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APEC Cities: Climate Hazards, Adaptation Plans, and Mitigation Actions

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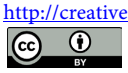


Abstract

Cities are the engines of economic growth and home to millions of people, but they are also major contributors to greenhouse gas emissions. In this context, APEC countries hold vital importance in global economic, cultural, ecological, and social affairs. However, climate change presents growing challenges to the region's development. This paper aims to analyze the main climate risks faced by APEC cities, as well as to examine the adaptation plans and mitigation actions undertaken by governments, and assess how these efforts are being funded. Data employed is collected in partnership by CDP and ICLEI—Local Governments for Sustainability 2023. This analysis highlights the key challenges and opportunities for urban development in the region, ensuring a just transition to sustainability.

Keywords

APEC Cities, Climate Risks, Urban Adaptation Goals and Plans, Climate Change Mitigation in Cities, Climate Finance in Cities

1. Introduction

Cities play a key role in the climate transition. Currently, 56% of the world's population lives in cities and 70% is expected to do so by 2050 (World Bank, 2023). Urban areas account for 70% of global greenhouse gas (GHG) emissions and 75% of global energy consumption (IEA, 2024), so urbanization highlights the urgent need for climate action and finance. Many cities, particularly in emerging markets and developing economies, are already dealing with frequent extreme weather events, such as floods and heatwaves (Qian et al., 2023).

According to CDP Disclosure Insight Action (2024)[1] data, more than 80% of

[1]CDP is a not-for-profit charity that runs the global disclosure system for investors, companies, cities, states, and regions to manage their environmental impacts. CDP was established as the "Carbon Disclosure Project" in 2000. In 2021 they launched a new strategy that expanded to cover all planetary boundaries.

cities have reported significant climate exposure. Flooding (58%) and extreme heat (54%) are the most common climate risks in cities. Nearly 70% of APEC cities expect these events to intensify and become more frequent. US$4 trillion is needed to fund challenges and increase resilience and adaptation (APEC, 2024).

CDP report highlights the significant impacts of climate risks on vulnerable populations. Among cities reporting flooding, 98% indicated that low-income households were affected, 77% indicated that the elderly were adversely impacted, and 67% mentioned marginalized communities. For cities reporting extreme heat, 97% said the elderly were negatively affected, 75% identified low-income households, and 73% identified children as affected (CDP Disclosure Insight Action, 2024).

Cities are confronted with several challenges, including the necessity to enhance energy efficiency (Cheng, Yu, & Zhang, 2023) and undergo a transition from heavy industry to high-tech manufacturing to achieve carbon neutrality (Xu et al., 2024) Furthermore, the development of intelligent, electrified transportation systems is essential, given the significant land area required for renewable energy installations (Mavlutova et al., 2023). The construction sector presents considerable obstacles, while new storage technologies, such as batteries, compressed air, and heat storage, will necessitate the construction of an extensive underground network for transportation and storage (Kasper & Schramm, 2023). Additionally, urban lifestyles, characterized by high consumption of disposable items and carbon-intensive diets, further complicate sustainability efforts (Hawes et al., 2024; APEC, 2024).

Cities have shown a strong willingness to work with national governments and take the lead in subnational climate action. At COP28, the Local Climate Action Summit emphasized the role of local leaders in reducing emissions, while the Coalition for High Ambition Multilevel Partnerships, supported by 72 governments, encouraged collaboration on updated Nationally Determined Contributions (CCFLA, 2024).

In this line, approximately 30% of all climate infrastructure projects reported in the CDP-ICLEI Track in 2023 (727 out of a total of 2346) aim to increase climate adaptation and resilience, 55% of these cities are in the Global South. These projects represent an estimated investment of US$47 billion (CDP Disclosure Insight Action, 2024). Despite this progress, urban climate finance needs to increase more than quintuple to achieve the 1.5˚C climate target, presenting a significant investment opportunity in low-emissions and resilient infrastructure, provided key challenges are addressed (Ahn et al., 2023; CCFLA. 2024).

Based on the above, we aim to analyze the main climate hazard, adaptation plans and goals, mitigation actions and climate funding resources in APEC cities, employing data collected in partnership by CDP and ICLEI—Local Governments for Sustainability, specifically Climate Hazards and Mitigation, to evidence the main challenges and perspectives of urban development in the region. Research is divided into six sections, the second part assesses the literature, the third part pre-

sents the methodology, the fourth section describes APEC cities, the fifth section examines the main APEC cities' Climate Hazards, section six analyzes Climate Adaptation Actions and Plans in APEC urban areas, and section seven presents information related to Climate Mitigation Actions and Climate Funding in APEC Cities. At last, we present some concluding remarks.

2. Literature Review

General: cities and climate action in the world

There is extensive literature about cities' climate hazards, Gwilliam et al., (2006), Gandini et al. (2021), and Laino & Iglesias (2024) describe approaches to evaluate climate hazards in cities. Huq et al. (2007) define climate risk in cities, identifying the main climate hazards and the cities most exposed to these risks worldwide. Fünfgeld (2010) argues that cities have focused on analyzing and assessing climate risk, thus imposing challenges on municipal governments, civil society and the private sector.

De Sherbinin, Schiller, & Pulsipher (2012) state the vulnerability of global cities due to their location near coasts and major river mouths to have easy access to infrastructure and communication ways. Thus, they are exposed to climate risks such as cyclones, high winds, flooding, coastal erosion and deposition, and sea-level rise.

Since the majority of urban areas are located close to the ocean, several studies have analyzed climate hazards in coastal cities, climate adaptation, and resilience (Klein, Nicholls, & Thomalla, 2003). Gaborit (2022) identifies multi-hazard climate-related risks to coastal cities in Indonesia. Laino & Iglesias (2023, 2024) and Laino et al. (2024) identify the main climate risk and define adaptation strategies in coastal cities in Europe. Solecki et al. (2015), Wallace (2017), and Rosenzweig et al. (2024), to mention some of them also analyze climate change risks and adaptation in New York City. The studies emphasize the multifaceted risks faced by coastal cities due to their proximity to oceans, compounded by rapid urbanization and climate change. They collectively argue for the need for location-specific solutions that balance immediate adaptation with long-term resilience planning.

In terms of climate adaptation Lin et al. (2021) mention that adaptation must integrate technological, nature-based, and social solutions to face climate challenges and propose solutions in three different urban circumstances and climates. They also mention that cities in systematically marginalized countries of the Global South, play a pivotal role in shaping future urban development and therefore warrant prioritization of global planning efforts.

Lee and Hughes (2017) examine how the geographical, socio-economical and institutional characteristics of cities and the risk perception impact the adaptation plans. They suggest that the climate hazards perception influence the development of adaptation agenda. The authors posit that the implementation of global-scale adaptation strategies and institutional collaboration is imperative to enable cities to implement an adaptation agenda that is not merely a simulation.

Singh et al. (2021) analyze climate adaptation in 53 Indian cities with a population of over one million. They review the literature and city agendas and conclude that most programs are project-based and are neither preventive nor include long-term responses. In the same line, Youssef (2024) examines the status of Tunisian municipalities regarding climate change policies and actions, as well as the obstacles and exemplary practices encountered. Through a survey of municipalities, the findings reveal significant discrepancies among cities, attributable to their disparate geographical locations, including some situated in arid regions and others positioned on the coast. Additionally, while municipalities lack the necessary equipment to monitor climatic variables, effective practices have been identified that could be replicated in other cities. Both studies provide a critical overview of urban climate adaptation, highlighting challenges and opportunities in different contexts. Together, these papers advocate for scalable, sustainable, and context-sensitive strategies to effectively address urban climate challenges.

Heikkinen et al. (2020) statistically test the link between network membership and adaptation planning progress in 377 global cities. Results show that network members are more likely to begin adaptation efforts, with membership in multiple networks associated with higher levels of planning. Pietrapertosa et al. (2023) examine adaptation planning in 73 cities in nine Mediterranean countries. Findings suggest that a third part of those cities have an adaptation plan, cities are more likely to develop plans if national governments also have one, common concerns are urban temperature and precipitation, drought and water scarcity. These studies offer valuable insights into the factors influencing urban climate adaptation planning, emphasizing the role of networks, national policies, and localized concerns. These insights argue for a multiscale approach to improving urban resilience worldwide.

As mentioned above, cities house most of the global population, making them central to achieving sustainable living and reducing overall carbon footprints. Effective mitigation strategies in cities can enhance resilience, improve air quality, and protect vulnerable populations from climate-related risks. Thus, extensive multi- and inter-disciplinary literature has been developed to propose how to account the emissions from both production and consumption perspectives (Sethi et al., 2020; Wiedmann et al., 2021; Ahn et al., 2023) and to analyze and propose climate change mitigation policies and actions (Mi et al., 2019; Salvia et al., 2021a; Neij & Heiskanen, 2021).

Hsu et al. (2020) analyze climate mitigation plans in the European Union (EU), they demonstrate that over 60% of the more than 1000 EU Covenant of Mayors' cities are on course to achieve their 2020 emission reduction targets. Larger emissions cuts are linked to strategies focused on improving energy efficiency. These city-level successes offer concrete evidence supporting the idea that subnational actors play a key role in global climate mitigation efforts. Salvia et al. (2021b) conducted an analysis of climate change mitigation ambitions in 327 cities within the European Union with the objective of determining whether cities contemplate

achieving carbon neutrality. The findings indicate that 78% of cities have a mitigation plan with defined targets, 25% of cities aim for carbon neutrality, the majority by 2050, and membership in a climate network influences the pursuit of zero carbon. European cities must enhance their ambitions by 100% to fulfill the Paris Agreement.

Hsu et al. (2020) and Salvia et al. (2021b) highlight the key role of subnational actors in advancing climate change mitigation in the European Union (EU), highlighting their achievements, ambitions, and challenges. EU cities show leadership in climate change mitigation, but urgently need to scale up innovations, strengthen networks, and align policies to meet global targets.The European Union is undoubtedly emerging as a pioneering region in climate action at the city level, which can offer valuable lessons to other regions.

Commane & Schiferl (2022) focus on air quality and its incorporation in climate mitigation plans. They also provide some recommendations to improve urban air quality: 1) Prioritize eliminating carbon-fuel combustion, especially coal and wood burning; 2) Electrify transport, focusing on cold regions and heavy-duty vehicles; 3) Remove sulfur from fuels; 4) Use air quality networks to boost CO_2 monitoring in cities globally. Cobbinah & Finn (2023) investigate a very interesting and important topic for cities, especially for those in the Global South, informal urbanization, which is characterized by being in risky places, and local authorities are not aware of the size and conditions of those establishments. Thus, informal urbanization is not contemplated in urban plans. It is important to see that the cities' climate action can provide co-benefits as enhancing the air quality and reducing risks for vulnerable population.

Since climate action needs funding sources, some studies are focused on analyzing how cities are getting those resources. Ulpiani et al. (2023) highlight that most cities have not estimated the investment needed for climate neutrality and lack financial expertise, with few specific climate projects in place. They face challenges in accessing capital markets, have underdeveloped co-financing mechanisms, and lack an investment-ready project portfolio. Additionally, existing financial and regulatory frameworks hinder the unlocking of financing and creating a supportive investment environment at the city level. In this regard, Dayal (2024) highlights that access to climate finance represents a significant challenge due to constraints on capacity and resources. Consequently, he suggests the implementation of a digital platform that would enable cities to access and obtain resources for climate finance projects. The objective is to establish an information and resources repository that will connect cities with financial institutions, thereby facilitating the process by which cities can access a variety of financial products. Ulpiani et al. (2023) and Dayal (2024) highlight the critical role of financial mechanisms in driving urban climate action while revealing significant barriers and proposing innovative solutions. The emphasis on creating investment-ready projects and leveraging digital platforms illustrates a path toward empowering cities to secure the resources needed for effective climate action. Therefore, we can

glimpse the importance of adequate financial planning and access to funding to ensure compliance and success of policies and actions against climate change and its impacts on cities.

APEC region: cities and climate action

APEC cities are vital due to their economic contributions, population dynamics, environmental responsibilities, and roles as centers of innovation and cultural exchange. On the other hand, they are major contributors to greenhouse gas emissions, making them key targets for reducing carbon footprints (Ness & Xing, 2020). Their dense populations and infrastructure present both challenges and opportunities for implementing sustainable practices and innovative solutions (Zhu & Wang, 2023). Additionally, cities are at the forefront of adapting to climate impacts, necessitating resilient urban planning and policies that can serve as models for broader regional and global efforts (Roberts, Lindfield, & Steinberg, 2017).

APEC (2000) states that rapid population growth, industrialization and the increase in the number of cars in the cities of the Asia-Pacific region are deteriorating environmental conditions. The impact of this pollution on productivity and health is estimated to be between 1% and 5% of GDP. The transport sector has been identified as a priority as the estimated losses due to congestion are enormous. The train and bus have emerged as the basis of the social revolution of public transport to reduce GHG emissions and facilitate mobility in cities.

As a response to climate issues in APEC, wide literature has been developed to analyze risks (Kim, 2021; Hong & Kim, 2024; Zhou et al., 2024), examine climate adaptation (Ivanova & Cuevas Tello, 2016; Ivanova, Serrano, & Torres, 2024), climate mitigation actions (Sinha & Sengupta, 2019; Wu et al., 2021; Jiang et al., 2022) and the role of climate finance in the region (Bayhaqi & Singh, 2019; Pigato & Stewart, 2020; Naqvi, Hussain, & Ali, 2023). Particularly, about climate action and climate finance in APEC cities, literature is very scarce, and it is described in the following paragraphs.

Roberts, Lindfield & Steinberg (2017) examine the evolving dynamics of cities and urban economic development corridors in the APEC region. Through an urban systems approach, they identify key issues and partnership practices that support sustainable city management. The findings highlight the growing importance of fostering diverse partnerships for sustainable urban development. Additionally, the research reveals opportunities for APEC to collaborate with cities through an Asia-Pacific Partnership to further promote sustainable development across the region. Pigato and Stewart (2020) delineate the prospective socioeconomic repercussions of climate change in APEC countries and the advantages of mitigating these effects. They also underscore the implications of climate risks for financial institutions and how the regulation of the financial system can assist institutions to hedge against these risks. Finally, it examines the policy, regulatory, and market impediments for institutional investors to contribute to climate finance and proposes solutions, thereby establishing a foundation for potential opportunities and

action. Zhu and Whang (2023) analyzed 231 cities in APEC region. They used a self-organizing feature map (SOFM) and indicators of the cities' natural environment and development. They identified nine types of cities. The results demonstrate the need to improve the efficiency and per capita income of cities. The above papers highlight the multiple challenges and opportunities for sustainable urban and economic development in the APEC region, focusing on partnerships, socio-economic impacts of climate change, and urban efficiency. They emphasize the need for integrated approaches that leverage partnerships, financial innovations, and data-driven knowledge to achieve sustainable and equitable development across APEC cities.

To expand knowledge about APEC cities and their response to climate challenges, we analyze the main climate risks faced by APEC cities, the climate actions developed and the main sources of funding to implement climate mitigation and adaptation plans.

3. APEC Cities

The Asia-Pacific Economic Cooperation (APEC) is a regional organization established in 1989 to promote interdependence in the Asia-Pacific region. The APEC region encompasses a diverse range of countries and regions along the Pacific Ocean, representing a significant concentration of wealth, urban centers, and natural resources, including some of the world's fastest-growing and most developed economies. In the 21st century, APEC has broadened its focus to include issues such as sustainable growth and quality regional economic integration (APEC, 2022).

With over 75 percent of gross domestic product (GDP) and jobs produced by cities, the future of the APEC region depends on the sustainable development of its cities (APEC, 2017). However, the population of some of Asia's cities is growing at more than 5 percent per annum, which makes it almost impossible to meet the demand for housing, infrastructure, and basic services.

In 2014, APEC introduced the framework for the Asia-Pacific Partnership for Urbanization and Sustainable City Development, which was approved by APEC leaders along with the APEC Cooperation Initiative for an Asia-Pacific Urbanization Partnership. This initiative identified the challenges and opportunities associated with urbanization and emphasized the need for a new approach to sustainable city development (APEC, 2014). Key focus areas included infrastructure and resource management, renewable energy, energy efficiency, climate change mitigation, education, health, social justice, and coordinated urban-rural development (APEC, 2016). These directives allowed APEC to evolve from a primarily economic cooperation organization to a leader in guiding sustainable development in the Asia-Pacific region (Zhu & Wang, 2023).

Cities in APEC economies represent approximately 40% of the global population and generate around 60% of the world's GDP. They also account for over 45% of global trade among the 21 member economies, with urban areas contributing more than 75% of the GDP. Consequently, cities have emerged as essential drivers

of economic growth both in the APEC region and globally (APEC, 2019).

Climate change presents severe risks to the Asia-Pacific Economic Cooperation (APEC) region. If actions remain insufficient, global temperatures could surpass pre-industrial levels by over 3˚C by 2100, with a 20% probability of exceeding 4˚C. Currently, 70% of the world's natural disasters occur within the APEC region, and their intensity and frequency are expected to escalate due to climate change (Ivanova et al., 2024). The region is particularly prone to experiencing more days of extreme heat, more frequent droughts, coastal land flooding, and increased coastal and river flooding, all of which would have significant human and economic impacts (International Bank for Reconstruction and Development/The World Bank, 2019).

Unmitigated climate change could have catastrophic impacts on APEC economies, leading to reduced agricultural and labor productivity, and economic output losses across multiple sectors (Zhou et al., 2024). Rising sea levels and more frequent extreme weather events are expected to cause severe coastal and river flooding, destroying capital stock (Molnar-Tanaka & Suminski, 2024). Lower and middle-income economies like Indonesia, Thailand, and Vietnam are likely to be hardest hit, with projected losses equaling 7.3% of GDP across the APEC region (International Bank for Reconstruction and Development/The World Bank, 2019).

Beyond the economic costs, climate change also presents a threat in human aspects. It is estimated that rising temperature extremes could cause 350,000 deaths per year in the APEC region. Similarly, more frequent and intense coastal and river flooding could lead to displacement and mortality. In addition, the continued growth of greenhouse gas emissions will continue to degrade air quality and cause respiratory diseases and premature mortality (International Bank for Reconstruction and Development/The World Bank, 2019).

The projected economic costs of reducing emissions to keep global warming below 2˚C are estimated to be only 2.6% of GDP by 2050 and 3.4% by 2100 across APEC economies. These costs are less than half of the anticipated damages from the physical impacts of unchecked climate change. Moreover, strict climate policies could save lives, as phasing out fossil fuels and reducing air pollution could prevent approximately 500,000 deaths annually by 2050, while limiting warming to below 2˚C by 2100 could help avoid 380,000 heat-related deaths each year (International Bank for Reconstruction and Development/The World Bank, 2019).

Disasters are a great challenge to APEC cities which are affected by extremes more than the global average. In 279 cities worldwide, the annual loss of GDP due to disasters is greater than their annual GDP growth. The mortality rate of extreme events has drastically fallen since 1960, but the economic losses due to disasters are increasing (APEC, 2024).

4. Methodology

The first research strategy is the Systematic Literature Review (SLR) adopted from Xiao and Watson (2019) based on the six stages: formulation of research questions,

search criteria and identification, screening process, title and abstract screening, quality assessment and data extraction. The aim of SLR in this project was to find clarity of scholarly communication, validity where the literature is defensible against bias, and audibility of the literature to get accurate results (Booth et al., 2021), and to develop a strategic recommendations approach.

The second strategy is statistical analysis. We employed data mining, this method serves to organize and filter data, bringing useful information to light, and to find undercover relationships between climate hazards and adaptation goals and strategies and the mitigation actions and funding sources used to develop those measures.

We conducted data significance and correlational analyses using two databases developed through a collaboration between CDP and ICLEI—Local Governments for Sustainability, and 2023 Cities Climate Hazards by Proportion of Population Exposed to Hazard. 2023 Cities Emissions Reduction Actions by Sector.

From the first database, we extracted data on the frequency and impacts of climate hazards, including their effects on vulnerable groups and the proportion of the population exposed. We then identified and correlated key adaptation plans and goals associated with each risk. Section IV, "Climate Hazards in APEC Cities," and Section V, "Adaptation Plans and Goals by Climate Hazard in APEC Cities" are based on these analyses. The databases did not present data on adaptation funding.

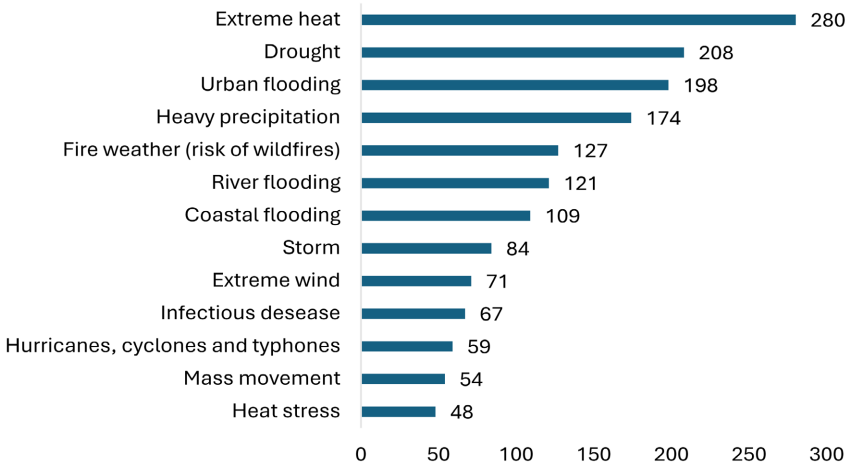
In the second database, we focused on emissions reduction actions. We identified the sectors most frequently targeted by cities implementing these actions and analyzed the primary funding sources used to support them. These findings are presented in Section VI, "Climate Mitigation Actions and Funding in APEC Cities."

It is necessary to highlight that in the case of adaptation only plans and actions were reported, while in the case of mitigation, the funding was assessed.

5. Climate Hazards in APEC Cities

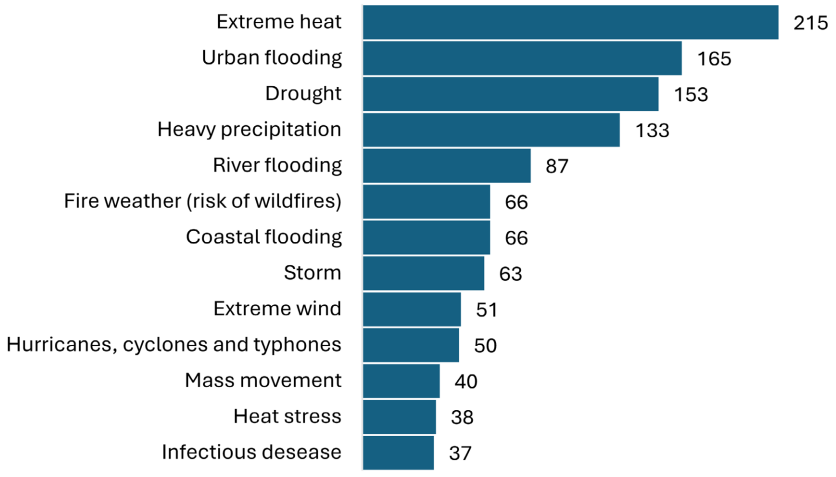
According to data collected in partnership by CDP-ICLEI—Local Governments for Sustainability (2023a), climate-related hazards have been identified in urban areas in 15 of the 21 APEC economies. **Figure 1** illustrates the climate hazards most cited by cities in 2023. According to the CDP questionnaire, the most cited climate hazard is extreme heat, appointed 280 times. It is followed by drought, referenced 208 times. The next three hazards are related: urban flooding (198 references), heavy rainfall (174 references), and river flooding (121 references). Fires are also a major concern, with 127 mentions. These risks represent 80% of the climate-related risks in urban areas in the APEC region.

In 103 cities, 90% - 100% of the population has experienced extreme weather events, and in 82 cities, a similar proportion has been affected by drought. These hazards represent the highest level of risk exposure in the surveyed cities. It is important to outline that, extreme heat, drought, urban flooding, heavy precipitation, and fires are not just the most common Cities Climate Hazards, but also the climate risk with the highest impact on cities and the major likelihood of occurrence.



Source: CDP-ICLEI—Local Governments for Sustainability (2023a).

Figure 1. 2023 cities climate hazards (number of times cities mention each hazard).



Source: CDP-ICLEI—Local Governments for Sustainability (2023a).

Figure 2. Climate risks of cities according to the proportion of Indigenous, marginalized, and low-income populations exposed to risks (number of times cities mention each hazard).

Figure 2 shows the climate risks of cities according to the proportion of indigenous, marginalized, and low-income populations exposed to risks. The low-income population is mainly threatened and affected by extreme heat, urban flooding, heavy precipitation, droughts, extreme heat, river flooding, and storms.

Extreme heat affects low-income urban dwellers more due to overcrowded conditions, lack of cooling systems, and poorly insulated housing. Air conditioning is often unaffordable, and urban heat islands, with more concrete and less vegetation, intensify the heat in underserved areas (Witze, 2021; Lo et al., 2022).

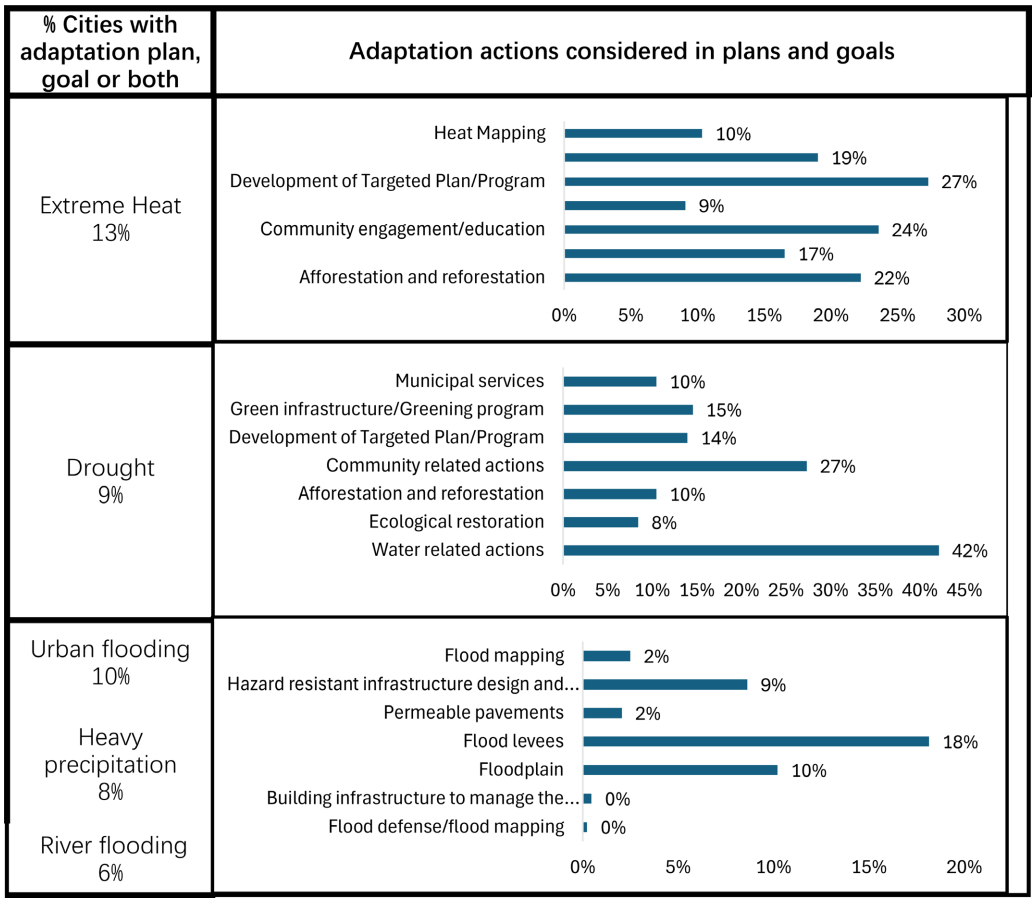
Low-income people are more vulnerable to heavy precipitation, urban flooding, river flooding, and storms because they often live in flood-prone areas with inadequate housing and limited drainage systems. This makes them more susceptible to flooding, waterborne diseases, and economic loss. In megacities, they typically

reside in slums, low-lying riverbanks, steep hillsides, or near industrial zones, where environmental risks are higher and municipal services are lacking (Rentschler, Salhab, & Jafino, 2022; Dąbrowska et al., 2023).

Even though urban floods are much more recognized than urban droughts, urban water scarcity is becoming increasingly complex and challenging. The vulnerability of urban communities to drought is exacerbated by several factors, including limited access to clean water, inadequate infrastructure, and high population density, which collectively increase demand. Economic constraints impede the ability to afford alternative water sources, and reliance on informal sources, such as wells, exacerbates vulnerability. These factors serve to exacerbate the impact of water scarcity in impoverished regions (Singh et al., 2021; Dąbrowska et al., 2023).

6. Adaptation Plans and Goals by Climate Hazard in APEC Cities

Figure 3 shows the proportion of cities reporting the most common climate risks. On the right, it shows the proportion of those cities that have an adaptation plan or objective related to actions recognized by the literature to adapt to each risk.



Source: Produced by the authors with data collected in partnership by CDP-ICLEI—Local Governments for Sustainability (2023a).

Figure 3. Adaptation actions undertaken to face each climate hazard.

A total of 1922 APEC cities submitted reports to the CDP-ICLEI Track, of which 1884 completed climate risk registers and 1691 reported adaptation plans and targets. Of the 13% of cities that reported having an adaptation plan or goal and also mentioned extreme heat as a climate threat, 27% indicated that they had developed a specific plan or program, 24% planned to promote community engagement and education, and 22% planned to In terms of specific measures, 19% of cities indicated that they were working with afforestation and reforestation plans, while 17% had incorporated green infrastructure and greening programs into their adaptation planning. Additionally, 10% of cities reported plans related to buildings, including codes, standards, and resilience, while 9% had included ecological restoration in their plans. Heat mapping was also a topic of interest, with 10% of cities mentioning it as a planned measure.

Drought is also an important climate hazard, but it seems to be less perceived, even though it is a very recurrent risk, and it presents important effects, only 9% of the cities reported an adaptation plan or goal. 42% of the cities reported considered water related actions, 27% mentioned community-related actions, 15% considered green infrastructure or greening plans, 14% reported developing a targeted plan, and 10% mentioned municipal actions and afforestation and reforestation actions.

In the case of closely related risks, such as urban flooding, heavy rainfall, and river flooding, 10, 8, and 6 percent of the cities, respectively, have an adaptation plan or objective. In the case of these climate risks, the number of reported plans is relatively low. Only 18% of the cities have plans to construct flood levees, 10% are considering the possibility of building in a floodplain, 9% are contemplating the design of infrastructure that can withstand potential risks, and only 2% have mentioned the possibility of flood mapping. A mere fraction of cities—less than one percent—have considered the construction of infrastructure designed to mitigate the effects of flooding and enhance flood defense.

7. Climate Mitigation Actions and Funding in APEC Cities

According to Data collected in partnership by CDP-ICLEI—Local Governments for Sustainability (2023b). The public data on cities' emissions reduction actions in 2023 reports that the most numerous emissions reduction actions were focused on Stationary Energy.

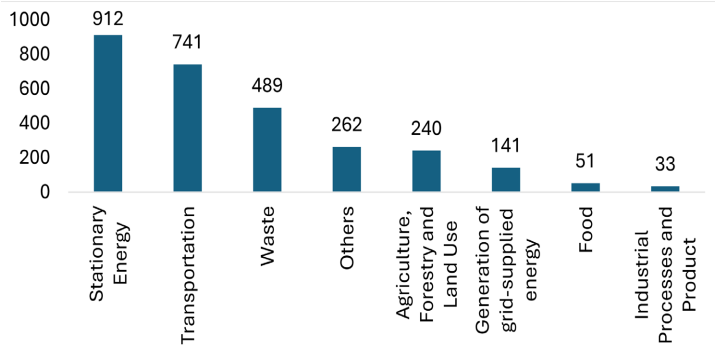
Of the 2869 cities that reported 2344, more than 80% declare the inclusion of the emissions reduction actions in the climate action plan and/or jurisdiction development/master plan.

Figure 4 shows 2023 APEC Cities Emissions Reduction Actions by Sector. It appears that the sector receiving the greatest attention from APEC cities is Stationary energy, with 912 cases identified. Transportation is the second-most-studied sector, with 741 cases, while Waste is the third-most-studied sector, with 489 cases. The Industrial processes and products sector has been insufficiently considered by the cities-only 33 cities has contemplated it. Nevertheless, this sector has

a substantial impact on global emissions (RHG, 2023).

Mitigation actions related to Stationary Energy sector were focused on energy efficiency 32%, On-site renewable energy generation 18% and in building cores and standards 10%, to mention the most important. In terms of transportation, mitigation emissions are related with the following actions 13% on improve fuel economy, and reduce CO_2 emissions of motorized vehicles, improve walking, 12% to cycling and integrated transit access, 11% to electric vehicle charging points and infrastructure, 11% improve bus infrastructure, services and operations.

Waste emissions have been tackled with the following actions: 19% increased awareness/engaged public with wasting reduction, 11% reduced organic disposal to landfills and incinerators, 9% recycling or composting collections or facilities and 9% waste prevention.



Source: Own elaboration with data collected in partnership by CDP-ICLEI—Local Governments for Sustainability.

Figure 4. Shows 2023 APEC cities emissions reduction actions by sector.

Lwasa et al. (2022) from IPCC Working Group identify three principal strategies for reducing urban greenhouse gas emissions: reducing the use of energy and material across all sectors, electrifying and switching net-zero emission resources, and promoting carbon stocks through the development of green and blue infrastructure.

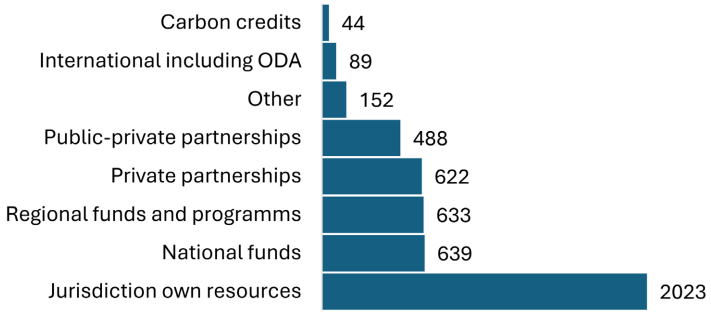
It appears that cities have implemented the initial strategy to a limited extent and with varying degrees of emphasis, favoring certain sectors (stationary energy and transportation) and neglecting others (agriculture, forestry and land use, and industrial processes and products). The second strategy has been largely overlooked by APEC city authorities, who have concentrated their efforts on renewable energy production and the development of electric vehicle charging infrastructure. The third strategy is only evident in the adaptation plans and goals, whereas in the mitigation measures, it appears to have a relatively limited impact.

The IPCC report also mentions that carbon lock-in can be avoided by implementing some measures, such as improving walking and cycling and integrated access to public transport, as well as enhancing infrastructure, services and bus operations. These measures reduce the dominance of car-centric urban forms. As mentioned above, only a small fraction of the cities reported this type of strategy.

Another strategy proposed by the IPCC is urban shape planning. This mitigation measure is not referenced in the reports produced by cities, nor is it included in action plans. The modification of emerging urbanization layouts to achieve greater compactness, walkability, and co-location has the potential to reduce future urban energy use by 20% to 25% by 2050. This strategy also offers a corresponding mitigation potential of 23%. This represents a potential reduction of up to 26% (Creutzig et al., 2015, 2016; Sethi et al., 2020; Lwasa et al., 2022), making it a plan that should be considered in the climate adaptation agendas of APEC cities.

Although only a few cities are currently focusing on electrifying, mobility plays a pivotal role in current mitigation efforts. While electrification technologies might involve some trade-offs, these can be mitigated through effective governance, the use of smart grids, circular economy approaches, and international collaboration. Additionally, it is vital to account for the potential rise in electricity demand that these shifts may bring.

Considering the expected increase in urban sprawl, updating building codes, standards and infrastructure is a crucial mitigation action, which has received little consideration in adaptation plans and goals for cities. There is an imminent need to assess the impact of the rapid growth in demand for mineral building materials. This could lead to an increase in GHG and CO_2 emissions early in the life cycle of a building. The transition to biomass-based materials has been considered as an alternative, e.g., the use of engineered structural timber products and assemblies can help mitigate this impact, if forests are managed sustainably (Churkina et al., 2020). It is essential to analyze timber supply, demand, trade and competition for land use in all regions, as urban expansion may increase the demand for timber in areas with low forest cover (Pomponi et al., 2020; Lwasa et al., 2022).



Source: Produced by the authors with data collected in partnership by CDP-ICLEI—Local Governments for Sustainability. Note: the number of funding sources is higher than cities reported because some of them reported more than one funding source.

Figure 5. Funding source for mitigation actions in APEC cities.

Lwasa et al. (2022) and Dąbrowska et al. (2023) emphasize that Nature-based Solutions (NBS) effectively tackle urban challenges like extreme heat, droughts, and floods. A holistic approach, incorporating green and blue infrastructure, pro-

tects and restores ecosystems while promoting human well-being and biodiversity, key for long-term urban sustainability. NBS include street trees, parks, sustainable drainage systems, green roofs, facades, and vertical forests (Davis & Naumann, 2017; Enzi et al., 2017). These cost-effective solutions can be implemented through community participation, awareness, and education.

In terms of funding, as shown in **Figure 5**, the main source is cities' own jurisdiction resources, followed by national funds, regional funds and private partnerships. This finding is consistent with the IPCC report (Lwasa et al., 2022), which notes that municipal governments often derive their authority and resources from provincial, state and/or national governments, and are subject to laws and regulations that regulate development and implement infrastructure. As a result, they rely on such funding to improve infrastructure, particularly transit infrastructure.

Cities in developing countries rely on local sources of funding due to their lack of international creditworthiness, which impedes their ability to secure commercial financing and access international credit markets (Thomopoulos, 2014; CCFLA, 2015; Floater et al., 2017; Buchner et al., 2019). This fact explains why climate funding mechanisms are very scarcely used.

In this regard, national governments and multilateral development banks could support debt financing by developing a municipal creditworthiness program and issuing sovereign bonds or providing domestic guarantees to investors (Floater et al., 2017). Green municipal bonds offer cities a promising avenue for expanding and diversifying their investor base (Lwasa et al., 2022).

Other funding sources are fiscal measures, carbon taxation presents a critical tool in advancing climate policies across APEC nations. Not only can carbon taxes generate significant revenue, averaging 0.6% of GDP, but they also facilitate the reallocation of resources from the informal to the formal economy, driving GDP growth in countries with large informal sectors (International Bank for Reconstruction and Development/The World Bank, 2019). Moreover, the implementation of strict climate policies aligned with the Paris Agreement could create vast investment opportunities, particularly in energy efficiency, renewable energy, and the development of energy transmission infrastructure. These investments are projected to yield benefits four times greater than their costs.

By aligning financial mechanisms such as green credit markets and carbon taxation with urban resilience strategies, APEC economies and cities worldwide can better position themselves to meet the challenges of climate change while unlocking new opportunities for sustainable growth.

8. Concluding Remark

The vulnerability of APEC cities to climate risks, including extreme heat, droughts, floods, and heavy rainfall, is increasing. This is accompanied by a growing proportion of the population exposed to these hazards. It is noteworthy, however, that only a small number of cities have developed comprehensive climate action plans or set clear targets to effectively address the challenges. Moreover, certain

sectors, such as industrial processes and product manufacturing, have been the subject of insufficient attention from sub-national authorities regarding mitigation efforts.

Mitigation efforts are typically funded through local and national resources. However, the limited use of climate action financing mechanisms in the region is due to several factors, including insufficient creditworthiness and a lack of awareness among city authorities. Many perceive these financing options as overly complex, hindering their ability to secure crucial funding for climate initiatives.

Moreover, local authorities should identify potential climate mitigation projects and consolidate them into a unified portfolio. In parallel, national governments should provide guarantees to back green loans and fund small and large-scale projects. Such a strategy would facilitate connections with potential investors, thereby enabling the financing of the initiatives necessary to mitigate the impacts of climate change.

Addressing the challenges posed by climate change requires a multi-faceted approach, particularly in the context of cities and APEC economies. Mitigation and adaptation efforts place significant demands on the internal organization of cities, necessitating cooperation among sub-national government institutions. To avoid duplicating efforts, it is crucial to define responsibilities clearly, standardize criteria, and ensure legal compliance. Achieving predetermined climate goals depends on this coordinated approach.

In APEC member economies, green credit markets represent an important path for funding low-carbon and climate-resilient investments. However, expanding these markets requires a blend of political leadership and market-driven initiatives, focused on standardizing definitions and maintaining market integrity and credibility (International Bank for Reconstruction and Development/The World Bank, 2019). With over $42 trillion in assets, APEC institutional investors face substantial risks from climate change, threatening retirement funds, insurance payouts, and regional stability. Yet, these investors are also positioned to capitalize on new climate policy opportunities, with an estimated $470 billion in potential investments annually (International Bank for Reconstruction and Development/The World Bank, 2019). As part of further research, it is necessary to access the funding for adaptation in APEC cities and highlight some financial innovation instruments and success cases for climate action in Asia-Pacific.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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