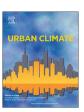
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Urban climate awareness and urgency to adapt: An international overview



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ABSTRACT

Urban climate manifests itself through thermal and wind environments specific to cities and can cause wind danger or overheating. Cities can benefit from preventing these effects through adaptation measures. However, before any action can be taken in improving these urban climate conditions, an awareness of the problems is needed. Numerous studies show that there is awareness of urban climate extremes as a problem, yet that knowledge lacks amongst different actors in society, and may further differ between countries. Therefore, we conducted an international study on the awareness levels regarding urban climate phenomena and the sense of urgency to act within four groups: citizens, local politicians, urban planners and designers, and urban climate experts. Semi-structured interviews with experts in ten countries worldwide were conducted. Results indicate that the urgency to adapt to climate change was acknowledged rather equally for the four groups of actors. In contrast, awareness of urban climate phenomena (urban heat islands and urban wind patterns) amongst citizens and politicians is rather low in most countries. Amongst urban planners and designers and the urban climate experts we observed a generally high awareness regarding urban climate phenomena. Raising awareness requires tailor-made strategies for specific needs of the different actor groups.

1. Introduction

The urban climate, with typical phenomena such as urban heat islands (UHI), low ventilation, or wind nuisance through downwash or corner streams around buildings, is an issue of concern for many cities especially when these phenomena become more extreme due to planning and design mistakes. Urban climate phenomena affect safety, health, comfort, and well-being of inhabitants (Blocken and Carmeliet, 2004; Kovats and Hajat, 2008; Smargiassi et al., 2009; D'Ippoliti et al., 2010; McKenzie, 2015). Rapid urbanization (Seto et al., 2011) and climate change (Klein et al., 2014) contribute to worsening conditions (Grimmond, 2007; Smith and Levermore, 2008). Various actors within cities must come together to effectively solve these urban climate issues (Carmin and Zhang, 2009; Georgi et al., 2012). As Rosenzweig et al. (2010) indicate, the design of the urban realm holds many keys to effective

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climate adaptation measures. Such adaptation involves many actors, from citizens and local politicians to urban planners and designers, and finally urban climate experts (Lenzholzer, 2015; Webb, 2017). The sense of urgency to adapt to climate change in general is seen in many societies (see, for instance Persson and Dzebo, 2019) and related special issue: https://link.springer.com/journal/10784/19/4), but the literature has not considered the sense of urgency to adapt in light of enhanced urban climate extremes (such as temperature and wind problems mentioned above).

Several researchers conducted historical research about urban climate adaptation and indicated that different urban climate adaptation strategies exist across cities (Hebbert and Webb, 2012; Hebbert and Jankovic, 2013; Hebbert and Mackillop, 2013; Hebbert, 2014; Webb, 2017). They provided first hints of awareness regarding urban climate phenomena amongst decision makers and planners in select cities (Tokyo, New York, Stuttgart, Tel Aviv, Manchester). Furthermore, a few studies addressed urban climate matters in the communication between urban climate experts and urban planners (case New York: Corburn, 2009), the sense of urgency regarding urban climate amongst Dutch urban planners (Runhaar et al., 2012) and amongst citizens in Rotterdam (Derkzen et al., 2017). Yet a broader overview of the awareness levels in more than some specific cases was lacking. As opposed to the scant studies on awareness regarding the typical urban climate phenomena temperature and wind, issues of urban flooding such as coastal, riverine and pluvial events, have been widely studied (e.g. Fatti and Patel, 2013; Poussin et al., 2014; Rambonilaza et al., 2016; Bustillos Ardaya et al., 2017; Tanner and Árvai, 2018).

Next to the lack of literature concerning urban climate awareness, we also observed that some of the literature mentioned above focus on municipalities; however, this literature does not address different perceptions of the four main types of actors involved (citizens, local politicians, urban planners/designers, urban climate experts). Hence, our main research questions are: What is the sense of urgency regarding urban climate adaptation and how aware are different actors in different countries about urban climate phenomena? How can the sense of urgency and awareness levels be explained and with which means can they be enhanced?

Climate change perception literature reports that variance in different countries might be explained or influenced by a range of factors, including common or daily experiences of predominant climate situations or weather extremes (Capstick et al., 2015; Lee et al., 2015; Demski et al., 2017), and the level of education in a country (Knight, 2016), which is also tightly related to income levels (see Zajenkowski et al., 2013). Based on the insights from past literature, we hypothesized that the experience of common urban climate phenomena, such as heat waves in the city or wind extremes can influence awareness levels about urban climate. We also assumed that the level of education in a country might explain the level of awareness related to urban climate-related matters. Both parameters (climate experience and education level) were therefore studied as potential explanatory factors for sense of urgency regarding urban climate adaptation and awareness levels of urban climate phenomena.

2. Materials and methods

Similar to other studies on awareness in climate issues (Leiserowitz, 2006) we used a mixed methods approach that combined quantitative and qualitative methods. The study was conducted in ten different countries worldwide that are situated in different climate zones and have different levels education/income levels. The countries studied are Belgium, Bulgaria, China, Germany, Indonesia, Kenya, Netherlands, New Zealand, South Korea, and USA. These countries represent the climate zones that are inhabited by the majority of the world's population. They belong to three zones of the Köppen climate classification system (Kottek et al., 2006): zone A equatorial (Indonesia, Kenya), zone C warm temperate (Belgium, Bulgaria, Germany, Netherlands, New Zealand), zone D snow (South Korea). China and the USA include various climate zones, but 90% of the respondents from the two countries came from the zone C. The choice of these countries forms—to some extent—a convenience sample because we could only work with students and colleagues who were able to speak the local languages.

The data collection was conducted from 2015 to 2017 inclusive, and consisted of semi-structured interviews with seven to twelve interviewees per country (n = 102). Most interviews were taken face-to-face. About one third were obtained through Skype or telephone and the questions 1 and 3 for the USA interviews were answered via SurveyMonkey. The interviewees were experts in the field of urban climate and sustainability from different sectors (business, government, academia or NGOs) and had an overview of the current urban climate issues and related debate and adaptation actions in their respective country.

The interviews included two sets of questions. The first set of questions dealt with the sense of urgency for climate adaptation in general. All respondents were asked to estimate the sense of urgency amongst four types of actors (citizens, politicians, urban planners/designers and urban climate scientists/experts) in their country (question 1). Respondents provided an estimate of the sense of urgency on a 5-point Likert scale (very urgent, urgent, neutral, less urgent, not urgent), or 'do not know'. Next to the quantifiable answers given in the Likert scale, respondents could comment on their answer; these qualitative comments were also recorded as they provided additional insights regarding the awareness levels. The respondents were also asked for suggestions about how to raise the sense of urgency in case it was deemed low (question 2).

The second set of questions concerned the level of awareness regarding typical urban climate phenomena, such as urban heat and wind discomfort. Here the respondents were asked to estimate the level of awareness for three types of actors (citizens, politicians and urban planners/designers) in their country (question 3). Urban climate experts were left out of this question as they are familiar with these phenomena by definition. We used a similar setup for the answering options as listed above, using a 5-point Likert scale (very aware, aware, neutral, less aware, not aware) and the option 'do not know'. In case the sense of awareness was considered low, the respondents could suggest measures to increase awareness (question 4).

The data derived from the Likert-scale answers were analysed with descriptive statistics in Excel (see Figs. 1–10) and the results from the respective countries were compared. The more than 500 comments coinciding with the Likert scale choices and more than 1000 answers to the open questions were analysed through a qualitative content analysis in Atlas.ti. We first analysed all individual

 Table 1

 Climate data that served as basis for regressions with interview data.

Temperature data				
Source	Countries covered	Data average temperatures year Data extreme temperatures range covered year range	Data extreme temperatures year range	website
Climate Knowledge Portal of the World Bank Wind data	Пе	1991–2016	1991–2016	https://climateknowledgeportal.; worldbank.org/download-data
source	Countries covered	Mean wind speed Year range covered		website
KNMI UN climate data	Germany, Indonesia, New Zealand Belgium, Bulgaria, China, Kenya, Netherlands, South Korea, United States	1979 to 2000 1961–1990 (Kenya only 1980–1987)	7)	https://dimexp.knmi.nl/ http://data.un.org/Data.aspx?d; = CLINO&f = ElementGode%3A16

Table 2

Overview of regression results for countries' education levels and climate data.

Relations per question	Category of actors	R ² values high level awareness	R ² values low level awareness
1. sense of urgency related to:			
Education levels	Citizens	0.266	-0.067
	Politicians	-0.17	0.013
Average temperature	Citizens	0.004	0.046
	Politicians	-0.103	0.057
	Urban pl./ des.	0.397	-0.006
	Urban climate exp.	0.325	0.388
Extreme temperature	Citizens	-0.066	0.203
	Politicians	-0.024	0.000
	Urban pl./ des.	0.234	-0.034
	Urban climate exp.	0.109	0.237
3a. awareness levels about UHI related to:	_		
Education levels	Citizens	-0.263	0.475
	Politicians	-0.844	0.646
Average temperature	Citizens	-0.064	0.089
	Politicians	-0.110	0.482
	Urban pl./ des.	-0.172	0.048
Extreme temperature	Citizens	0.051	-0.029
	Politicians	0.019	0.031
	Urban pl./ des.	0.001	-0.013
3b. awareness levels about wind related to:	•		
Education levels	Citizens	-0.110	0.143
Zadedion 10.00	Politicians	-0.416	0.540
Mean wind speeds	Citizens	0.013	-0.021
	Politicians	-0.004	0.059
	Urban pl./ des.	0.038	-0.003

comments and answers on their content and created a coding list of 35 codes that represent similar types of answers. All answers and comments were then coded, and the outcomes were presented in co-occurrence tables relating codes to countries (see appendix).

As mentioned above, we assumed that the national climate circumstances might have an influence on the awareness about urban climate as populations may be exposed to its typical phenomena to varying degrees in their country. To compare the interview data with climate data, we collected relevant climate data for all countries: data for the mean and the extreme temperatures, as well as for the mean wind speed. We retrieved the data from different weather station data sources depending on their availability, which are listed in Table 1. The sources of climate data for yearly averages and extreme air temperatures and the mean wind speeds are shown in Table 1. We analysed these data in Excel. We clustered the results by an affirmative answer to the respective question (e.g. 'very aware'/ 'aware') and the dissenting answers ('less aware'/ 'not aware') and omitted 'neutral' and 'do not know' as these responses do not provide usable data for statistical comparison. Based on these data, we generated regressions relating climate data to affirmative and dissenting responses. For the regressions, we related sense of urgency and awareness to rising average/extreme temperatures and wind speeds (the latter only for question 3, wind discomfort awareness, and vice versa).

As we hypothesized that the education levels in different countries may influence the sense of urgency and awareness levels, we also related data on education levels to our data. Since education levels in countries are closely related to income levels (Zajenkowski et al., 2013) we refrained from relating our data to income levels because the predictive values would be the same. We only related sense of urgency and awareness levels of politicians and citizens to these data because urban planners/ designers and urban climate experts are highly educated by default. We ranked the countries according to the education index 2013 of the United Nations, 2013. Within this index, the countries studied belong to the following groups: - countries with highest education levels (first quartile of ranking): Belgium, Germany, Netherlands, New Zealand, South Korea, USA

- countries with medium education levels (second quartile of ranking): Bulgaria, China
- countries with lower education levels (third quartile of ranking): Indonesia
- countries with low education levels (fourth quartile of ranking): Kenya.

The data for all countries per education level group were accumulated and averages were calculated for the classes 'very aware' ('aware' and 'less aware' / 'not aware'. The classes 'neutral' and 'do not know' were omitted as they do not provide usable data for regressions. We then generated regressions for the education level data and their relationship to the awareness level data. We compared the outcomes to understand the relationship between the sense of urgency regarding urban climate adaptation and awareness levels about urban climate phenomena for different education levels. We averaged the data for urban heat and wind awareness and calculated averages for the classes 'very aware' / 'aware' and 'less aware' / 'not aware'. These were related to the different education levels.

3. Results and discussion

Here we present and discuss the results of the inquiries for each interview question and each type of actor, respectively. Results from questions 1 and 3 are presented and discussed in the context of the interviewees' comments, and regression results. Results from questions 2 and 4 are presented in co-occurrence tables (see appendix) and discussed in the context of the interviewees' comments and quotes. We emphasize that the presented data do not reflect the opinions of the specific actor types asked about in the interviews (citizens, politicians, etc.) but that they are an informed estimation by the interviewees (experts in the field of urban climate and sustainability from different sectors; n = 102). For lingual simplicity, we will refrain from mentioning this fact in each sentence when the results are described. The relationships between sense of urgency or awareness levels and education levels are represented in column diagrams; the relationships between the weather data and these levels are shown in scatterplots. All can be found in the appendix. In Table 2, we provide a short overview of these data and in the discussion of the data by question. For simplicity, we only mention cases in which relationships between factors can be stated. We conclude the presentation of the results by question with a short summary and comparison of results between actor groups.

3.1. Question 1. What is the sense of urgency to adapt the urban environment to climate change amongst the following groups: citizens/politicians/urban planners and designers/urban climate experts in the future?

3.1.1. Citizens

In general, citizens across all countries have not developed a strong sense of urgency related to climate change adaptation in urban environments. However, there are significant differences between countries. In countries like Bulgaria, China, South Korea and Kenya, the sense of urgency is quite prominent compared to New Zealand, Belgium, Indonesia, and the Netherlands. This resembles the outcomes of studies by (Hagen et al., 2016), showing that Europeans generally seemed rather ambiguous about climate change and the need for suitable adaptation, and that African and Asian countries show a higher awareness (Lee et al., 2015). Interviewee comments that explain a lower sense of urgency, reported denial of the need to adapt to climate change (USA) – which has also been reported by (McCright et al., 2014) and (Lee et al., 2015) – and the prevalence of other priorities (USA, New Zealand, also see Leiserowitz, 2006). Furthermore, the abstract nature of climate processes was indicated as an issue, as expressed by a Korean respondent: "Climate is an invisible thing. But we invented temperature. 'Degree' is the quantification of invisible thermal sense." The reasons for a higher sense of urgency in other countries were based on experience of extreme events, such as long heat waves or flooding (Netherlands, South Korea) or daily exposure to climate change effects (Kenya). These results are in line with the findings by (Lee et al., 2015). A higher sense of urgency was also based on education of citizens (New Zealand, South Korea), or media campaigns around climate (South Korea, Kenya) that were also identified by Capstick et al. (2015), but also political activities such as bottom-up pressure groups from citizens (Belgium, USA),

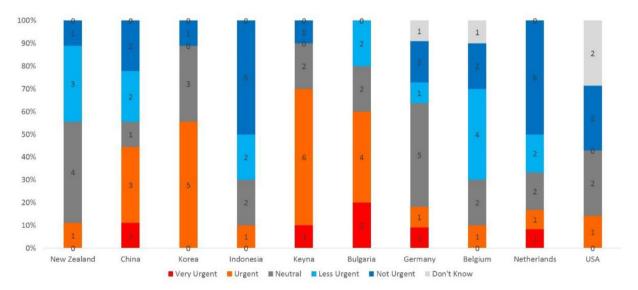


Fig. 1. Sense of urgency of citizens about climate change adaptation across all countries. Numbers in columns indicate absolute counts.

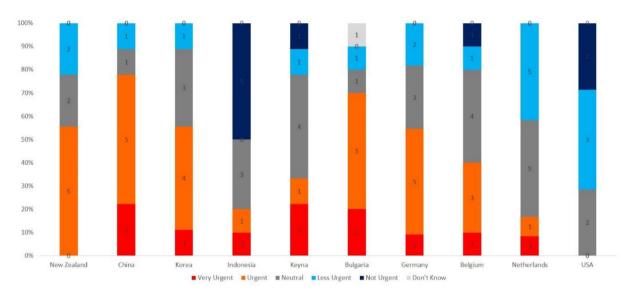


Fig. 2. Sense of urgency of politicians about climate change adaptation across all countries. Numbers in columns indicate absolute counts.

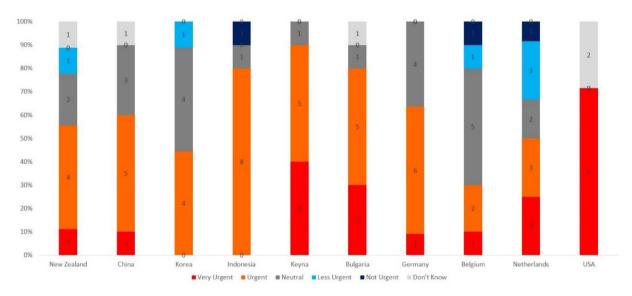


Fig. 3. Sense of urgency of urban planners and designers about climate change adaptation across all countries. Numbers in columns indicate absolute counts.

A high sense of urgency seems to associate with lower education levels in the regression data. The fact that a lower sense of urgency is related to a higher education level and vice versa was an unexpected result. We hypothesized that higher education levels would bring about a higher sense of urgency. Conversely, groups with lower education are usually more directly affected by climate change impacts due to lower incomes and housing situation (i.e., low adaptive capacities, also see Laukkonen et al., 2009; Carmin and Zhang, 2009).

The heat extreme data (maximum temperature) seem to have a weak relationship with the sense of urgency. This result corresponds with the additional comments of the interviewees we discussed above, expressing that extreme events and daily exposure to rather extreme situations raises the sense of urgency (also see Lee et al., 2015).

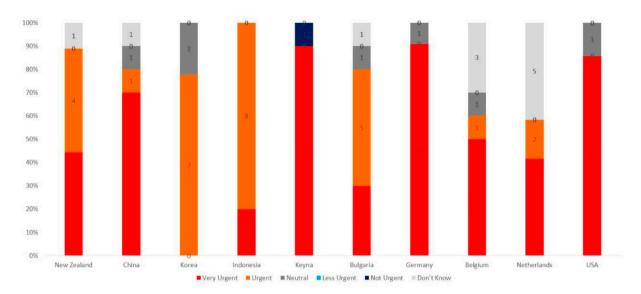


Fig. 4. Sense of urgency of urban climate experts about climate change adaptation across all countries. Numbers in columns indicate absolute counts.

3.1.2. Politicians

In general, local politicians have developed a sense of urgency for climate adaptation in cities, but not in all cases. Various interviewees stated that a lower sense of urgency is attributable to the fact that climate is a rather abstract phenomenon (South Korea, Netherlands), that usually other priorities prevail (Belgium, Kenya, Netherlands, New Zealand, South Korea), and that there is a lack of political will (Belgium, Kenya). Similar reasons were identified by Archie et al. (2018) for the situation in New Zealand. The results also show a rather large amount of mentions within the category 'neutral'. This choice has been justified by several respondents with reasons such as: "Dependent upon political persuasion" (New Zealand); "very different senses of urgency amongst politicians" (Belgium).

The reasons stated as to why a high sense of urgency exists include the everyday experience of climate phenomena (Kenya) and media campaigns (South Korea, Kenya). In some countries such as Germany, China, and South Korea, the politicians' strong sense of urgency might be attributable to the fact that environmental issues due to industrialization (e.g. air pollution) have made urban climate an important topic in local policies (Lee et al., 2015; Ren et al., 2018). However, in some cases a lower sense of urgency amongst local politicians was mentioned and a typical reason was that politicians are more interested in producing tangible short term outcomes (Netherlands).

The sense of urgency to adapt the urban environment to climate change amongst local politicians is not very clearly related to education levels of the countries. This result may be attributable to the fact that many politicians have a stronger sense of urgency in general, and being informed about urgency depends less on their education level but rather the political agenda of their respective parties (also see McCright et al., 2014; Lee et al., 2015; Hornsey et al., 2016). Average temperatures show a weak relationship with sense of urgency which can be supported by responses from Kenya attributing the daily experience of hot temperatures to raising the sense of urgency amongst politicians. Similar relationships are also reported in the literature (Lee et al., 2015).

3.1.3. Urban planners and designers

In general, our data indicate that urban planners and designers have developed a strong sense of urgency for the adaptation of cities to cope with a changing urban climate. Some comments indicated that previous education, local environmental laws, or the presence of appraisal mechanisms (e.g. urban climate maps in Belgium) help raise the sense of urgency amongst urban planners and designers. Comments by various interviewees showed that a lower sense of urgency mainly occurs due to other priorities during the planning process (Belgium, Netherlands, Kenya) or the lack of resources (Kenya), typical issues that have also been identified by Aylett (2015).

Relating the sense of urgency to the temperature, data we see connections between a higher sense of urgency for both average and extreme temperature data. Urban planners and designers in countries with higher temperatures and more weather extremes must respond to these threats, and are thus well aware of the urgency to act, as was also shown by (Madsen et al., 2019).

3.1.4. Urban climate experts

Urban climate experts are generally aware of the urgency to act on climate change adaptation. The interviewees' comments report that this is mainly based on this group's education. However, in some countries urban climate experts do not exist, which has been stated for Kenya, Bulgaria and Indonesia - a problem that has also been recognised by McPhearson et al. (2016).

Overall, the air temperature data correlate well with the sense of urgency amongst climate experts. The profound knowledge about climate circumstances within this group and their knowledge about the implications of higher temperatures (and climate

change) explain their strong sense of urgency.

3.1.5. Summary and comparison of results for question 1

Citizens have a rather high sense of urgency in countries with lower education levels and a rather low sense of urgency in countries with higher education levels and their sense of urgency relates to either the daily experience of climate situations or experience of disastrous incidents. The politicians' sense of urgency to act is also partly influenced by the daily experience of climate phenomena, but probably more so by political agenda of their respective parties. Urban planners and designers have a relatively high sense of urgency in general, particularly in countries with higher temperatures where the need to adapt is higher. Further, urban climate experts are generally well aware of the need to adapt, given their expertise. However, in various countries a lack of such experts has been stated.

3.2. Question 2. In case the sense of urgency is low, what is needed to raise sense of urgency within those groups about adapting the urban environment?

3.2.1. Citizens

Numerous factors that may raise the sense of urgency amongst citizens were mentioned. One of the most prominent measures belongs to learning about urban climate and its consequences through citizen education(New Zealand, but also the Netherlands and South Korea). Another method to raise the sense of urgency belongs to experiential learning, such as seeing best practice examples of urban climate adaptation, which was frequently mentioned by German respondents and might be induced by the long-standing tradition of urban climate adaptation in Germany, as reported by Hebbert (2014).

Another direct way to become aware can be negative everyday experiences of citizens (Bulgaria, Kenya), such as extreme events. The occurrence of disastrous events that form a 'wake-up-call' is also mentioned by respondents from highly developed countries (Germany, Netherlands, New Zealand) that are less vulnerable to climate events than less developed countries. An interviewee from New Zealand phrased it this way: "data (graphs, statistics, etc.) won't make people change behaviour - behaviour only changes when people are in a critical situation".

Communication is seen as important to actively influence the sense of urgency. Media campaigns were mentioned by all countries, apart from the Netherlands, and seem to play a very important role in China and other countries, although to a lesser degree. The prominent role of media, or as the Chinese respondents called it "propaganda", might be linked to a traditional centralistic information provision. More interactive approaches such as workshops, conferences or 'climate' festivals are also mentioned often. Especially in South Korea, such activities are seen as an effective means to foster sense of urgency.

Communication of specialist knowledge in simple language without jargon is mentioned in countries with very different education levels. To communicate general climate change-related information, Wirth et al. (2014) and Corburn (2009) also emphasized the comprehensibility of communication. One of the strongest means to raise a sense of urgency is a lively public discussion, that has been identified by Lee and Hughes (2017) as well when it comes to the recognition of urban climate hazards and adaptation measures. The answers from our respondents mainly derive from countries with a long-standing democratic political tradition. Such public debates can also build up political pressure (Belgium, Germany) that by itself can strengthen a sense of urgency.

Different tools and regulations can help foster the sense of urgency. For instance, appraisal tools such as urban climate maps, are considered effective tools by German and Belgian respondents (also see Ng and Ren, 2015). Related to such tools, the use of quality labels and certifications for sustainable building and urban design (e.g., BREEAM LEED) is also seen as an effective initiative in Germany and USA. In addition, visualizations of urban climate adaptation options to create a more understandable picture was mentioned by several German interviewees, a measure that Corfee-Morlot et al. (2011), Sheppard (2015) and Moser (2016) also suggested. Furthermore, the enforcement of local rules such as zoning plans can raise a sense of urgency and acting can be nudged with special subsidies.

3.2.2. Politicians

The local politicians' sense of urgency can be influenced through similar learning and educational means. Education was mentioned often, mainly in countries with lower education levels. Furthermore, experiential learning seems to be important for politicians, for instance through seeing demonstration projects, or conversely through experiencing harmful extreme events (the Netherlands), which relates to the findings regarding urban flooding (Madsen et al., 2019). Experiencing such extreme events were not mentioned as a means to enhance a sense of urgency amongst politicians in other countries. Possibly, the Dutch vulnerability to flooding has brought these issues into political focus.

Other means reported to raise politicians' sense of urgency include interactive events (exhibitions, festivals, conferences) in various countries, a measure that was also suggested by Lee and Hughes (2017). Bringing the issues about climate adaptation into the political debate is considered a good way to raise the sense of urgency amongst politicians, mainly in countries with democratic systems. This method can also be fostered by the presence of powerful spokesperson coupled with citizens' pressure on politicians.

Some respondents mentioned that appraisal mechanisms such as urban climate data and maps "showing the hard facts" are useful. In the context of climate change awareness (Ding et al., 2011) other authors also emphasized the necessity for providing reliable data as decision support. The enforcement of existing rules or laws is also seen as a way to raise the sense of urgency for urban adaptation. Politicians in countries where such regulations exist (e.g. urban climate plans in China, or translation of urban climate directives into legal plans, such as zoning plans in Germany) seem to have a higher sense of urgency.

3.2.3. Urban planners and designers

Lifelong learning with dedicated courses for the professionals is generally seen as a main tool to raise the sense of urgency amongst urban planners and designers. Respondents from all countries apart from Bulgaria, New Zealand, and USA mention this as a key measure. Some also see demonstration/pilot projects as useful methods to raise the sense of urgency, which connect to IT tools, such as web-applications and adaptation visualization tools are useful for increasing knowledge and urgency. Finally, comprehensible language (no jargon) is needed amongst the urban planners and designers, and access to interactive events (e.g. conferences). Planners and designers' sense of urgency can be raised by the need to meet sustainability certificates, such as BREEAM, or having to follow existing environmental laws. Financial incentives for adaptation, as well as IT tools such as web-apps for urban climate and adaptation visualization, are seen as useful, too.

3.2.4. Urban climate experts

Within urban climate experts, the sense of urgency is already high, which may be due to the nature of their expertise. Still, some suggestions were made such as getting to know best practice (New Zealand), communication (i.e. simple language; Belgium, New Zealand) and interactive events with other stakeholders (China, Indonesia). Also, the use of appraisal tools (Belgium, Indonesia) is considered to raise the sense of urgency for adaptation in this group.

3.2.5. Summary and comparison of results: question 2

For all groups, except for the urban climate experts, a range of suggestions was made to enhance a sense of urgency that reoccurred frequently. These include: media campaigns, public discussion and citizen engagement, education of citizens and professionals, interactive events (exhibitions, festivals, etc.) and law enforcement. In some countries we could observe a tendency to prefer
different methods: one-way communication (e.g. 'propaganda' in China), education of citizens and politicians (China, Indonesia, New
Zealand) or 'top-down' methods (law enforcement in Bulgaria, Germany, Indonesia, Kenya) to two-way communication in events and
political debate (Kenya, Indonesia, South Korea) to 'lead by example' (demonstration projects in Germany). In general, urban
planners and designers as well as urban climate experts, are involved from a professional perspective and the ways to raise the sense
of urgency differ from other groups by placing lifelong learning into the centre of attention.

3.3. Question 3. How aware are the different groups of the following two urban climate phenomena?

3.a) Urban Heat Island

3.3.1. Citizens

In general, citizens are not very aware of UHI phenomena. However, in a few countries such as South Korea and Germany, the awareness is higher than in others, especially Bulgaria, Indonesia, New Zealand, and Belgium. The interviewees' comments showed that lower awareness is generally related to a lack of knowledge about cause and effect of urban heat (New Zealand, Kenya, Belgium) or because urban heat is perceived less of an issue due to the prevailing climate conditions (New Zealand). Awareness is higher when citizens are confronted frequently with extreme heat waves, as South Korean respondents emphasized. Other climate effects like urban flooding are sometimes seen as a more prominent issue, for instance in the Netherlands, (Runhaar et al., 2012; Boezeman and Kooij, 2015; Derkzen et al., 2017) or in the UK (Spence et al., 2011). The prevalence in awareness when it comes to urban flooding

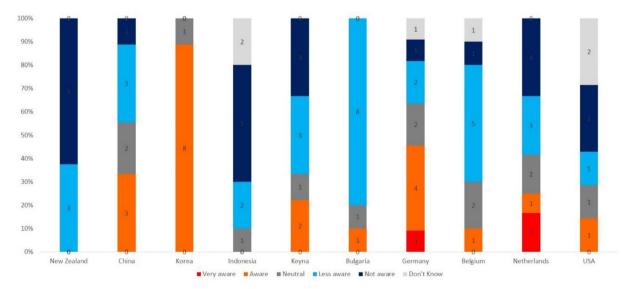


Fig. 5. Awareness of citizens regarding UHI phenomena across all countries. Numbers in columns indicate absolute counts.

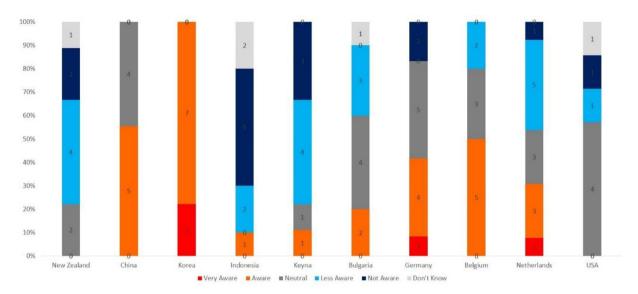


Fig. 6. Awareness of politicians regarding UHI phenomena across all countries. Numbers in columns indicate absolute counts.

issues as opposed to UHI issues causing overheating has also been itemised by Carmin et al. (2012).

An influence of education levels on the awareness of UHIs seems to exist: lower education levels relate to lower awareness of UHI and vice versa. Higher education seems to provide better access to knowledge about urban climate issues, either during formal education or due to the use of media.

3.3.2. Politicians

The awareness levels reported for local politicians have an almost even distribution for those who are aware of the UHI and those who are not. Respondents' comments point out that this distribution is related to the respective political dossier of local politicians. However, in a few countries, such as South Korea, China, Belgium, and Germany, the awareness amongst politicians is clearly higher than in others (Kenya Indonesia, Netherlands, New Zealand, USA). This may be partly explained by the fact that some of these countries, such as China and Germany, have developed intensive dialogues between urban climate researchers and decision makers (Hebbert, 2014). Awareness of the UHI and urban heat was raised when confronted with extreme heat waves (South Korea) or local climate studies (Belgium), but also due to pressure from citizens (USA). Awareness is lower because "it is a new issue" (Belgium) and due to a lack of basic scientific knowledge or as a Kenyan interviewee put it: "they have some understanding but cannot connect cause and effect". However, interviewees also mentioned that politicians who are aware still choose not to act accordingly due to other priorities (The Netherlands), an issue that has been raised in the literature on climate adaptation more widely (e.g. Henstra, 2012; Hagen et al., 2016).

Higher education levels are related to higher levels of UHI awareness as the regressions show. The data for average temperatures show that warmer countries are related with lower awareness. On first thought, this seems contradictory but the lower awareness level in the two tropical countries can also be influenced by their lower education level, given this strong correlation with education levels.

3.3.3. Urban planners and designers

These data show a very clear picture: urban planners and designers have a generally high level of awareness of the UHI. The interviewees mentioned that urban planners and designers are aware as a result of their professional training (New Zealand, Kenya). It seems that early efforts to 'teach the teachers' (Hebbert and Mackillop, 2013) in the planning and design community have been fruitful. However, it was also stated that planners and designers do not act according to that awareness due to other urban planning priorities or lacking knowledge about climate adaptation measures (New Zealand, Belgium, The Netherlands).

3.3.4. Summary of results for question 3a

The awareness of the UHI amongst citizens is rather low and it seems that higher awareness levels are mainly influenced by education levels in different countries. Local politicians seem to be more aware than citizens but we also observe a clear influence of the countries' education levels where countries with higher education levels display higher levels of awareness. Urban planners and designers are generally quite aware of the UHI phenomenon, but in their practice, they often do not act accordingly, e.g. due to other priorities.

3.b) Wind Discomfort.

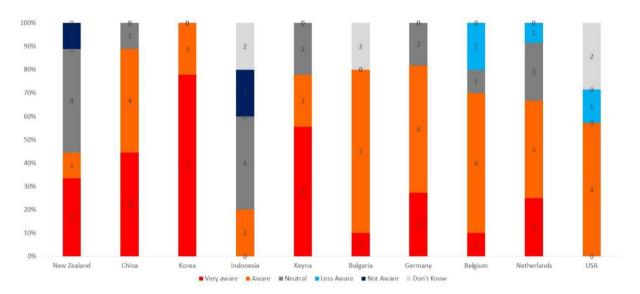


Fig. 7. Awareness of urban planners and designers regarding UHI phenomena across all countries. Numbers in columns indicate absolute counts.

3.3.5. Citizens

Citizens, it seems, are generally less aware of wind discomfort in cities. However, in a few countries such as New Zealand and The Netherlands, the awareness is clearly higher than in most other countries. The awareness of wind extremes and related discomfort are especially low in countries like South Korea, Bulgaria and Indonesia. The interviewee's comments showed that citizens in New Zealand and The Netherlands are more aware of wind discomfort given the prevailing wind conditions in both countries and experiences with wind danger near tall buildings, or as a Belgian interviewee put it: "depending on where you live you know wind issues, for instance when you live in a neighbourhood with tall apartment flats".

Interviewees from other countries (Korea, Kenya and Belgium) think that there is a lack of knowledge about the causes and effects concerning urban wind phenomena. The average wind speeds in the respective countries do not seem to explain the awareness of urban wind effects amongst citizens. This result is partly in contrast to our data on awareness and the comments of the interviewees that show that people do know such effects through daily exposure to wind discomfort. A potential explanation might be that wind danger or discomfort is mainly felt during gusty situations which are not adequately represented by the data of average wind speeds.

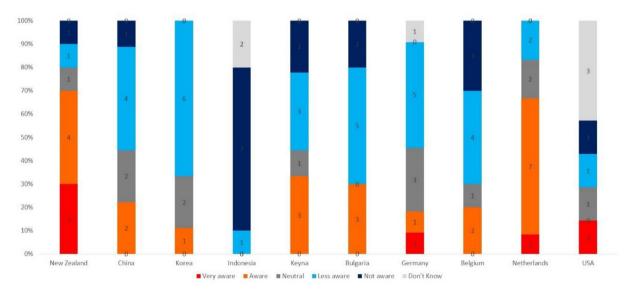


Fig. 8. Awareness of citizens regarding urban wind phenomena across all countries. Numbers in columns indicate absolute counts.

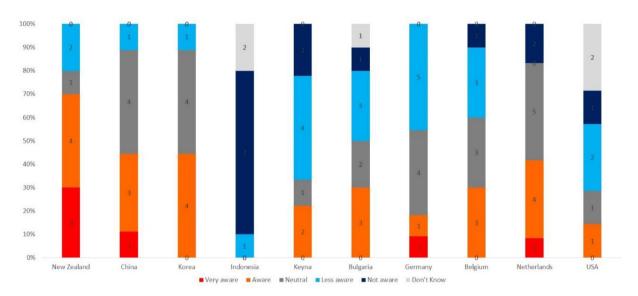


Fig. 9. Awareness of politicians regarding urban wind phenomena across all countries. Numbers in columns indicate absolute counts.

3.3.6. Politicians

The results for the local politicians show limited awareness about urban wind discomfort in most countries. Yet, in New Zealand and The Netherlands, the awareness is higher than in most other countries, while the awareness amongst politicians is low in countries like Kenya, Bulgaria, Belgium Indonesia and the USA. The interviewees provided similar arguments for the reasons regarding these awareness levels as for the citizens. However, they also perceived that even when politicians are aware of urban wind discomfort, they choose not to act on it because of a lack of political will or other priorities (New Zealand, South Korea, Belgium, The Netherlands).

Awareness of wind discomfort shows clear relations with the education levels of countries when the group of politicians is considered. Countries with lower education levels show lower awareness of wind discomfort issues.

3.3.7. Urban planners and designers

The data indicate a high level of awareness amongst urban planners and designers concerning wind discomfort effects in almost all countries apart from Indonesia and Belgium. The interviewee's comments showed that urban planners and designers are aware due to their training and building standards, such as the norm NEN 8100 in The Netherlands, which includes recommendations on wind nuisance and risk prevention. However, it was also mentioned that these recommendations are ignored and "architects often go for the beautiful option and not the one that is wind conscious" (The Netherlands). The Belgian interviewees stated that similar regulations also

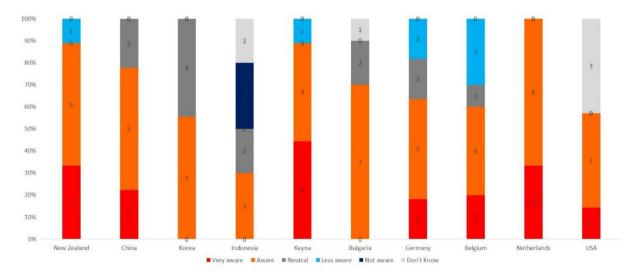


Fig. 10. Awareness of urban planners and designers regarding urban wind phenomena across all countries. Numbers in columns indicate absolute counts.

exist in Belgium, but that urban designers perceive these as something forced upon them and do not act accordingly in their professional practice.

3.3.8. Summary of results for question 3 b

Amongst citizens and politicians we observed low awareness levels, but in the Netherlands and New Zealand, people tend to be more aware of urban wind phenomena than elsewhere. In general, politicians are more aware than citizens, and so are urban planners and designers who are aware of urban wind issues mainly due to their education and, in some cases, to national regulations.

3.4. Question 4. In case awareness is low, what is needed to increase the awareness about the two urban climate phenomena mentioned in question 3?

3.4.1. Citizens

The interviewees suggested a wide variety of measures to raise awareness amongst citizens about urban climate phenomena. Media campaigns were mentioned the most and by interviewees from all ten countries, pointing out visual communication like films and videos. Other information and communication measures that were mentioned include interactive events, communication amongst stakeholders, and communication in simple language. The category of information and communication measures was mentioned the most by respondents from Kenya and Germany. Moreover, the interviewees from Germany especially emphasized the potential of taking an interactive approach, for instance "through interactive/personal experience by e.g. climate walks/UHI walks on local level"

The second most frequently mentioned measure was education of citizens (almost all countries, especially China, Indonesia and Kenya). Education should raise awareness about the causes of urban climate phenomena people are experiencing, such as heat, as expressed by an interviewee from Kenya: "A similar approach can be taken to what was done for HIV Aids. In the universities it was made a compulsory subject." The results show that many interviewees consider informing citizens about urban climate phenomena as a first step, but that the key challenge is to engage citizens more actively. Consequently, the third most mentioned measure was public discussion and engagement, especially by interviewees from Indonesia (who called this 'socializing'), China, and Kenya. An interviewee reported that some Dutch municipalities invited citizens to be actively involved in the (re)design of their street or public space (Netherlands), which also resulted in increasing numbers of bottom-up initiatives for greening and de-paving the city and private gardens (Netherlands). Such 'social learning approaches' have also been suggested in the context of raising awareness about climate change (Collins and Ison, 2009; Pahl-Wostl, 2009) and for developing countries (see Pardo Martínez et al., 2018)

Other measures were mentioned, yet far less, including the use of IT tools (interviewees from six different countries). However, given the rapid technological development these tools may become more important in the future to support communication as well as information gathering and sharing about local urban climate issues, e.g. through urban climate apps, climate maps (Ren et al., 2012), and social media. Other studies have similarly identified such interactive IT tools as a suitable measure to raise citizen awareness on urban climate and adaptation (Vachon et al., 2013; EEA, 2012).

3.4.2. Politicians

The most frequently mentioned measure to raise awareness amongst local politicians was lifelong learning, especially by interviewees from Indonesia, China and Kenya. Interviewees from Indonesia and Kenya pointed out that politicians need to be advocates for awareness raising of urban climate phenomena, but first they need to be trained, because "Politicians need to see a solution. Now, many people are confronting them with problems" (Kenya).

The second most mentioned measure was communication amongst stakeholders by interviewees from seven different countries, especially Germany and Kenya. German interviewees stressed the need for good and comprehensive scientific advice and Kenyan interviewees that politicians should engage with urban planners and designers as well as citizens. Other frequently mentioned were media campaigns and interactive events. Enforcement of rules and laws was mentioned by interviewees from nine different countries, demonstrating a general need for clear policy guidelines to raise awareness amongst politicians. At present they perceive a general lack of urban climate policies and guidelines (New Zealand, Indonesia, Kenya, Bulgaria, Netherlands and USA), a need for national objectives and hard measures (Germany, also see the legalistic and interventionistic "Germanic tradition" in Mees, 2017, p. 383), a need to link urban climate policy more clearly to other missions of the city (Belgium), or a need to raise awareness amongst politicians of relevant policies and laws (China).

In general, the measures mentioned by the interviewees show that politicians not only need to be aware of the urban climate phenomena and their extremes, but to also require knowledge about more integrated approaches and solutions. In practice, they are confronted with the challenge to balance urban climate issues against and link with other urban challenges, such as food supply, leisure and biodiversity.

3.4.3. Urban planners and designers

Generally, education of current and future professionals is seen as the primary measure for raising awareness amongst urban planners and designers. Lifelong learning was mentioned the most, by interviewees from all countries, apart from Indonesia. Education and training of future professionals was mentioned by interviewees from seven countries, especially China, who stressed the need for certificate training and exams (three interviewees from China). Training of current and future professionals should also provide more tools and confidence in designing with urban climate issues (New Zealand) and knowledge about innovative solutions and measures to build supportive infrastructure and capacity (Bulgaria).

3.4.4. Summary of results: question 4

Results showed a distinct difference between measures suggested for raising awareness amongst citizens and those for raising awareness amongst politicians, planners and designers. Measures for raising awareness amongst citizens were predominantly information and communication measures, and education. However, the interviews also showed that raising awareness through information and communication is a first step and should be supplemented with more interactive approaches, in order to raise public discussion about and engagement with urban climate issues.

Raising awareness amongst politicians, urban planners, and designers is mainly seen as a challenge of educating future professionals and lifelong learning of current professionals. Overall, the first seems to be widely applied already, while the latter is in need of further improvement. Additionally, the results show a need for knowledge about more integrated approaches and solutions. Politicians need such measures and solutions to deal with urban climate issues in the political arena, to support them in their decision making. These measures include the need to communicate with both professionals and citizens, and ways to balance urban climate issues with and link to other urban challenges for creating synergies. Urban planners and designers especially need new approaches and solutions to incorporate urban climate issues in their urban designs and plans.

3.5. Relating sense of urgency to adapt the urban environment to climate change to the awareness about urban climate phenomena

We had pondered how far education levels in countries might influence the sense of urgency to adapt to the awareness about urban climate phenomena, specifically because our descriptive statistics and the respondents' comments pointed towards a thought-provoking paradox: It seemed that countries with lower education levels have a higher sense of urgency to adapt to climate change, and that countries with higher education levels have a lower sense of urgency. At the same time, awareness levels regarding urban climate phenomena were lower in counties with lower education levels and higher in countries with higher education levels. We analysed the data further and our results indicate that indeed, these relations seem to exist (see appendix).

4. Conclusions

Our findings concerning the sense of urgency to adapt urban environments to climate change support findings by other researchers who studied perceptions of climate change risks, adaptive capacity and other related fields. Our results similarly indicate that levels of the sense of urgency in different countries vary significantly. We noted that education levels of countries can be a good predictor for the sense of urgency but also 'climate experience', which is in line with, e.g. (Lee et al., 2015). We observed a varying sense of urgency amongst citizens and politicians and a rather high sense of urgency amongst urban planners/designers and climate experts.

Regarding awareness of urban climate problems, we observed a general lack of awareness amongst citizens and politicians in all countries, although there are significant differences between the responses by country. The education levels in the different countries were a good predictor for the awareness levels, but the climate data were only a predictor in some cases. Urban wind phenomena were less known amongst these actor groups than urban heat effects. The awareness levels amongst urban planners and designers about the problems regarding urban climate is rather high in all countries, showing that the formal education seems to devote sufficient attention to the topic. Various countries have urban climate experts who can also advise politicians, urban planners and designers.

We saw a gap between the higher sense of urgency about the need for climate adaptation and the low awareness about urban climate phenomena in the less developed countries. As these countries have populations more vulnerable to climate impacts (Scoville-Simonds et al., 2020), especially when it comes to urban heat, awareness about urban climate phenomena needs to be raised and citizens and politicians need to get acquainted with suitable measures to prevent urban climate issues. But also, awareness amongst citizens and politicians needs to be strengthened in developed countries.

We noticed that education and communication are perceived as the most effective means to raise people's awareness levels. Yet there was also a clear plea for demonstrations of best practice, as well as taking more interactive approaches in communicating climate issues, especially to raise public discussion and engagement. The general lack of knowledge amongst citizens and politicians might also be attributable to the abstract and 'invisible' nature of urban climate processes, which is different from the very visible and tangible impact of another type of urban climate phenomenon: flooding. This finding calls for more visualization tools and due to the ephemeral nature of urban climate phenomena, non-static imagery (e.g. videos or animations).

Our study confirmed other researchers' findings about the sense of urgency when it comes to urban climate adaptation and added new findings to the literature concerning countries that have not been studied before. Our research has also added a new dimension by clearly differentiating the different actors who play a role in urban climate adaptation processes, being citizens, local politicians, the planning and design professionals, as well as the urban climate experts. The awareness of urban climate phenomena has not been studied before and hence our study presents fresh data in this new field of research.

But more research in this context needs to be conducted because our study also has its limitation: The data we collected only covers a range of ten countries and our data are therefore only indicative, especially for the countries with lower education (and income) levels which are less well represented in our work. A broader study that involves more countries, especially from the global South, or from countries with different political systems than the overrepresented democratic countries, could provide useful data. Furthermore, our study had a limited number of interviewees per country and the quantitative data only allow simple statistics. Irrespective of these limitations, we believe that our novel results can form the basis for valuable further research on perceptions of different actors regarding urban climate issues and that the recommendations given by all our respondents can help to support awareness building and eventually the adaptation of urban context to safer and healthier environments.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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