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THE ROLE OF RAISING AWARENESS IN ENSURING THE RESILIENCE OF CITIES

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This paper explores the significant role of raising awareness in ensuring the resilience of cities towards climate change. Climate change is an imminent threat to urban development and its adverse effects can only be mitigated with the collective efforts of city dwellers. By evaluating the level of awareness and relating it to the greenhouse gas emissions emitted by three selected countries - namely Germany, Brazil and Kenya - this study highlights the need for awareness-raising campaigns and community-engagement initiatives centered around the risks of climate change and its potential impact on cities. The findings suggest that raising awareness, through several social action campaigns, can enhance the public understanding of climate change and facilitate the adoption of sustainable behaviors to reduce greenhouse gas emissions. Furthermore, raising the awareness of a population will make their participation in the decision-making processes of the different adaptation plans more effective. The paper concludes that raising awareness by enhancing public understanding and ensuring their participation in combating climate change is a crucial step in building resilience to climate change.

Keywords: climate change, raising awareness, social action plans, greenhouse gases, emissions, adaptation, resilience

1. Introduction

Although government policies and plans are key components when facing challenges, they are insufficient in themselves. The public needs to be made aware of the risks, acquire knowledge about the options that are available in response and be empowered to take their own actions [1]. Even though numerous cities aim to mitigate their contribution towards climate change and provide a liveable environment in the context of sustainable development [2], nowadays, cities are facing a growing array of threats and challenges ranging from natural disasters to social and economic crises. To effectively manage these risks and ensure their resilience, it is essential to raise awareness among citizens as well as stakeholders about these potential threats and their impacts. By educating individuals and communities about the risks, encouraging them to take action in response as well as informing them that in the decision-making process they should always choose the sustainable and low risk initiatives for the environment [3], cities can build a culture of resilience that is better equipped to withstand and recover from adverse shocks and stresses. As a result, raising awareness has becom e an increasingly important aspect of urban planning and management [4]. Raising population awareness - through surveys, advertisements and mini games [5] - has positive impacts on several aspects of life such as our health by making people better prepared to make decisions when unwell [6]. As an example, a campaign to raise public awareness of persistent coughs as a symptom of lung cancer was launched in England in 2014, which had a positive impact by increasing the percentage of patients diagnosed early with lung cancer in the country [7]. Furthermore, thanks to various actions aiming to raise awareness in several countries, the general public is more familiar with how to preserve biodiversity [8]. Public awareness can also play a critical role in the waste management sector since waste is produced by human activities and everyone needs to have a good understanding of issues related to it, without which the success of even the best conceived waste management plan is questionable [9].

The main objective of this paper is to study how effective raising awareness about reducing the effects of climate change and ensuring the resilience of cities is.

Climate change is one of the most significant global challenges facing our world today. It is also a critical issue for our cities [10]. Global warming throughout the

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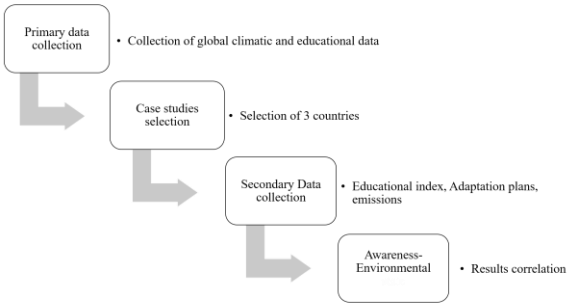

Figure 1: Work methodology

21st century is projected to be considerably greater than over the previous century. The average global temperature since 1900 has risen by about 1.5 °C. By 2100, it is projected to rise by another 2 to 11.5 °C [11]. Cities play a key role in developing and implementing initiatives to combat climate change because they are at the crossroads between local action, climate change adaptation on national as well as international levels, and mitigation commitments [12]. Consequently, cities have started drawing up strong strategies to improve local air quality and enhance their resilience, which has become widely regarded as a key goal for both adaptation and mitigation efforts in cities as well as urban regions [13]. In 2008, the European Commission (EC) launched the Covenant of Mayors (CoM) whereby local and regional authorities are brought together to voluntarily develop and implement a Sustainable Energy and Climate Action Plan (SECAP) [14]. In order to reduce their energy-related Greenhouse Gas (GHG) emissions, a voluntary agreement was made under which local authorities were committed to reducing CO_2 emissions by at least 20% within 2020 [15], then they focused on the active role of local authorities and increased its targets in 2016, through the SECAPs in terms of GHG from 20% to 40% by 2030 [16]. Furthermore, an ambitious target has been set to achieve climate neutrality by 2050 [17]. Based on the action plans listed on the CoM website, one of the most common strategies applied recently by several cities is to create tools that include different layers of society (adults, researchers, students, stakeholders) in order to raise awareness of the current situation as well as provide a platform to share their opinions on how to tackle climate change. Our goal in this paper is to identify the impacts of applying such a strategy as well as determine how basic education and awareness can affect the trend of greenhouse gas emissions by evaluating the trend in emissions in three countries with different levels of awareness.

2. Experimental

The aim of this study is to evaluate the effectiveness of raising public awareness as an adaptation strategy to safeguard the resilience and sustainability of cities. Consequently, the concept, presented in *Figure 1*, consists of three selected case studies (countries) before extracting and analyzing the maximum values of awareness indicators from each state. Finally, the relationship between the analysis results and emission levels is determined in order to compare and deduce the impact of the level of public awareness on tackling the effects of climate change.

Table 1: Main climatic and educational characteristics of Germany, Brazil and Kenya

Country	Population	Climatic zone	Global education ranking (2023)
Germany	83,294,633	temperate, rainy	3
Brazil	216,422,446	equatorial	36
Kenya	55,100,586	hot, temperate subtropical	68

2.1. Selected case studies

Selecting the three countries is key to maximize the relationship between public awareness and air quality. Consequently, they must be located in different climate zones as well as belong to various educational and awareness levels. In this study, the three countries selected are Germany, Brazil and Kenya. Germany is situated in a temperate, rainy climate zone of the mid-latitudes [18]. The difference in annual mean temperature between Sylt (an island in northern Germany) and the Zugspitze (the highest peak in Germany) from 1961 to 1990 was 8.2 °C. The education system in Germany is ranked third / globally and fourth among the countries with the most educated populations (*Table 1*).

Brazilians experience equatorial, tropical as well as subtropical climates [19]. The annual average temperature in the region is 22 to 26 °C with little variation between the warmest and coldest months. The education system in Brazil is ranked 36 in the education ranking of 2023 (*Table 1*).

Kenya is subjected to three types of climate: a temperate subtropical climate in the west and southwest highlands (where Nairobi is located), a hot and humid one along the coast, as well as hot and dry weather in the north and east [20]. The education system in Kenya is ranked 68 in the education ranking of 2023 (*Table 1*).

2.2. Secondary data collection

This step consists of collecting useful data, namely visualizing the level of awareness and the air quality in each country selected. In addition to the education ranking, other education indexes were collected such as the percentage of students admitted to tertiary and upper secondary education. Surveys were conducted in Germany and Kenya in order to determine the level of

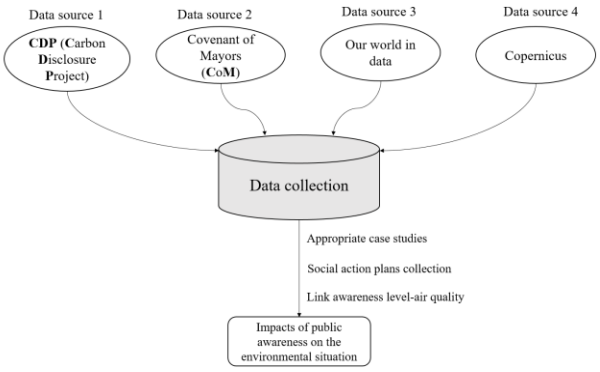

Figure 2: Data sources

awareness related to some climatic issues. These data will be crucial when comparing the level of awareness between these two countries. The adaptation plans will be collected and specified from the Carbon Disclosure Project website in order to check whether these countries are taking into consideration social action in their strategies or not.

The main data collected evaluating the air quality in Germany, Brazil and Kenya are the annual CO_2 emissions, the contribution of each country towards the rise in temperature and the level of harm resulting from the GHG emissions.

2.3. Public awareness – Air quality

This step consists of analyzing awareness indexes extracted and linking them to the emissions in each case study in order to compare the emissions of these three countries with their different climatic zones and education levels, thereby deducting the impact of public awareness on air quality and improving the resilience of each country.

2.4. Data sources

Collecting the maximum amount of useful data is key. The data sources used in this study are presented in *Figure 2*:

- The "*Our World in Data"* website
  A huge amount of data is being added by researchers on this website to tackle the most significant problems worldwide. This website was accessed to collect several emission levels and education indexes.
- CDP (Carbon Disclosure Project)
  A more transparent mixed record has been produced [21]. In fact, the large amount of data extracted from this website was key when initiating this study to evaluate the environmental situation in the different case studies and analyze the adaptation plans of Germany, Brazil and Kenya.
- Copernicus
  It is a program dedicated to monitoring Earth's atmosphere for the benefit of all European citizens [22], in our case, to visualize the climate zones worldwide.

Table 2: Education indexes of Germany, Brazil and Kenya [23]

Country	Adult literacy rate (2021)	Average years of schooling (2021)	Public spending on education as a share of GDP (2018)
Germany	>99%	17.01	4.99%
Brazil	93.23%	15.60	6.09%
Kenya	81.53%	10.70	5.08%

Table 3: Completion rate of the different educational levels in Germany, Brazil and Kenya in 2021 [23]

Country	Tertiary education	Upper secondary education	Primary education
Germany	31.30%	54.90%	99.02%
Brazil	20.10%	36.90%	99.00%
Kenya	3.40%	21.15%	99.68%

3. Results

3.1. Evaluation of the educational situation

As mentioned in *Table 1*, Germany is rated the best (3rd) in the education ranking among the case studies followed by Brazil (36th) and finally Kenya (68th). The extraction and analysis of the other education indexes (*Table 2*) confirm this ranking.

In 2021, only 81.53% of individuals 15 years of age and older were literate. Although this rate is higher in Brazil (93.23%), it is still less than Germany's where the adult literacy rate is close to 100%. Germany has the highest average years of schooling among the 3 countries, while the lowest is Kenya with 10.7 years. Should the number of years of schooling be too low, students will not be thoroughly trained which can affect their awareness about several topics related to climate change and environmental challenges in general.

Over 99% of primary school students complete their schooling in the three countries. However, only 3.4, 20.1 and 31.3% complete their tertiary education in Kenya, Brazil and Germany, respectively. The resilience of cities impacts of climate change and different ways of improving the air quality are all topics that can be mentioned, mainly in upper secondary and tertiary education. In the event that the percentage of students who complete these levels is low, the knowledge of the upcoming generation will be lacking in these areas (*Table 3*).

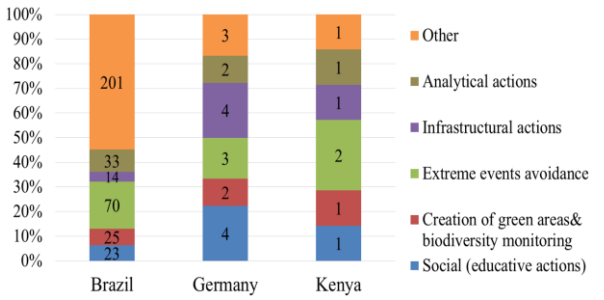

Figure 3: Classification of adaptation plans in 2017

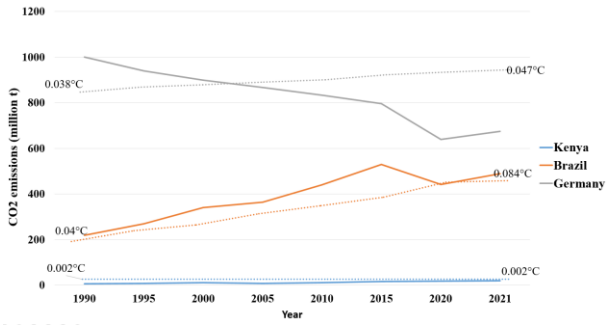

Figure 4: Annual CO_2 emissions in Germany, Brazil and Kenya and their contribution towards global warming

3.2. Adaptation plans and public awareness

Adaptation plans play a crucial role in ensuring the resilience of communities as well as ecosystems in the face of climate change and other environmental challenges. By anticipating and preparing for the potential impacts of climate change - e.g. rise in sea level, extreme weather events as well as changes in temperature and precipitation patterns - adaptation plans can help to reduce the number of vulnerabilities, moreover, increase the capacity of communities and ecosystems to adapt. Adaptation plans can also help to identify and prioritize actions that can be taken to mitigate the impacts of climate change such as reducing GHG emissions, conserving natural resources as well as improving infrastructure and land use practices. Furthermore, adaptation planning can be an important tool for promoting equity and social justice by ensuring that vulnerable and marginalized communities have a voice in decision-making and are included in the planning process. Ultimately, adaptation planning is essential for building more sustainable as well as resilient communities and ecosystems that can withstand the impacts of climate change amongst other environmental challenges.

In 2017, 366 action plans were announced by different Brazilian cities. Only 6.3% of these intend to include the society in their adaptation strategies by raising awareness (*Figure 3*). Out of 7, only one social adaptation plan was published in Kenya. Despite the low number of action plans announced by German cities that year, 22.22% of them have social and educative targets to encourage citizens to act in order to tackle the impacts of climate change.

Two sub-categories of social adaptation strategies are applied as action plans in the three countries: educative actions to improve the knowledge of citizens with regard to future challenges and the targets of its cities; and another type of social actions encouraging public engagement in decision-making through surveys and websites.

A survey conducted in 2020 aimed to evaluate the level of awareness related to specific environmental impacts in several countries. The results of the survey show that the citizens and politicians in Kenya are totally unaware of the influence of the layout of cities on the urban climate. 9.09% of German citizens are aware of this influence, while 36.36% of their politicians have been informed about the topic. 45.45% of citizens and 40% of politicians in Kenya are aware of the influence of vegetation on the urban climate. 36.36% of German citizens and 90.9% of its politicians are aware of or well-informed about this influence [24].

3.3. Greenhouse gas emissions and climatic hazards

Data presented in the document entitled "Brazil's Initial National Communication" indicated that the country is one of the highest GHG emitters worldwide. The vast majority of Brazil's GHG emissions originate from deforestation of the Amazon biome to create agricultural land on which to raise livestock [25].

Sub-Saharan African countries such as Kenya are having to face deteriorating air quality in their cities due to the high urbanization rates [26].

The annual CO_2 emissions decreased in Germany from 1 billion tons in 1990 to 674 million tons in 2021. However, in Brazil, this parameter increased from 218 million tons in 1990 to 488 million tons in 2021, while in Kenya, from 5 million tons in 1990 to 20 million tons in 2021 (*Figure 4*).

The air quality index is good in all three countries: highest in Germany at 25, followed by 24 in Brazil and just 10 in Kenya. The influence of air pollution on the death rate is significant in Kenya, reaching 124 deaths per 100,000 people compared to 27 and 14 in Brazil and Germany, respectively [27]. In Kenya, 24% of this death rate, equating to 29 deaths per 100,000 people, is caused by particulate matter, the main pollutant in the country, compared to 70% in Brazil and 86% in Germany [28]. 43% of climatic hazards caused by Kenyan citizens are extremely harmful. 86% of those caused by Brazilians are either serious or extremely serious. Although no hazards occurred in Germany are extremely damaging, 80% of its emissions are classified as harmful (*Figure 5*). While Germany isn't facing the most extreme weather events, climate change still poses a serious threat, with a staggering 80% of climate hazards classified as serious.

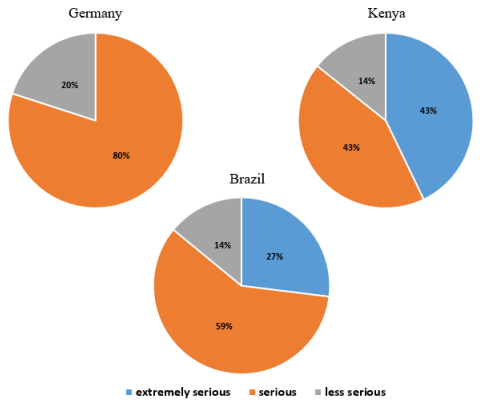

Figure 5: Climatic hazards classification in Germany, Brazil and Kenya

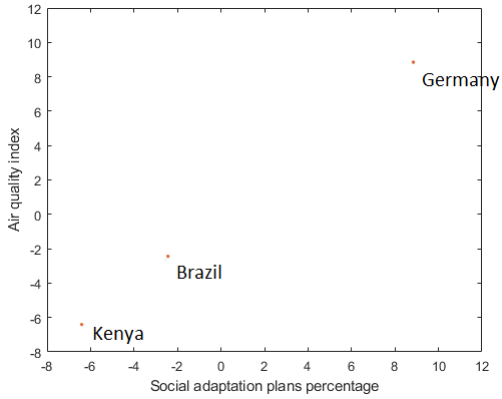

Figure 6: Multidimensional scale figure linking the air quality index with the percentage of social adaptation plans in Germany, Brazil and Kenya

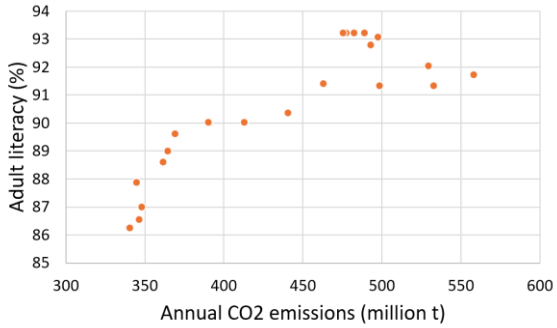

Figure 7: The correlation between the adult literacy rate and CO_2 emissions in Brazil

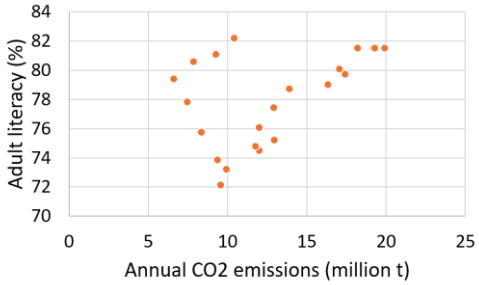

Figure 8: The correlation between the adult literacy rate and CO_2 emissions in Kenya

3.4. Awareness level – GHG emissions

As is shown in *Figure 3*, 22.22% of German adaptation plans published in 2017 seek to involve the society, which is higher than in Brazil (despite the large number of action plans drawn up there) and Kenya. A calculation made intending to link this factor to the air quality index on a figure covering multiple dimensions confirms a correlation between these two parameters (*Figure 6*). Despite the high quantity of adaptation plans applied in several Brazilian cities, the CO_2 emissions increased between 2017 and 2021 (*Figure 4*). In fact, applying various categories of action plans, depending on the situations affecting the cities and related issues, can be more effective than focusing on the quantity of them. The low percentage of social actions applied in Brazilian cities from 2017 to 2021 could be a reason for the rising trend in emissions in the country.

The adult literacy rate and average years of schooling are two of several educational indexes that can have a direct impact on the level of public awareness. A regression calculation was conducted to identify a correlation between the adult literacy rate and annual CO_2 emissions in Brazil and Kenya alone because the level of adult literacy has been stable throughout almost the whole of Germany over the last decade. The results show a strong correlation between these two parameters in both countries, that is, a low adult literacy rate can cause greater emissions (*Figures 7* and *8*).

The adult literacy rate and the years of schooling are higher in Germany than in Brazil and Kenya (*Table 2*), moreover, correlate with the nature of the climatic hazards occurred in each country. The Kenyan population has a low literacy rate and causes a high percentage of extremely serious climatic hazards which can be explained by their lack of knowledge with regard to the impacts of emitting such components, which is not the case in Germany (*Figure 5*).

Since the percentages of those who complete tertiary education are low in Brazil and Kenya, the main social actors, namely politicians and citizens, are unaware of several topics related to the urban climate. This lack of awareness could lead to breaches in the decision-making procedure and increase GHG emissions.

4. Conclusions

Public awareness has become essential to achieve the targets of cities in several fields such as agriculture, waste management, health and air quality. Many case studies have confirmed the effectiveness of engaging the community with the decision-making procedure on

achieving set targets and this would not be possible without raising their awareness of them.

Raising the awareness of a population has become one of the main categories of adaptation plans published by several countries to ensure resilience and sustainability due to their positive impacts. An analysis of the action plans listed on the Covenant of Mayors website shows that approximately 25% of these actions seek to raise the level of public awareness and engage them with the challenge of tackling climate change.

Evaluating the education level by extracting several education indexes is key to measuring and visualizing the level of awareness of the population. The results of this study show a high, medium and low education level in Germany, Brazil and Kenya, respectively, which correlate with the level of awareness of the environment-related topics measured in these three countries.

The results show a correlation between GHG emissions in Germany, Brazil as well as Kenya and the levels of education and awareness in these countries. CO_2 emissions are decreasing in Germany as a result of the adaptation plans set by the country.

REFERENCES

[1] Khatibi, F.S.; Dedekorkut-Howes, A.; Howes, M.; Torabi, E.: Can public awareness, knowledge and engagement improve climate change adaptation policies?, *Discov. Sustain.*, 2021, **2**, 18, DOI: 10.1007/s43621-021-00024-z

[2] Sebestyén, V.; Somogyi, V.; Szőke, S.; Utasi, A.: Adapting the Sdewes Index to two Hungarian cities, *Hung. J. Ind. Chem.*, 2017, **45**(1), 49–59, DOI: 10.1515/hjic-2017-0008

[3] Rózsenberszki, T.; Koók, L.; Bakonyi, P.; Nemestóthy, N.; Bélafi-Bakó, K.: Comparative study on anaerobic degradation processes of pressed liquid fraction of organic solid waste, *Hung. J. Ind. Chem.*, 2021, **49**(1), 31–35, DOI: 10.33927/hjic-2021-05

[4] Santos, S.L.: Developing a risk communication strategy, *J. Am. Water Works Assoc.*, 1990, **82**(11), 45–49, DOI: 10.1002/j.1551-8833.1990.tb07051.x

[5] De Jans, S.; Van Geit, K.; Cauberghe, V.; Hudders, L.; De Veirman, M.: Using games to raise awareness: How to co-design serious mini-games?, *Comput. Educ.*, 2017, **110**, 77–87, DOI: 10.1016/j.compedu.2017.03.009

[6] Seymour, J.: The impact of public health awareness campaigns on the awareness and quality of palliative care, *J. Palliat. Med.*, 2018, **21**(S1), S30–S36, DOI: 10.1089/jpm.2017.0391

[7] Ironmonger, L.; Ohuma, E.; Ormiston-Smith, N.; Gildea, C.; Thomson, C.S.; Peake, M.D.: An evaluation of the impact of large-scale interventions to raise public awareness of a lung cancer symptom, *Br. J. Cancer*, 2015, **112**(1), 207–216, DOI: 10.1038/bjc.2014.596

[8] Turner-Erfort, G.: Public awareness and perceptions of biodiversity, *Trans. Ill. State Acad. Sci.*, 1997, **90**(3-4), 113–121

[9] Hasan, S.E.: Public awareness is key to successful waste management, *J. Environ. Sci. Health A*, 2004, **39**(2), 483–492, DOI: 10.1081/ESE-120027539

[10] Bulkeley, H.: Cities and climate change (1st edition) (Routledge), 2013, DOI: 10.4324/9780203077207

[11] Karl, T.R.; Melillo, J.M.; Peterson, T.C.; Hassol, S.J. (Eds.): Global climate change impacts in the United States (Cambridge University Press), 2009, ISBN: 9780521144070

[12] Heidrich, O.; Reckien, D.; Olazabal, M.; Foley, A.; Salvia, M.; de Gregorio Hurtado, S.; Orru, H.; Flacke, J.; Geneletti, D.; Pietrapertosa, F.; Hamann, J.J.-P.; Tiwary, A.; Feliu, E.; Dawson, R.J.: National climate policies across Europe and their impacts on cities strategies, *J. Environ. Manage.*, 2016, **168**, 36–45, DOI: 10.1016/j.jenvman.2015.11.043

[13] Leichenko, R.: Climate change and urban resilience, *Curr. Opin. Environ. Sustain.*, 2011, **3**(3), 164–168, DOI: 10.1016/j.cosust.2010.12.014

[14] Lo Vullo, E.; Monforti-Ferrario, F.; Palermo, V.; Bertoldi, P.: Greenhouse gases emission factors for local emission inventories - Covenant of Mayors databases - Version 2022 (Publications Office of the EU, Luxembourg), 2022, DOI: 10.2760/776442

[15] Croci, E.; Lucchitta, B.; Janssens-Maenhout, G.; Martelli, S.; Molteni, T.: Urban CO_2 mitigation strategies under the Covenant of Mayors: An assessment of 124 European cities, *J. Clean. Prod.*, 2017, **169**, 161–177, DOI: 10.1016/j.jclepro.2017.05.165

[16] Scorza, F.; Santopietro, L.: A systemic perspective for the Sustainable Energy and Climate Action Plan (SECAP), *Eur. Plan. Stud.*, 2021, DOI: 10.1080/09654313.2021.1954603

[17] Manzan, M.; Bacaro, G.; Nardini, A.; Casagrande, G.; Pezzi, A.; Petruzzellis, F.; Tordoni, E.; Fontolan, G.: Climate change risk and vulnerabilities analysis in Trieste SECAP, *Sustainability*, 2022, **14**(10), 5973, DOI: 10.3390/su14105973

[18] Kaspar, F.; Müller-Westermeier, G.; Penda, E.; Mächel, H.; Zimmermann, K.; Kaiser-Weiss, A.; Deutschländer, T.: Monitoring of climate change in Germany - data, products and services of Germany's National Climate Data Centre, *Adv. Sci. Res.*, 2013, **10**(1), 99–106, DOI: 10.5194/asr-10-99-2013

[19] Alvares, C.A.; Stape, J.L.; Sentelhas, P.C.; de Moraes Gonçalves, J.L.; Sparovek, G.: Köppen's climate classification map for Brazil, *Meteorol. Z.*, 2013, **22**(6), 711–728, DOI: 10.1127/0941-2948/2013/0507

[20] Griffiths, J.F.; Gwynne, M.D.: The climate of Kenya Masailand, *East Afr. Agric. For. J.*, 1962, **28**(1), 1–6, DOI: 10.1080/00128325.1962.11661833

[21] Matisoff, D.C.; Noonan, D.S.; O'Brien, J.J.: Convergence in environmental reporting: Assessing the Carbon Disclosure Project, *Bus. Strategy Environ.*, 2013, **22**(5), 285–305, DOI: 10.1002/bse.1741

[22] Thépaut, J.N.; Dee, D.; Engelen, R.; Pinty, B.: The Copernicus programme and its climate change service, *IGARSS 2018 - 2018 IEEE Int. Geosci Remote Sens. Symp. Valencia, Spain*, 2018, 1591–1593, DOI: 10.1109/IGARSS.2018.8518067

[23] Roser, M.; Ortiz-Ospina, E.: Our world in data - Global education, 2016, https://ourworldindata.org/global-education

[24] Lenzholzer, S.; Carsjens, G.-J.; Brown, R.D.; Tavares, S.; Vanos, J.; Kim, Y.; Lee, K.: Awareness of urban climate adaptation strategies - an international overview, *Urban Clim.*, 2020, 34, 100705, DOI: 10.1016/j.uclim.2020.100705

[25] Cerri, C.C.; Maia, S.M.F.; Galdos, M.V.; Cerri, C.E.P.; Feigl, B.J.; Bernoux, M.: Brazilian greenhouse gas emissions: the importance of agriculture and livestock, *Sci. Agric.*, 2009, **66**(6), 831–843, DOI: 10.1590/S0103-90162009000600017

[26] Ngo, N.; Kokoyo, S.; Klopp, J.: Why participation matters for air quality studies: risk perceptions, understandings of air pollution and mobilization in a poor neighborhood in Nairobi, Kenya, *Public Health*, 2017, **142**, 177–185, DOI: 10.1016/j.puhe.2015.07.014

[27] Ritchie, H.; Roser, M.: Our world in data - Air pollution, 2017, https://ourworldindata.org/air-pollution

[28] Ritchie, H.; Roser, M.: Our World in Data – Outdoor air pollution, 2019, https://ourworldindata.org/outdoor-air-pollution