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Climate change and extremes: implications on city livability and associated health risks across the globe

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Abstract

Purpose – As global warming intensifies, climatic conditions are changing dramatically, potentially affecting specific businesses and cities' livability. The temperature increase in cities significantly affects urban residents whose percentage is to reach about 70% by 2050. This paper aimed at highlighting the climate change risks in cities, particularly focusing on the threats to people's health due to a continuous temperature increase.

Design/methodology/approach – This study was conducted in three main steps. First, the literature review on the effects of climate change, particularly on the continuous temperature rise in cities, was conducted based on the publications retrieved from PubMed, Science Direct, Google Scholar and Research Gate. Second, the survey was conducted for the sample cities for one month. Third, the questionnaire was used to assess possible climate change threats to the livability of cities.

Findings – The findings showed that urban areas are usually warmer than the surrounding rural areas, mainly due to the urban heat island effect, causing more hot days in metropolitan areas compared to rural areas. This paper outlines some mitigation and adaptation measures, which can be implemented to improve the livability in cities, their sustainability and the well-being of their populations.

Originality/value – This study reports on the climate change impacts on the health and livability of 15 cities, in industrialized and developing countries. It examines the average and maximum temperature and relative humidity of each city and its correlation with their livability. It was complemented by a survey focused on 109 cities from Africa, Asia, Europe, Latin America, North America and Oceania.

Keywords Extreme weather events, Rural areas, Increasing temperatures, Health condition, Food security, Literature review

Paper type Research paper

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1. Introduction

To meet the 1.5°C and 2.0°C temperature control goals set out in the Paris Agreement, countries implemented development strategies such as emissions reduction, energy and industrial structure reform and others to strengthen the urban system's resilience and ability to mitigate and adapt to climate change(Alijani *et al.*, 2020). Along with urban growth and environmental change, urban administrators, inhabitants and scholars have been paying more attention to urban livability. livability encompasses a variety of factors, including a healthy environment as well as equal access to employment, housing and other public services for city residents (Cui *et al.*, 2018). It is both a normative and an analytical tool, with different definitions depending on time, space and assessment goals. Urban livability is a key concept for improving urban resilience to a range of shocks and stresses (Allam *et al.*, 2020). In the context of global climate change and continuous urbanization, correlation studies between urban livability and interacting components such as climate change, tourism development or hazardous pollutants are especially significant. Globally, urban livability research methodologies primarily comprise complete index evaluation, questionnaire survey and geospatial analysis, among others. For example, Zanella *et al.* (2015) developed a comprehensive evaluation method for urban livability based on both human well-being and environmental effect using the data envelopment model and directional distance function. Kovacs-Györi *et al.* (2020) found that urban morphology and traffic-related problems had the largest influence on residential satisfaction in a research of over 400 people from across the world to assess their urban environment based on significant living elements. Haddad *et al.* (2020) used climate models to investigate the impact of urban architectural changes on decreasing urban ambient temperature. The advancement of big data, remote sensing and geographic information technology has assisted in the modernization of urban livability research methodologies in recent years. The purpose of this research was to conduct an in-depth survey to assess the livability of cities.

Various studies (Mazdiyasni *et al.*, 2017; Mitchell *et al.*, 2016; Mora *et al.*, 2017) have shown that increasing temperatures pose a serious threat to general public health and can also be directly related to high mortality and morbidity rates. This is especially true among vulnerable groups of people (Åström *et al.*, 2011). Heatwaves have a great impact on people residing near cities and cause the impairment of human performance. General work productivity and the ability to work are reduced by heatwaves (Zander *et al.*, 2015). A significant number of large cities around the world are located near coastlines. It is estimated that more than 600 million people live in coastal areas that are 10 meters or less above sea level. Moreover, nearly 40% of the world's population, or about 2.4 billion people, live 100 kilometers off the coast. Hence, rising sea levels are a major risk factor for climate change. As the population living near coastal cities grows, they are exposed to threats such as coastal floods, storms and hurricanes (Chowdhury *et al.*, 2021).

These severe events can affect urban residents through casualties, injuries and damage to property and infrastructure. Heavy rainfall that accompanies a storm can cause flooding in the cities.

Climate change is a major risk in the public health sector. There is an increasing number of inter-linkages between climate change and health, showing serious threats to human health (USGCRP, 2016). It is shown to either exacerbate pre-existing health conditions or introduce new ones. Table 1 shows some of the different impacts on public health from climate change-related stressors.

There is a variety of previous research on urban livability in cities, with regionalized urban livability assessment and impact factor analysis being the most popular. Wang *et al.* (2011) compared Beijing's urban livability to that of other worldwide cities and concluded

Stressors	Health outcomes	References
Heat stress	• Heat-related mortality and morbidity • Increased cases of cardiovascular, respiratory and neurological disorders	Mazdiyasni *et al.* (2017) Mitchell *et al.* (2016) Linares *et al.* (2017)
Extreme weather events (flood, heavy rainfall, storm and wildfire)	• Death, injuries, infectious diseases and mental health disorders	Paterson *et al.* (2018) Finlay *et al.* (2012) Lane *et al.* (2013)
Vector-borne diseases	• Malaria, dengue fever, tick-borne diseases, chikungunya, West Nile virus and Leishmaniasis	Campbell-Lendrum *et al.* (2015) Ogden (2017), Baylis (2017)
Food and water-borne diseases	• Water-borne diseases like cholera and gastro-intestinal infections like diarrhea	Wu *et al.* (2014) Cann *et al.* (2013) Bhandari *et al.* (2020)
Increased air pollution	• Respiratory diseases like asthma, cardiovascular disease and pre-mature deaths	Orru *et al.* (2017) D'Amato *et al.* (2015) Revi *et al.* (2014)
Food security	• Undernutrition	Phalkey *et al.* (2015) Wheeler and Von Braun (2013) Lloyd *et al.* (2011)
Mental stress	• Mental health disorders (post-traumatic stress disorder, anxiety, adjustment disorder and depression)	Trang *et al.* (2016) Dean and Stain (2010) Berry *et al.* (2010)

Source: Modified from Paci (2014) and Smith *et al.* (2014)

Table 1.
Impacts of climate change on public health

that environmental quality in Beijing has to be improved. In addition, Zhan *et al.* (2016) developed an indicator system for evaluating urban livability in Beijing and analyzed its geographical features. In bottom-up studies of urban livability, large-scale questionnaire surveys are used to analyze satisfaction with urban livability across the world. However, most studies focused on urban livability in a static way to find how it changed as a result of climate change. Specifying the key concepts and mechanisms of urban livability and establishing a quantitative assessment framework is critical to urban studies, as they could be a valuable tool and effective utilization of climate services for assessing the mechanism of climate change effects on urban livability, improving urban livability under climate change scenarios and mitigating climate change's impact on cities. Specifying the important concepts and mechanisms of urban livability and establishing a quantitative assessment framework are critical to urban studies, as they could be a valuable tool and effective utilization of climate services for assessing the mechanism of climate change effects on urban livability, improving urban livability under climate change scenarios and mitigating climate change's impact on cities. This paper aimed to evaluate the livability of climate change impact in cities. In particular, this study conducted a comprehensive literature review, supported by a survey, focusing on 15 tropical and industrialized countries around the world, as shown in Table 2. More importantly, this study has focused specifically on public health threats due to the constant rise in temperature.

Table 2.
List of large cities in developing and industrialized countries with average, maximum temperature and relative humidity

S. No.	City	Country	Population (in million)	Avg. temperature (in °C)	Max. temperature (in °C)	Highest relative humidity (in %)	Lowest relative humidity (in %)
1	Berlin	Germany	3.76	2.9 (January) 23.7 (July)	39.0 (June 2019)	88.0 (November, December, January)	65.0 (May, June, July, August)
2	Athens	Greece	3.15	9.5 (January) 27.8 (July)	48.0 (July 1977)	71.9 (November)	47.6 (August)
3	Madrid	Spain	6.64	5.0 (January) 24.0 (July)	40.6 (August 2012)	74.0(December)	38.0 (July)
4	Milan	Italy	1.35	1.9 (January) 23.8 (July)	37.2 (July)	86.0 (January, December)	74.0 (March, June, July)
5	Sao Paulo	Brazil	12.18	15.4 (July) 21.5 (January)	38.3 (March)	80.0 (January, March, April, December)	74.0 (August)
6	Rio de Janeiro	Brazil	6.32	20.6 (July) 26.1 (January)	43.2 (December 2012)	80.0 (March, April, May, October)	77.0 (July, August)
7	New Delhi	India	21.75	14.2 (January) 34.3 (June)	48.0 (June 2019)	73.0 (August)	33.0 (May)
8	Bangkok	Thailand	8.28	25.6 (December) 30.2 (April)	40.1 (March 2013)	79.0 (September)	66.0 (December)
9	Chennai	India	7.09	24.3 (January) 33.0 (May)	45.0 (May 2003)	78.0 (November)	57.0 (June)
10	Barranquilla	Columbia	1.21	26.6 (January) 28.5 (June)	41.1 (April)	82.9 (October)	71.7 (January)
11	Quezon	Philippines	1.86	25.3 (January) 28.9 (May)	36.6 (April 2019)	86.0 (September, October)	65.0 (April)
12	Ho Chi Minh City	Vietnam	8.99	25.9 (December) 29.5 (April)	41.7 (July)	85.0 (September)	70.0 (February, March)
13	Shanghai	China	24.28	4.3 (January) 28.0 (July)	40.9 (July 2017)	79.0 (June)	71.0 (December)
14	Dhaka	Bangladesh	8.91	18 (January) 29 (August)	40.2 (April 2014)	74.0 (August)	37.0 (February)
15	Sydney	Australia	5.23	22.3 (February) 12 (July)	45.8 (January 2013)	66 (February)	55.0 (September)

Sources: Climate Data (2010); Weather Atlas (2010)

2. Methods

2.1 Data source

This research was conducted in three main steps. In the first step, an in-depth literature review on the impacts of climate change was conducted with a focus on the continuous rise in temperature in cities. In this study, special attention was paid to the impacts of climate change on the health and livability of residents in cities. The literature review was done using an electronic search strategy across various databases. PubMed, Science Direct, Google Scholar and Research Gate were identified to have reliable and scientifically accurate articles and journals. These databases were then searched extensively for the following keywords: climate change, health, cities, urban areas, livability and global warming. Moreover, reports from the World Health Organization, United Nations, European Environmental Agency and Inter-Governmental Panel on Climate Change were also used to extract information. Only papers, journals and reports published after 2010 were included in this study to provide recent information.

In the second step, this study investigated the climate risks in tropical cities suffering from the global effects of climate change, focusing on cities with a population of more than one million. Based on this, 15 cities were selected, including seven cities from Asia, four cities from Europe, three cities from South America and one city from Oceania (Figure 1). Cities were selected based on their sizes and geographical locations. The idea was to provide a diverse view of situations and contexts (Leal Filho *et al.*, 2018; He *et al.*, 2021). The survey for the sampled cities took place for one month, i.e. from the first week of April 2020 to the first week of May 2020.

Climate and weather-related variables, such as temperature and humidity for the 15 selected cities were also separately searched using online search engines. The databases that were mainly used for this purpose were Weather Atlas, Climate-data and Time and date. The data from these sources were then cross verified with each other to maintain reliability.

In the third step, a questionnaire survey was used to collect data to assess the possible threats of climate change to the viability of cities, as perceived by urban residents in many countries. Twenty-five open- and closed-ended questions were divided into two categories "demographic details" and "climate change and livability." The reliability and validity of the questionnaire were based on feedback received from an international team of climate change

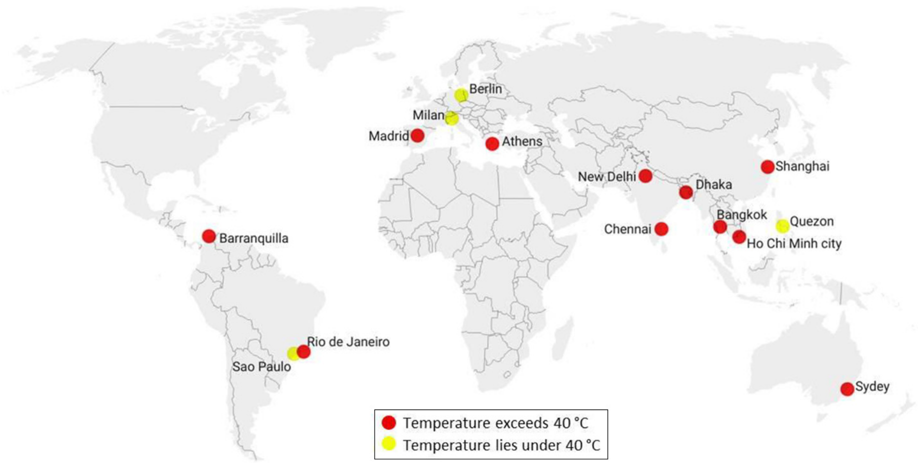

Figure 1. World map, highlighting the sampled cities (created with Datawrapper)

scientists. Data was collected for approximately three weeks from January to February 2021 through the Google Forms online survey tool. Statistical analysis and visualization of the obtained results were performed in Microsoft Excel.

3. Results and discussion

3.1 Literature review and survey on climate risks

Research has shown that urban areas are usually warmer than the surrounding rural areas (Macintyre *et al.*, 2018). This is mainly due to the urban heat island (UHI) effect, causing more hot days in metropolitan areas when compared to rural areas. Table 2 indicates that tropical cities of both developed and developing countries around the world are already experiencing high temperatures and high humidity in recent years. New Delhi recorded a maximum temperature of 48.0°C in June 2019. This follows a rise in temperature trend in the city, which recorded maximum temperatures of 42°C in June 2018, 44°C in June 2017 and 42°C in June 2016 (Timeanddate, 2017). A similar rise in temperature trend is observed in Berlin, which recorded maximum temperatures of 39°C, 32°C, 30°C and 35°C in the month of June in 2019, 2018, 2017 and 2016, respectively. Although Shanghai's maximum temperature (40.9°C) was recorded in July 2017, a comparison with other years shows a consistent pattern in temperature rise, e.g. 40°C in 2016 and 38°C and 39°C in 2018 and 2019, respectively (Timeanddate, 2019). Heatwaves during this period have affected several people. For instance, during the heat waves of 1994 and 2004, the citizens of Berlin city suffered from more heat-related stress and mortality than those in the neighboring state of Brandenburg (Gabriel and Endlicher, 2011). People living in the cities are vulnerable, as climate change worsens the UHI effect. The constant change in climate has increased the intensity and frequency of temperature fluctuations, which intensifies the occurrence of heatwaves and tropical nights (Lee *et al.*, 2020), as supported by Table 2, which shows that the city of Berlin experienced hot summer days with temperatures reaching up to 39°C during summer of 2019. The humidity level also remained high during that period. During heat waves, cases of diarrheal diseases seem to peak in developing countries such as Bangladesh (Prince, 2017), along with respiratory and cardiovascular diseases (Dang *et al.*, 2019).

Shanghai's population of 24.28 million inhabitants (Table 2) is exposed to the impacts of the UHI effect, and the temperatures are expected to rise further, causing an increased intensity of heatwaves in the city's center when compared to its outskirts (Tan *et al.*, 2010). Other densely populated cities like New Delhi, Ho Chi Minh City and Chennai are also highly exposed to the impacts of the UHI effect. According to Dang *et al.* (2019) and Ragettli *et al.* (2019), the main reasons for hospitalization during hot summer months in Switzerland, South Korea, Vietnam and Bangladesh were respiratory and cardiovascular disorders and renal and infectious diseases. The deterioration of the physical and mental health of the population has also been linked to the increasing temperatures. In Australia, an increase in hospital admission for mental disorders (e.g. anxiety) during heat waves has been documented (Nitschke *et al.*, 2011). In Sweden, people with previous hospital admissions for a mental disorder were found to have the highest relative risk of death as the duration of the heat waves increased (Oudin Åström *et al.*, 2013).

As specified in Table 2, Bangkok (Thailand) and Ho Chi Minh City (Vietnam) experienced an average temperature of 25.6°C to 30.2°C and 25.9°C to 29.5°C, respectively, which are quite similar. However, the humidity for Ho Chi Minh City was relatively high when compared to Bangkok. These unusual climatic conditions could increase the rate of hospital admission due to heatwaves. This assertion is supported by an earlier study that showed an increase of 2.5% in hospital admissions during periods of heatwaves in Vietnam

(Dang *et al.*, 2019). Total ambulance calls increased by 18.8% in Brisbane, Australia during heatwave days when compared to non-heat wave days (Tong, 2013).

Further, according to Table 2, Rio de Janeiro and Madrid recorded high temperatures of 43.2°C and 40.6°C, respectively, in 2012. Rio de Janeiro has shown a trend in increasing temperature, recording maximum temperatures of 38°C in 2013, 39°C in 2015 and 40°C in 2015. This follows a similar rise in temperature trend in the city of Madrid, which records a maximum temperature of 39°C in 2013, 38°C in 2014 and 40°C in 2015. These cities have a population of around six million people, whose health is at risk because of climate change. The continuous increase in temperature could increase the mortality rate in these tropical cities.

Although Athens experienced a maximum temperature of 48.0°C in 1977, recent data have shown a consistent pattern in temperature rise like the other cities. Also, some studies have highlighted increased hospital admissions during heatwave days (Ragettli *et al.*, 2019). Outdoor workers in tropical and subtropical cities (e.g. New Delhi, Chennai and Dhaka) are particularly more vulnerable to heat strokes caused by high temperatures. Outdoor female workers' health is another issue that has come to the, especially during pregnancy, as it creates additional heat stress problems. Respiratory and cardiovascular diseases, secondary to exposure to poor air quality, were found to have a greater impact on women due to their greater propensity for higher particulate deposition in the lung tissue (Ylipaa *et al.*, 2019).

3.2 Questionnaire on climate threats – demographic profile

Residents of 109 cities from six regions, Africa (31.4%), Asia (21.4%), Europe (29.3%), Latin America (5.7%), North America (7.9%) and Oceania (4.3%) participated in the survey (Figure 2).

The demographic profile of the respondents is shown in Table 3. The age group of the participants was between 18 and 58 years. In addition, most of the respondents (65.50%) were in the age group of 29 and 58 years old. According to the research findings, nearly 2.9% of participants had a high school degree and 89% of participants had received a postgraduate degree. From the occupation perspective, 36% of the participants have trained professionals and 1.4% of the participants were unemployed. Survey results showed that 33.1% of the participants received a monthly income of above 3,000 € and 10.3% had an

Figure 2.
Cities of respondents (created with Datawrapper)

Variable	*N*	(%)
Gender		
Male	57	40.1
Female	82	57.7
No answer	3	2.1
Total	142	100.0
Age (years)		
18–28	7	4.9
29–38	24	16.9
39–48	43	30.3
49–58	26	18.3
Over 58	39	27.5
Education level		
High school or less	4	2.9
Graduate	10	7.2
Postgraduate	125	89.9
Occupation		
Unemployed	2	1.4
Retired	14	10.1
Student	9	6.5
Temporary employee	3	2.2
Administrative staff	5	3.6
Trained professional	50	36.0
Junior management	5	3.6
Middle management	18	12.9
Upper management	23	16.5
Consultant	7	5.0
Monthly income (€)		
Below 500	21	15.4
500 to 1,000	24	17.6
1,001 to 1,500	14	10.3
1,501 to 2,000	14	10.3
2,001 to 2,500	11	8.1
2,501 to 3,000	7	5.1
Above 3,000	45	33.1
Type of housing		
Flat	68	48.9
Semi-detached house	21	15.1
Detached house	42	30.2
Adults in the household		
1	18	12.9
2	73	52.5
3	22	15.8
4 or more	26	18.7
Children (less than 18 years old) in the household		
None	71	50.4
1	25	17.7
2	20	14.2
3	16	11.3
4 or more	9	6.4

Table 3.
Demographic profile of the respondents

income between 1,000 to 2,000 €. Almost 48.9% of the participants lived in flats and 15% lived in semi-detached houses. The household participants of the respondents included two adults (52%), no children (50%) and 17% with one child (less than 18 years old).

3.3 Descriptive analysis of climate change impacts on cities' livability

Temperature increase on a global scale is a big environmental threat all over the world. Rapid urbanization has raised the city's emission levels and affects the temperature of the atmosphere. However, the COVID-19 pandemic and associated worldwide lockdown have recently lowered pollution levels. There are significant impacts that have been observed in the major megacity of the world. For example, the lockdown due to the COVID-19 pandemic in the cities caused the pollution level of the city significantly improved (Sahani *et al.*, 2020). As shown in Table 4, 17.8% of the participants stated that they have a full lockdown. The results also show that 2.4% of participants experienced no lockdown and 16.7% have a partial lockdown.

Table 4 shows participants' awareness of the impact of climate change on the livability in their city. Based on the findings of this study, 46% of the respondents were, to some extent, aware of climate change impacts on the livability in their city, and only 28% of respondents were sufficiently aware of this issue. Also, 1.4% of respondents were not aware of such impacts. According to the results presented in Table 4, around 46% of participants in this survey had approximate knowledge about climate change that affects the quality of life of the city dwellers. Specifically, 22.3% stated that climate change does not pose a significant threat to the residents' quality of life, and 2.2% were not aware of this issue.

Individuals, communities and governments react to climate change in a variety of ways, which are also influenced by public views of its causes, impacts and broader implications (Demski *et al.*, 2017). This survey investigated respondents' opinions about rising temperature over the last decade, most of whom considered human activities and natural causes to be major contributors to climate change (49% and 2.2%, respectively). Also, 44.5% of participants consider both human activities and natural causes and 2.2% stated that there is no change in the temperature of their city. Therefore, it can be concluded that more people have knowledge about the raising weather temperature and the factors causes. According to Kashef (2016), human activities are the main drivers of climate change and have a significant impact on many aspects of human settlements. For example, human activities and natural causes can influence human settlements through a variety of intermediary factors, including natural environmental change (Si *et al.*, 2014), the socioeconomic system (Si *et al.*, 2014), extreme weather/climatic events and human health (Lo *et al.*, 2019).

The current survey considered basic descriptive for some of the phenomena that contribute to climate change in the city. These phenomes were displacements, floods, greater inequalities, higher vulnerability, health problems, increased food security problems and increased poverty. According to the survey, most of the respondents experienced higher vulnerability and health problems (23% and 22%, respectively). The findings revealed that only 3% of people reported increased food security problems due to the climate change impacts. The factors of displacements and greater inequalities included approximately equal percentages (10%). These findings are in line with Tiihonen *et al.* (2017) study as their results showed that increasing temperature caused by human activities can directly affect cities' livability.

In this survey, seven items were discussed that could be positive steps to the reduction of climate change in cities. These items included buying organic foods, planting more trees, using public transport, participating in environmental campaigns, buying more energy-efficient devices, recycling waste and use less electricity. Based on the findings of Table 4,

Variable	*N*	(%)
Stage of lockdown at the height of the COVID-19 pandemic		
No lockdown	9	2.4
Partial lockdown	63	16.7
Full lockdown	67	17.8
Does climate change impact the livability of your city?		
Not at all	7	5.0
Yes, to a limited extent	26	18.6
Yes, to some extent	65	46.4
Yes, to a great extent	40	28.6
I do not know	2	1.4
Does climate change threaten the quality of life of the residents of your city?		
Not at all	3	2.2
Yes, to a limited extent	31	22.3
Yes, to some extent	64	46.0
Yes, to a great extent	38	27.3
I do not know	3	2.2
Which of the following components of your city are most significantly impacted by climate change?		
Housing	51	35.9
Telecommunications	13	9.2
Transportation	42	29.6
Waste management	53	37.3
Water provision	83	58.5
Drainage system	70	49.3
Energy supply	56	39.4
Food, agriculture	4	2.8
Do you think the temperature in your city has been rising over the past decade?		
No, there is no change	3	2.2
Yes, because of human activities	68	49.6
Yes, because of natural causes	3	2.2
Yes, both because of human activities and natural causes	61	44.5
I do not know	2	1.5
Which phenomena related to climate change have you experienced in your city?		
Abnormal rainfall and drought	2	0.5
Displacements	39	10.2
Flood	2	0.5
Greater inequalities	42	10.9
Higher vulnerability	90	23.4
More health problems	87	22.7
Increased food security problems	1	0.3
Increased in poverty	51	13.3
I do not know	2	0.5
Which of the following do you think has contributed the most to climate change?		
Aerosols	1	0.7
Deforestation	26	18.7
Greenhouse gases	67	48.2
Land use and land cover change	40	28.8
Capitalism	2	1.4
I do not know	3	2.2

(*continued*)

Table 4.
Factors associated with climate change and the livability of cities

Variable	N	(%)
How much do you think climate change threatens the personal health and safety of residents in your city?		
Not at all	1	0.7
To a limited extent	26	18.6
To some extent	63	45.0
To a great extent	49	35.0
I do not know	1	0.7
Which climate hazards do you experience in your city?	91	64.1
Floods	80	56.3
Dry spells	42	29.6
Storm surges	1	0.7
Droughts	25	17.6
Wild/bush fires	1	0.7
Higher rainfall	11	7.7
Heat	4	2.8
Cyclones	91	64.1
Which of the following are the direct socioeconomic impacts of climate change in your city?		
Poverty	81	57.0
Overpopulation	34	23.9
Unemployment	56	39.4
Insecurity and crimes	44	31.0
Inequalities and marginalization	73	51.4
Which of the following actions should be taken to address climate change and make your city more livable?		
Climate-resilient urban planning	109	76.8
Enhanced economic development	49	34.5
Environmental regulations to curve carbon emissions and pollution	80	56.3
Promote renewable energy	84	59.2
Sustainable public transportation	66	46.5
Waste management through recycling/reuse	66	46.5
Who do you think should have the main responsibility to tackle climate change impacts in your city?		
Individuals and stakeholders	88	62.0
Environmental organizations/lobby groups	42	29.6
Local government	89	62.7
Central government	113	79.6
Business and industry	75	52.8
All of us	6	4.2
Which of the following entities are taking initiatives to reduce climate change impacts in your city?		
Citizens themselves	69	48.6
Environmental groups	105	73.9
Private companies	30	21.1
Regional government	54	38.0
National government	63	44.4
International organizations	52	36.6
Which of the following activities can help decline climate change?		
Buy organic food	18	12.7
Plant more trees	95	66.9
Use public transport	79	55.6
Participate in environmental campaigns	39	27.5

(*continued*)

Table 4.

Table 4.

Variable	*N*	(%)
Buy more energy-efficient devices	77	54.2
Recycle waste	78	54.9
Use less electricity	37	26.1
What do you think is the level of socioeconomic burden of public health hazards due to climate change in your city?		
None	2	1.4
Uncertain	2	1.4
Low	23	16.4
Moderate	42	30.0
High	41	29.3
Very high	30	21.4

66.9% of the respondents stated that planting more trees is an effective way to decline climate change. The percentage of responses that included using public transport, buying more energy-efficient devices, recycle waste approximately were equal among participants (55%).

To determine the importance of different contributions to climate change, respondents were asked, "Which of the factors do you think has contributed the most to climate change?" These factors were aerosols, deforestation, greenhouse gases, land use, land cover change and capitalism. Table 4 demonstrates that most people (48%) determined that greenhouse gases have the highest effect on climate change. In the next level, land use and land cover change were considered 28.8% as the second factor which contributes to climate change. The lowest contributors were for aerosols and capitalism with 18.7% and 1.4%, respectively. Table 4 shows respondents¨ attitudes regarding how climate change threatens on personal health and safety of residents in their city. According to the findings of this study, 45% of respondents to some extent believed that climate change threatens the health of citizens and only 0.7% of people were not sufficiently aware of this issue. The authors investigated the natural hazards that most people have experienced. The items mentioned included floods, dry spells, storm surges, droughts, wild/bush, fires, higher rainfall, heat and cyclones. Approximately 64% of respondents stated that they experienced floods, 56% dry spells and a lower percentage declared they experience droughts (0.7%) in their city.

Extreme weather conditions such as heatwaves, droughts and floods are expected to become more common and intense as a result of climate change (Donkor, 2020). These adjustments are likely to increase property and crop losses, as well as trigger costly societal disruptions (Béné *et al.*, 2018). As shown in Table 4, 57% of the participants stated that poverty is the most important factor that leads to direct socioeconomic impacts of climate change. Following it, respondents regarded inequalities and marginalization to be the major socioeconomic factor in climate change in their cities (51%).

In this survey, the authors considered six actions that can be taken to mitigate climate change impacts and make cities more livable including climate-resilient urban planning; enhanced economic development; environmental regulations to curve carbon emissions and pollution; promote renewable energy; sustainable public transportation; waste management through recycling/reuse. According to Table 4, most of the participants (76.8%) in this survey stated that climate-resilient urban planning is an essential action to address climate change impacts in cities. Besides, promoting renewable energy (59%) was the second most important factor for people. Nearly, 46.5% of the respondents had the same attitude about reducing climate change through sustainable public transportation and waste management.

For the question of who the main responsibility should have to tackle climate change impacts in the city, most people declared that the central government has the highest responsibility (79%). After that, individuals and stakeholders and local government were considered (62%) (Table 4). Concerning the question of what institutions are working to reduce climate change impacts in the city, most of the respondents declared that environmental groups have the greatest responsibility (73.9%).

Table 4 exposes respondents' awareness level of the socioeconomic burden of public health hazards due to climate change. Based on the findings of this study, 30% of people had a moderate attitude and 21.4% of people were sufficiently aware of this issue.

4. Conclusions

This study, as exploratory research, identified the key concepts and mechanisms of urban livability. The effect of climate change on urban viability as well as adaptation in the urban system was analyzed. Based on a comprehensive assessment of urban viability in 15 cities, including 7 in Asia, 4 in Europe, 3 in South America and 1 in Oceania, key functions were identified, and a questionnaire survey was used to assess possible threats of climate change to the livability of cities. The findings of this study emphasize that, after the recent deadly heatwaves, there is clear pressure in many countries to introduce plans, and so their development was necessarily rapid. As such plans are being introduced by an increasing number of countries, the authors recommend that the contents of these plans be consistently developed as information on the effectiveness of interventions accumulates. More importantly, the notion of gradual acclimatization to heat in elderly groups to build up their physiological defenses is a potentially valuable concern that has been given little attention.

The bottom line is that the actions need to be taken to make our communities less vulnerable to the already ongoing impacts of climate change. Many communities have programs to address health issues that are climate-sensitive. Based on the findings of this study, there are a few approaches for managing the health threats associated with extreme heat, as follows:

- by communicating heatwave risks and suggesting protective actions, heatwave early warning systems can protect individuals. These warning systems are much less costly than heat illness treatment and coping strategies;
- encouraging people to hydrate during heat warnings and avoiding strenuous outdoor exercise;
- easy access to public drinking fountains, swimming pools and spray pads, which can help keep individuals cool during periods of extreme heat; and
- urban forests might mitigate UHI, including street trees and wooded areas, reducing local air temperatures.

A stricter mitigation policy should also be implemented, to reduce greenhouse gas emissions. Many studies have shown that lower greenhouse gases are related to lower mortality rates during extreme heat events, especially in tropical cities. Moreover, mitigation measures are also linked with health co-benefits. A case in point is how the promotions to use cleaner alternatives such as public transportation, walking or cycling for daily commute can bring about reductions in climate-altering pollutants in the air, causing direct health benefits for people. Similarly, diets that restrict foods with high carbon footprints, such as meat and dairy products, not only reduce carbon emissions but also offer health benefits by lowering the risk of cardiovascular diseases.

Adaptation measures from public health and health-care services should also be pursued, especially in the tropical cities of low- and middle-income countries. This helps to promote health and reduce the disease burden during increasing temperatures. Some public health interventions include infectious disease surveillance, early warning systems, vulnerability mapping and resilient health-care services. It is suggested that outdoor activities should be reduced during those periods. Vulnerable groups of people should be especially protected. Finally, smart technologies for cooling can also be used to reduce indoor heat and improve the health and well-being of the urban population in developing countries. These include upgrading the housing infrastructure with cooling methods such as ventilation, fans and renewable air conditioning. There are some limitations in this study as it covers a small number of cities around the globe. Moreover, the research only uses data gathered after 2010, hence providing a picture of current trends and limited insights into past trends. Another limitation of this study is that, due to data limitations, it only assessed urban livability after 2010, allowing for only geographical comparisons of urban livability in cities. Investigations on the temporal characteristics of urban livability may help to better understand the influence of climate change on the urban system and may support future adaptation efforts. Furthermore, rather than focusing on nature-based solutions to climate change mitigation and adaptation in urban contexts, this study looks at urban livability and climate change as a function of cities. However, from an ecological aspect, such as ecosystem services, different key insights into this topic will be gained and so may form part of our future study agenda. From an ecological standpoint, a new framework for evaluating urban functions and livability may be developed. The outcomes of this research can help city planners and managers focus on improving urban livability through technological innovation and industrial transformation, which also meets the demands of climate adaptation.

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