/ year)	1,577.9	1,577.9	1,577.9	1,577.9	1,577.9	1,577.9	1,577.9	1,577.9	1,577.9	1,625.24	1,625.24	1,625.24
Occupation												
Agriculture (%)	40.8	72***	41.2	44.2	52.9**	51.3	53.4**	36.8	6.2++	17.1	10.5	3.3+++
Non-Agriculture (%)	59.2	28	58.8	55.8	47.1	48.7	46.6	63.2	93.8+++	82.9	89.5++	96.7+++
Services/ thousand persons (persons)	51.7	56.1	312.3+++	65.1	22.4	20.4***	28.6	14.7***	25.2	82.9++	22.2	23.1

Source: Department of Planning of Siem Reap Province (2022), and Field Survey in 2021-2022
Note: *** significant in terms of vulnerability
+++ important in terms of resilience

susceptible to climate change, and percentage of urbanization); and education-poverty-occupation indicators (percentage of illiteracy, university students, poverty levels such as ID Poor I and ID Poor II family, and GDP/capita, and occupation encompassing of percentage of population engaged in agriculture, non-agriculture, and services per thousand persons). These indicators are used as basic analysis to assess the vulnerability and resilience of inhabitants in Siem Reap municipality based on the statistical data gathered from the Siem Reap Provincial Department of Planning and interactive consultations with Siem Reap municipality relevant officials and commune councilors. The study has found that Siem Reap City is highly vulnerable to climate change impacts, especially flash floods from Siem Reap River and its tributaries, and the influence of Tonle Sap Lake flood during the wet season. However, some communes (Sangkats) in the city are most highly vulnerable to floods. For instance, Teuk Vil, Chong Khnies, Srangae, Chreav, Sambour, and Svay Dangkum because the last five communes are located in flood-prone areas of Tonle Sap lake, and Teuk Vil is situated in Baray area (Angkorian reservoir). The population of younger age groups and elders age above 60 years is physically vulnerable to climate change-induced impacts and disasters, for instance, in Sangkat Sla Kram, Krabei Riel, and Chong Khnies.

In terms of development indicators, Sangkat Sla Kram has a high percentage of urban slum households with the highest population density and smallest area of total land area, but it has a small number of poor urban households vulnerable to climate hazards. In addition, Sangkat Srangae has the highest number of urban poor households susceptible to climate hazards, followed by Sangkat Krabei Riel and Sala Kamreuk. Almost 99% of the total land area in Sangkat Sala Kamreuk is composed of urban housing and commercial buildings, and 90% of Sangkat Svay Dangkum, indicating that there is little space for green infrastructure in support of preventive disaster and adaptation measures when extreme climate change events occur. The assessment of vulnerability based on education, poverty, and occupation indicators, Siem Reap city is partially vulnerable due to the non-balance of socioeconomic development. Some communes have different scales of dependence on farming and non-agriculture occupations. For instance, the contribution of agriculture as the main career provision in Siem Reap city is fairly high if compared with other occupational sectors, which means that agriculture is more vulnerable to the impacts of climate change.

In conclusion, the analysis of variables of socioeconomic indicators in the HIGS framework for urban vulnerability and resilience building shows that Siem Reap City is vulnerable to climate change, which means some interventions of specific sectors of socioeconomic development are to be promoted. It is required that Siem Reap City authorities enhance the socio-economic

development plans to make a balanced local economic development in each commune that ensures there is well kept and distribution of the entire city of Siem Reap and communes. In addition, the priority support programs should be made available to those who are most vulnerable to climate change impacts and disasters like children and elderly people. The balanced development should also be made for the communes (Sangkats) that are vulnerable to climate change impacts, especially the green infrastructure, social services, and job creation and livelihood diversification for vulnerable groups, which help reduce the vulnerability of urban areas to climate threats and also key factors for the enhancing response capacity and adaptation of the city, or scalling up small, more local and city-based climate actions.

The study has provided key issues of urban climate change by using socioeconomic indicators. The framework is useful for socio-enomic development by generating appropriate data and information for decision and policy makers, particularly the city planning resilient to climate change impacts and relevant sectoral development planning. The conclusion of vulnerability assessment and resilient building in Siem Reap City may be limited as other indicators like climate hazards, infrastructure, and governance have not been included. The future study should consider all the HIGS framework indicators for comprehensive analysis. Getting in-depth data for specific issue identification and solution for urban climate resilience is important.

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Declaration of competing interest

The authors declare that they have no competing interests. All authors have read and approved the final, published version of the manuscript.

Credit authorship contribution statement

Sophat Seak: research design, data collection and analysis, writing draft, reviewing and editing. Lyna Khan: data collection, preparing the draft of article, reviewing and revising. Vin Spoann: Reviewing, commenting and editing. Chandara Phat: research design, data collection, reviewing, editing. Kimseng Choeun: Reviewing, editing. Sreynoch Seak: data collection and analysis, map processing, reviewing, editing. All authors have read and agreed to the published version of the manuscript.

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