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Atmospheric pollution and climate change in urban areas: a review of implemented policies

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Abstract: Research on air pollution and climate change in urban areas, as well as policies combating this issue, remains fragmented. Most of these studies focus on specific regions, limited time frames, or analyse different pollutants. To address this fragmented research issue, we reviewed articles on air pollution in urban areas, with particular emphasis on policies aimed at combating the problem, and, when possible, validated the findings. The purpose of this study is to offer policymakers that they could use to develop strategies for addressing climate change, mitigating the environmental impact of pollutants, and protect human health. Thus, these strategies would rely on integrated policies and collaboration of all stakeholders.

Keywords: policy; air pollution; urban areas.

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1 Introduction

The massive increase in atmospheric pollutant emissions results from the economic and industrial growth that started in the previous century and continues to this day. This constantly accelerating growth has elevated air quality to a paramount environmental concern (D'Amato et al., 2013), and this has resulted in global climate change posing an unprecedented challenge for humanity (Seddon et al., 2020). Most research has focused on the air quality in urban areas, concentrating on atmospheric pollutants and the policies implemented by local authorities (Amesho et al., 2021; Gu et al., 2021; Ribeiro et al., 2021; Ziola et al., 2021).

Human activities, commonly driven by urban settlements, such as vehicular traffic, thermoelectric power plants, agriculture, building heating and air conditioning, and the lack of urban green spaces, are predominantly accountable for emitting pollutants into the atmosphere, which in turn disrupt urban air quality and cause climate change. Pollutants can originate either from primary or secondary sources. Primary pollutants, such as NO_x, SO_2, and C_6H_6 (Giua et al., 2014), are directly emitted into the atmosphere from either natural or human activities. Secondary pollutants, such as fine particulate matter (PM10 and PM2.5) and ground-level ozone (O_3) (Balanzino et al., 2011), originate from chemical reactions among substances, physical interactions among primary pollutants, or interactions between these primary pollutants and other atmospheric components.

The pollutants emitted from human activities are accountable for a range of environmental issues, including waste release and mining-related pollution (Kasum, 2010). To control and diminish atmospheric pollution, policymakers should implement effective prevention strategies to steer the actions of stakeholders, ultimately reducing atmospheric pollution in urban areas and making a positive contribution to climate change issues. Local governments can wield significant influence in combating climate change (Martins and Ferreira, 2011). Over time, governments have implemented effective strategies to prevent and control air pollution (Bidabadi et al., 2023). The 2030 Agenda (UN, 2015) advocates immediate action at all levels to combat climate change (SDG 13) and to achieve a reduction in greenhouse gas emissions, which have increased by 50% since 1990. Furthermore, this agenda, particularly SDG 11, underlines the strategic significance of cities. Cities have facilitated the enhancement of people's social and economic well-being, while also playing a crucial role in efforts to alleviate urban air pollution. The advantages of integrated policies designed to mitigate air pollution and address climate change far exceed their associated costs (Italian Ministry of Health, 2019). Therefore, the examination of air quality data is crucial for comprehending the implications on human health from various carbon mitigation strategies (Tang et al., 2022).

For all the aforementioned political, environmental and health considerations, it is important to direct our focus toward the urban environment, emissions, and potential strategies to diminish the adverse impact of human activities on the climate. Additionally,

understanding the policy instruments capable of altering the current emission trajectory is of great importance.

In response to this growing demand, multiple urban governments are actively seeking their own solutions. In alignment with this trend, our institutions were invited by an Italian municipal authority to support them in identifying the best solution to mitigate air pollution and address climate change in their city.

As per the environment councillor, the initial action for the municipality would involve reviewing the international practices outlined in academic literature. This step is intended to provide guidance for the development of a customised and cutting-edge climate strategy.

We classified the mapped experiences in accordance with the 2004 OECD environmental policy model, which identified four policy types: direct regulation, market-based measures, market creation, and public participation (Arbatani et al., 2016).

From this perspective, the paper has a threefold purpose:

1 to provide an updated literature review on air pollution and climate change in urban areas and corresponding mitigation policies

2 to identify the most diffused practices for policymakers

3 to propose new avenues for research in this domain.

The present research aims to answer the following research questions:

- How are policymakers taking action to combat climate change in urban areas?
- What unexplored practices should be analysed by future research?

To answer these questions, the researchers accessed the Scopus database and employed a keyword algorithm to identify relevant articles. They also constructed a connection matrix between the study object and the adopted policy.

The matrix adds significant value to this study as it provides an innovative and brand-new approach to effectively outline the policy categories that authorities can employ to combat climate change in urban areas and then assess their outcomes.

The analysis findings revealed that the most commonly implemented policy for addressing air pollution in urban areas is direct regulation, followed by integrated policies. In contrast, policies falling under the categories of public participation and market-based measures are less frequently utilised, and market creation does not appear to be a viable policy option. Our review highlighted the challenges of devising a single strategy to diminish air pollution and improve air quality. It became evident that we must integrate multiple policies (Molina et al., 2004) to promote collaboration among different countries (Amann et al., 2017) and to enable broader societal participation (O'Neill et al., 2008) in efforts to mitigate air pollution and combat climate change in urban areas.

2 Reference framework

Air pollution in urban environments has emerged as a significant research challenge in recent decades due to its far-reaching implications for the urban human population's well-being (Sedláček et al., 2022). This importance has led to several important studies on urban air quality (Borrego et al., 2003; Buccolieri et al., 2011; Amorim et al., 2013;

Salmon et al., 2013). The consequences of urbanisation encompass social, environmental, and ecological dimensions (Madhusudhan and Ambujam, 2022). It is imperative to mitigate these negative effects as they cause adverse climatic conditions that elevate mortality rates (Bakshi et al., 2019). Therefore, measuring the emission volumes (Faria et al., 2023) and understanding global air pollution levels are for facilitating public interventions (WHO, 2023). According to the World Health Organization's analysis of air quality, there has been a consistent decline in particulate matter – PM (10 and 2.5) levels in recent years. For example, between 1990 and 2004, there was a 24% reduction in emissions in Europe. In contrast, during the same period, emissions increased by 28% globally (UN, 2008).

The decrease in emissions in Europe resulted from implementation of appropriate policies by national and local authorities aimed at discouraging or taxing pollution production. However, air pollutant levels remain excessively high in numerous cities, with frequent exceedances of air quality standards (EEA, 2021).

The observed reduction in Europe was made possible by all European countries collectively implementing air pollution control policies. In contrast, the rest of the world struggled to reach a consensus on action plans. To achieve global outcomes, every country must embrace a collaborative and well-structured strategy (Tripathi et al., 2019). Several researchers, including Amesho et al. (2021), Gu et al. (2021) and Ribeiro et al. (2021), have conducted analyses on air pollution in urban environments, identifying the policies already in place or that can be implemented to address the issue. Cities presently receive the primary attention in air quality management (QA). The objective of QA is to improve the urban environment, elevate the quality of life, and safeguard health of citizens (Viana et al., 2020). Achieving this requires cities to adopt well-designed strategies founded on a set of policies that guide the actions of companies, residents, and administration bodies. The impact of urban environments in terms of emissions and air quality aligns with the global priority outlined in the 2030 Agenda's target 11.6.

3 Research method: an action review

In alignment with this framework, this paper introduces a novel method for conducting a non-systematic review, which can be regularly updated to reflect academic and scientific developments. The method enables the research to assist a client, in this case, a local administration, in constructing an algorithm with 'material' words that exactly address the client's request, avoiding overly complex and rigorous steps.

The method can be characterised as an action review because it arises from research that assists a client in acquiring the necessary knowledge to instigate change in their collaborative work environment. A comprehensive review of the literature on urban pollution and policies is crucial to offer a complete and transparent perspective on potential solutions that can assist policymakers in shaping decisions on climate and urban air quality. Nevertheless, it falls short if it doesn't offer all the required information to transition from an academic tool to a decision-making instrument.

Governments are confronted with the primary challenge of diminishing local and regional air pollutants to restrict the public's exposure to air pollution (OECD, 2004). This necessitates the adoption of effective pollution control policies (OECD, 2004).

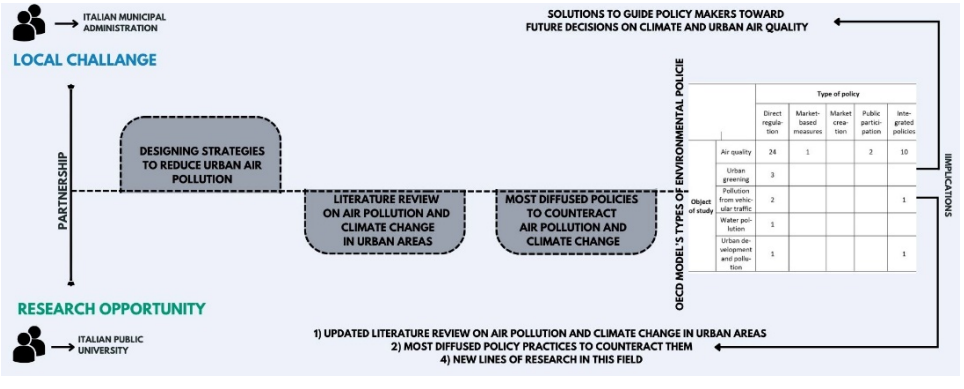
We collected all the papers that pertain to air pollution and climate change, and that describe the policies for controlling and mitigating pollution. To analyse the policies, we

employ the OECD's environmental policy classification, which has been utilised in previous studies (Roshandel et al., 2016). This classification distinguishes four policy categories: direct regulation (laws, standards, licenses, and limitations), market-based measures (environmental taxes, resource pricing, pollution discharge fees; special subsidies, and green credits), market creation (establishment of property rights, emission trading), public participation (public engagement and information disclosure).

This model, as elaborated later, constitutes a shared and credible framework as it has been published by an international organisation. Classifying the contributions within the framework of the OECD model provided the local authority with a comprehensive understanding of the practices and tools in use. As a result, the objective of this paper is to pinpoint the most effective policy or combinations of policies for addressing air pollution and mitigating climate change in urban areas.

In the public sector, bureaucratic procedures frequently hinder local initiatives. Therefore, our objective was to identify political practices implemented by other urban administrations globally. The entire research journey, aligning research prospects with local requirements, serves to elucidate the local authority's potential capacity to act with regard to the specific pertinent project.

Figure 1 Research path (see online version for colours)



Source: Own data processing

We identified the relevant articles by referencing the Scopus database, known for its comprehensiveness. It encompasses approximately 24,600 journals and overall collection of about 70 million documents. The large number of internal contributions guarantees comprehensive content coverage, helping in constructing a comprehensive understanding of international experiences related to the study object.

The review is founded on articles identified through application of a customised keyword algorithm. As previously mentioned, to comprehensively address the requirements of the administration, the selection of keywords for the algorithm was deliberated and formulated in collaboration with local authority managers and politicians. Given that our review was non-systematic, we did not adhere to the standard process for selecting keywords for inclusion in the algorithm, as is typically required in systematic literature reviews (Xiao and Watson, 2017). Instead, the review was specifically designed to uncover the requirements of a municipal administration, subsequently aiding in identifying its unique policy strategy for addressing air quality and pollution concerns. In

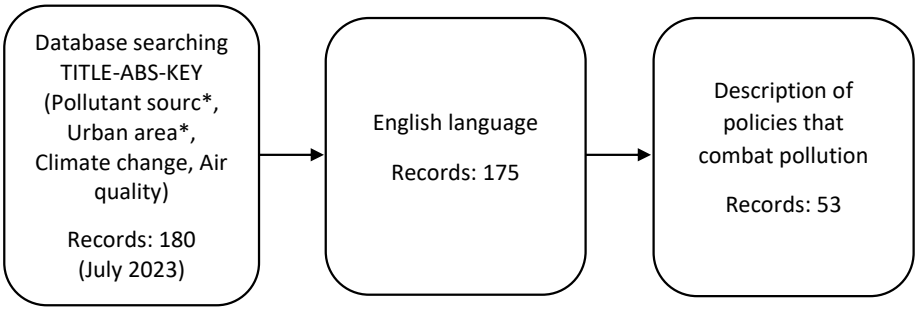
this regard, the review provided an initial overview of the worldwide state-of-the-art policies implemented in urban areas.

The keywords found in the articles' title, abstracts, or keywords included: pollutant source*, urban area*, climate change, and air quality. 'Pollutant source*' was incorporated into the algorithm to show all the primary observed sources of pollutants in the literature. This information, when combined with the distinctive characteristics of the city under examination, equipped policymakers with a unique perspective through which to assess their own circumstances.

The inclusion of both 'climate change' and 'air quality' is due to the distinct nature of these two topics, which are not always interrelated concepts or phenomena and thus warrant individual examination. Finally, the term 'urban area' was employed to establish a perimeter for the analysis within the urban context, due to the microclimatic peculiarities that affect the level and the concentration of pollutants in an urbanised setting.

The research enabled us to identify 180 scientific contributions. To maintain an international perspective, we excluded contributions not written in English. Other exclusion criteria included duplicates, irrelevant articles, and those that did not specify any policies. As a result, we selected and incorporated 53 scientific contributions for the review analysis (Figure 2).

Figure 2 Literature review process selection



Source: Own data processing

To furnish the local authority with insights into appropriate policy instruments, we examined and reclassified the 53 scientific contributions in accordance with the OECD environmental policy model, as detailed by Arbatani et al. (2016). This model categorises environmental policies into four categories: direct regulation, market-based measures, market creation, and public participation. Direct regulation refers to a mandatory environmental policy that restricts polluting emissions by overseeing production processes, material usage, and other business activities that impact the environment within a specified timeframe or area (Tang et al., 2020). Typical direct regulation tools include discharge standards, permits, quotas, and usage limitations (Pan et al., 2019).

Market-based measures are a government mechanism designed to encourage companies to reduce pollution emissions by considering market signals (Cheng et al., 2017; Tang et al., 2016). To be more precise, the government manages market-related instruments, such as pollution-linked subsidies and/or environmental taxes, to influence the actions of businesses or citizens. This can also involve creating emissions trading systems.

Market creation encompasses the establishment of property rights and emission trading, as well as incentives for new business models focused on green management. Finally, public participation involves any process that directly engages the public in a decision-making and empowers them to contribute to such decisions (US Environmental Protection Agency, 2018). This process primarily relies on voluntary public participation and information tools (Arbatani et al., 2016). In our analysis, we introduced a fifth category: integrated policies. Integrated policies encompass cases where a combination of different policies is employed rather than the implementation of a single, specific initiative. Subsequently, we curated articles that revolved around subjects associated with air quality in urban areas. Each paper addresses different issues related to the impact of air quality, all of which corresponded to the categories in which the papers were classified. 'Air quality' papers encompassed those that addressed air quality monitoring and the control of local air pollutants, including emissions from industrial and civilian sources.

The 'urban greening' category comprised papers focusing on local initiatives, such as urban gardening programs designed to mitigate local pollution and absorb pollutants. 'Vehicular traffic pollution' refers to papers dealing with initiatives aimed at reducing traffic air pollution emissions in urban areas. 'Water pollution' refers to experiences involving the effects of water pollution and improper management of urban discharges on air quality. Finally, 'urban development and pollution' refers to the deep connection between urban planning and development and its effects on air pollution.

This analytical phase resulted in a matrix (Table 1), enabling us to understand the relationship between the implemented environmental policies (columns) and their object (rows).

Table 1 Matrix of the type of policy and the study object. Source: own data analysis

Object of study	*Type of policy*				
	Direct regulation	*Market-based measures*	*Market creation*	*Public participation*	*Integrated policies*
Air quality					
Urban greening					
Vehicular traffic pollution					
Water pollution					
Urban development and pollution					

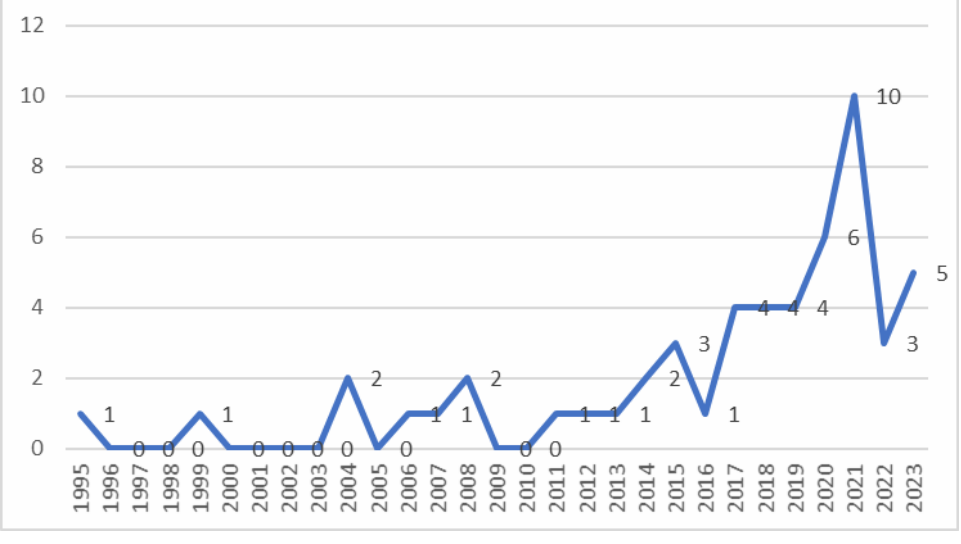
4 Results of the analysis

The 53 selected scientific contributions span trend from 1995 to 2023 (Table 1). In general, the articles serve diverse purposes, encompass various territorial areas, and are affiliated with different scientific disciplines. The publication year statistics show a fluctuating trend up to 2016. This year is likely perceived as a pivotal moment, primarily because of the 2015 New York Conference, where the 2030 Agenda and initiatives to combat climate change were officially introduced as global priorities. The publication trend steadily increased, reaching its peak in 2021. The publication of articles on this topic increased from one to four. The numbers remained constant from 2017 to 2019.

However, from 2019 to 2021, the number of published articles doubled from four to ten papers.

Finally, the algorithm incorporated a document addressing these concerns, which was associated with 2022 and available as an early-view document. In 2021, there were ten articles published, constituting 19% of the total number of published articles. With 55% of the global population residing in densely populated urban areas, these statistics indicate the increasing interest among researchers in this subject (Borrego et al., 2003; Buccolieri et al., 2011; Amorim et al., 2013; Salmon et al., 2013).

Figure 3 Publication of the analysed articles over time. Source: our own data processing (see online version for colours)



The studies were conducted in various countries worldwide (Figure 4). In particular, 18 articles, accounting for approximately 34% of the total, focused on research conducted in Asia, where this issue holds particular significance (WHO, 2022).

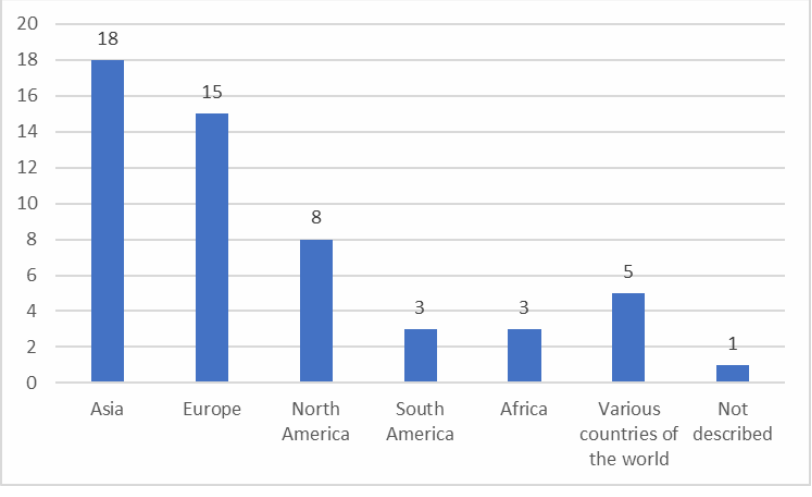
In 2020, the nine countries with the highest concentration of PM2.5 in the atmosphere were Bangladesh, Pakistan, India, Mongolia, Afghanistan, Oman, Qatar, Kyrgyzstan, and Indonesia (WHO, 2022). South Asia stands as the most polluted region in the world, with 37 of the 40 most polluted cities globally (WHO, 2022). Notably, 11 articles were published in China, constituting approximately 21% of the total.

As of WHO's 2022 data, 42 Chinese cities are included among the 100 most polluted cities worldwide (WHO, 2022). Fifteen articles are dedicated to European cases, constituting approximately 28% of the total. In Europe, air quality monitoring holds significant importance for the regional governing bodies and environmental agencies. Europe is actively harnessing its resources to combat pollution. In this context, the European Commission has introduced an initiative for achieving zero pollution in Europe as part of European Green Deal (European Commission, 2021).

The continents with the least number of conducted studies are Africa and South America, each having only three articles. Despite t the pressing pollution issues in these continents, there remains a shortage of air quality monitoring, which leaves vast populations without the necessary information to address this problem (WHO, 2022).

Finally, five articles refer to cases involving multiple countries. In total, over 20 countries are implicated in these studies (Figure 4).

Figure 4 Articles published by geographical area (see online version for colours)



Source: Own data processing

Through the analysis of the 53 scientific contributions, we have compiled the following matrix describing the policies employed by the authorities (Table 2). The matrix clearly and concisely describes the policies and objects of study outlined in the articles.

Table 2 Matrix of the type of policy and the study object

		Type of policy				
		Direct regulation	*Market-based measures*	*Market creation*	*Public participation*	*Integrated policies*
Object of study	Air quality	27	1	0	3	13
	Urban greening	3	0	0	0	0
	Pollution from vehicular traffic	2	0	0	0	1
	Water pollution	1	0	0	0	0
	Urban development and pollution	1	0	0	0	1

Source: Own data processing

Table 3 provides a detailed description of the study's objects, continents, countries, and the references, along with publication years of the analysed articles.

Table 3 Policies, objects of study, countries, continents, references, and publication years of the case studies analysed

Policy	*Object of study*	*Continents*	*Study countries*	*References and publication year*
Direct regulation	Air quality	Asia	China	Xiao et al. (2020), Chen et al. (2020), Ji et al. (2017), Tao et al. (2015), Chen et al. (2012) and Slanina et al. (1995)
			Iran	Borhani et al. (2021)
			Korea	Sim et al. (2020)
			Nepal	Putero et al. (2015)
			India	Latha et al. (2022) and Amann et al. (2017)
		North America	USA	Coelho et al. (2023), Garzón et al. (2014) and Aneja et al. (2006)
			Canada	Healy et al. (2017)
		South America	Brazil	Andrade et al. (2015)
			Chile	Romero et al. (1999)
		Europe	Italy	D'Ambra et al. (2021) and Quéré and Levasseur (2020)
			Various	Dressel et al. (2022), Viana et al. (2020) and Oliveira et al. (2020)
			Portugal	Sá et al. (2016)
			Cyprus	Achilleos et al. (2014)
			Slovenia	Kikaj et al. (2023)
		Africa		Moodley et al. (2011)
		Various		D'Amato et al. (2013)
	Urban greening	Europe	Portugal	Rafael et al. (2018)
		Various		Fierravanti et al. (2017)
		North America	USA	Gu et al. (2021)
	Pollution from vehicular traffic	Asia	Malaysia	Akibu et al. (2021)
		Africa		Abbass et al. (2018)
	Water pollution	Asia	China	Song et al. (2021)
	Urban development and pollution	North America	USA	Stone et al. (2007)

Source: Own data processing

Table 3 Policies, objects of study, countries, continents, references, and publication years of the case studies analysed (continued)

Policy	*Object of study*	*Continents*	*Study countries*	*References and publication year*
Market-based measures	Air quality	Asia	China	Chen and Chen (2019)
Public participation	Air quality	Various		O'Neill et al. (2008)
		Europe	Various	Erhart and Erhart (2023)
			Italy	Annesi et al. (2021)
Integrated policies	Air quality	Asia	China	Fang et al. (2023), Amesho et al. (2021) and Zhao et al. (2018)
			Lebanon	Baayoun et al. (2019)
		Africa		Salama et al. (2022)
		Europe	Poland	Ziola et al. (2021)
			Spain	Salvador et al. (2019)
			Romania	Călămar et al. (2017)
			UK	Longhurst et al. (2008)
		North America	USA	Felix et al. (2023) and Restrepo (2021)
		Not described		Al-Thani et al. (2018)
		Various		Molina et al. (2004)
	Pollution from vehicular traffic	South America	Brazil	Ribeiro et al. (2021)
	Urban development and pollution	Various		Molina and Molina (2004)

Source: Own data processing

The matrix reveals that 34 articles (approximately 64% of the total) advocate for the use of direct regulation as a policy to address urban pollution. Additionally, 15 articles (approximately 28% of the total) describe the implementation of integrated policies to combat pollution, while four articles (about 7.5% of the total) discuss public participation and market-based measures as methods. Notably, none of the articles consider market creation as a viable approach to address urban pollution.

A total of 44 articles analyses air quality: Three of them focus on urban greening and traffic-related pollution, two explore the relationship between pollution and urban development, and one article describes waterway pollution. A total of 27 articles focused on air quality advocate for a direct regulation policy. This underscores an important concern for air quality and highlights the importance of regulations in mitigating air pollution and controlling emissions. Thirteen articles discuss air quality and integrated policies as a means of tackling urban pollution. Other observed combinations are residual: Three articles describe urban greening and a direct regulation; two articles focus on traffic pollution and a direct regulation; and finally, three articles describe a combination of air quality and public participation, water pollution and a direct regulation, urban development and a direct regulation, air quality and market-based

measures, traffic pollution and integrated policies, and urban development and integrated policies.

None of the articles explore combination of market-based measures with urban greening, pollution from vehicular traffic, water pollution, and urban development. Furthermore, no article takes into consideration a policy of market creation to address the issue of urban air pollution, which could potentially provide a novel approach by utilising emissions markets for this analysed problem. Furthermore, no article explores the combination of public participation and urban greening, pollution from vehicular traffic, water pollution, and urban development issues. Finally, none of the articles considers integrated policies in conjunction with urban greening and water pollution. These issues should be subjected to future analysis to assess the potential outcomes in terms of reduced urban air pollution. We will now proceed to analyse the various groups of articles.

4.1 Direct regulation

The direct regulation group consists of 34 articles, which accounts for 64% of the total. Within this cluster, the case studies primarily revolve around air quality, with 27 articles addressing this theme. In this area, several articles emphasise the necessity of implementing rigorous control systems (Tao et al., 2015) to ensure compliance with emission limits (Euro 4/5/6) and to enable prompt responses in case of limit exceedances (D'Ambra et al., 2021). These control systems facilitate processes of innovation and improvement (Ji et al., 2017) aimed at reducing ozone concentration levels (Coelho et al., 2023; Borhani et al., 2021) and atmospheric PM10 concentration (Achilleos et al., 2014). Control measures are essential in addressing the air quality challenges arising from rapid urbanisation, land use changes, socio-economic transformations, and population growth (Putero et al., 2015).

Several articles underscore the challenges faced by policymakers in implementing effective strategies, often due to the lack of essential information needed for decision making (Quéré and Levasseur, 2020), particularly in developing countries. From this perspective, the transfer of information and knowledge from countries that have already implemented such policies should assist developing countries (Slanina et al., 1995). Furthermore, certain articles detail the challenges associated with insecurity arising from the ineffectiveness of mitigation strategies, the complexities of promoting co-benefits, the absence of cost-benefit analysis tools, and the necessity for communication strategies and the exchange of best practices (Viana et al., 2020).

The articles emphasise the urgent requirement for implementing prevention tools (Chen et al., 2020), and stress the importance of instituting emission regulation programs (Kikaj et al., 2023; Andrade et al., 2015; Moodley et al., 2011), local long-term policies (Latha et al., 2022; Oliveira et al., 2020), strategies to reduce air pollution (Dressel et al., 2022; Garzón et al., 2014), and recommendations for enhancing air quality (D'Amato et al., 2013).

Hence, it is imperative for policymakers to factor in their region's climatic characteristics during the urban planning process (Romero et al., 1999). Moreover, they should strive to implement policies geared toward enhancing air quality (Sim et al., 2020) through collaboration with their neighbouring areas or states (Amann et al., 2017). A smaller number of articles focus on the theme of urban greening combined with direct

regulation policies. Three articles explore urban greening as a strategy for mitigating atmospheric pollution through the use of vegetation barriers close to roads.

This strategy has resulted in a slight reduction in air pollution by a few percentage points (Rafael et al., 2018). Furthermore, it has yielded several positive effects on ecosystem services (Fierravanti et al., 2017). Green cities adopting these strategies should also consider the use of vegetation with low volatile organic compound (VOC) emissions to prevent further deterioration of urban air quality (Gu et al., 2021). In the first group, two articles address the issue of pollution from vehicular traffic in conjunction with a direct regulation. These articles highlight that vehicular traffic constitutes the primary source of air pollution in urban areas.

Additionally, the articles emphasise the importance of models that help decision makers in mitigating traffic emissions to protect citizens residing in close proximity to highways (Akibu et al., 2021). Finally, the articles discuss the lack of comprehensive emission inventories and the potential for employing innovative technologies to control emission concentrations (Abbass et al., 2018). One article explores water pollution in combination with direct regulation, emphasising the importance of acquiring information regarding pollution sources in waterways to formulate effective control strategies (Song et al., 2021).

Finally, another article examines the combination of direct regulation, urban development, and pollution. It suggests that land use change can have a measurable impact on improving regional air quality over time (Stone et al., 2007).

4.2 Integrated policies

Integrated policies represent the second group in terms of number of articles. In total, 15 contributions discuss integrated policies for combating atmospheric pollution in urban areas. Within this group, the case studies are predominantly related to air quality. Indeed, ten articles focus on this theme, highlighting that mitigating pollution necessitates political actions with consequent synergistic effects, such as reduced climate change impacts (Amesho et al., 2021). Such actions should be coordinated across various government levels (Salvador et al., 2019).

The paper highlights the importance of process management, fuel selection, the adoption of clean technologies, and urban vegetation as potential sustainable mitigation policies for controlling PM pollution in cities and urban areas (Al-Thani et al., 2018). Furthermore, public transport is promoted as a solution, and private transport is identified as one of the most relevant sources of impact (Baayoun et al., 2019). The article also provides an example of an integrated policy-based air pollution management program developed in the UK. In this case, the local authorities determined the appropriate objective levels by considering technical, economic, and social factors at both the local and the national levels (Longhurst et al., 2008). Integrated policies are essential, because individual strategies alone cannot effectively reduce air pollution in megacities.

A combination of policy measures is necessary to improve the air quality, as past experiences have shown that public engagement is crucial for effective implementation of the required activities to tackle air quality concerns (Felix et al., 2023; Molina et al., 2004). Additionally, integrated policies are essential for formulating a regulatory plan with the goal of optimising industrial and energy structures. The latter is a fundamental factor in improving air quality (Zhao et al., 2018), and monitoring atmospheric pollutants (Fang et al., 2023; Salama et al., 2022; Călămar et al., 2017). Finally, the articles detail

the outcomes achieved through the implementation of these integrated policies. First, the authors noted a slight reduction in black carbon concentrations attributed to the enforcement of emission regulations concerning petrol and diesel vehicles, alongside increased investments in the development of green spaces (Ziola et al., 2021). NO_2 concentrations became evident following the implementation of regulations concerning fuel efficiency and emissions from vehicles (Restrepo, 2021).

4.3 Market-based measures and public participation

The third group combines contributions concerning market-based measures and public participation policies, with both categories characterised by a limited number of articles discussing air quality. The only article addressing market-based policy measures explains the importance of integrating a policy tailored to the diverse economic development conditions of various cities. It emphasises that it is crucial for less developed cities to provide subsidies to incentivise industries to achieve low carbon emissions (Chen and Chen, 2019).

The first article elaborates on how the public participation policy highlights essential role of the community in combating climate change and reducing air pollution. The engagement of society enables the documentation of potential inequalities and the promotion of remedial measures (O'Neill et al., 2008).

A second article, focusing on the community's role, highlights the potential of bottom-up pressure in initiating integration and subsequently to institutionalising climate change policies and sustainability priorities at the municipal level (Annesi et al., 2021).

The third article outlines the monitoring of water and atmospheric emissions within 10,000 European companies. It emphasises that even companies can voluntarily monitor and take actions to reduce their emissions (Erhart and Erhart, 2023).

5 Discussion

The results show the endeavours of local authorities to implement policies aimed at reducing urban air pollution by actively involving society and fostering national and international cooperation to address pollution and climate change as global problems. The articles show the efficiency of the implemented policies by detailing the achieved results in the context of reduced urban air pollution. A significant number of articles also elaborate on the application of a direct regulation. Administrations primarily operate through command-and-control initiatives, which steer citizens' behaviour by establishing regulations for specific activities and imposing sanctions for non-compliance. Policymakers can induce a certain societal shift by directing citizens' actions toward the fight against climate change and reducing air pollution through direct regulation. Additionally, a considerable percentage of articles considers integrated policies as an effective solution for reducing air pollution. This approach is favoured because the more initiatives are, implemented, the greater potential for achieving results in pollution reduction and combating climate change. Market-based measures and public participation are utilised to a much lesser extent, representing residual policies. These encompass incentives or voluntary with the aim of identifying long-term, stable, and collective solutions. Therefore, this 'long-term' solution is more challenging for the public to understand and often offers fewer immediate rewards for policymakers, who often need

short-term results. Finally, the analysis revealed that none of the policies considered market creation as a means to reduce urban area air pollution.

This shows that policymakers have not considered the bond issue market as a potential instrument for mitigating atmospheric pollution. However, these three policy types possess significant innovation potential, as they enable market players to engage in urban areas to connect the benefits of environmental protection policies to their reputational and business advantages.

Companies can play a proactive role, rather than adopting a reactive approach solely focused on ensuring compliance with the regulations. These policies could foster new opportunities for businesses by establishing new market niches, fostering innovative business models for green-related products and services and enhancing social acceptance among all stakeholders in businesses. Ultimately, they enable the utilisation of market principles as motivating factors for sustainable technological and managerial innovations.

The analysed articles emphasise several key themes related to more effective strategies for combating urban air pollution. Scholars have explained the complexity of the environmental challenges confronting humanity, making it challenging to identify a single course of action to combat pollution. From this perspective, as outlined by Molina et al. (2004), a combination of various policies is necessary to improve air quality.

Restrepo (2021) advocates for a similar solution, underscoring the importance of implementing integrated policies to combat the air pollution issue through regulations and restrictions, motivating voluntary citizen actions, and introducing incentives to achieve the desired short-term results.

Research has shown that numerous policies are regulation-based and integrated in their approach, while there is a lack of policies centred on market creation to tackle the atmospheric pollution problem in urban areas. It is crucial not only to formulate policies associated with regulation, but also to integrate voluntary participation, incentives, and market-based approaches for a more effective outcome, harnessing the efforts of all contributors toward the common goal. The combination of direct regulation policies, voluntary participation, and incentive strategies has the potential to yield more gratifying results in achieving the stated objectives. From this standpoint, certain reported experiences seem to endorse integrated policies as the suitable and widely adopted approach to address this complex issue. The various measures taken to attain this goal facilitate the reduction of atmospheric pollution, ensuring improved air quality, health, and overall human well-being, which, in essence, all contribute to combating climate change.

6 Conclusions

This paper represents the initial output of a broader project aimed at assisting a municipal administration in formulating its climate strategy. While the design of the climate strategy is in its early phases, we can delineate certain accomplishments that have emerged during the preliminary assessment. The review of air pollution in urban areas clearly identifies the policies adopted to execute actions aimed at mitigating the impact of pollutants in urban areas. Moreover, the review offers recommendations for new research directions in this field. The findings can serve as guidance for other local administrations in identifying effective strategies to address air pollution in urban settings.

Our paper explains the more commonly adopted policy categories and the outcomes achieved concerning the reduction of air pollution in urban areas. It highlights the challenges that arise in the selection and implementation of policies to combat air pollution in urban areas. Direct regulation and integrated policies are the most commonly employed instruments, with market-based instruments being used sparingly.

These findings have been shared with the municipal administration to serve as a foundation for the subsequent stages of implementing a sustainability strategy. In this regard, the municipal administration has gained insights into policies that are less viable and those that could potentially pose challenges rather than yielding favourable outcomes.

With a forward-looking perspective, this information also offers insights to other local authorities planning to pursue a similar course of action. As previously emphasised, the latter aspect underscores the challenge of perceiving policies as advantageous for the market.

The same principle applies to connecting the interests of market participants in safeguarding the natural environment and public health with pertinent information. In this context, it appears that the perspectives of various stakeholders remain of secondary importance when it comes to initiatives directed at mitigating and controlling the sources of impact.

Even when integrated policies are promoted, the aim is to evaluate various sources of impact rather than endorsing comprehensive development policies. Nevertheless, the latter approach could amalgamate reputation, stakeholder interests, and growth objectives, thereby catalysing innovative business models.

Based on the gathered evidence, future research endeavours should focus on examining the impact of market creation policies on reducing atmospheric pollutants, a topic notably absent in the existing literature.

This in-depth exploration could centre on potential policies designed to foster novel business models, create fresh opportunities for green jobs in urban areas, cultivate new skills, and devise technological solutions that align ‘quality’ objectives with development opportunities. This serves as an initial recommendation for researchers and policymakers to test such policies for reducing air pollution in urban areas. Moreover, local and national authorities have embraced categories related to public participation and market-based measures in a residual fashion.

The findings of this paper should also encourage administrations that have implemented market-based policies to spread information regarding the outcomes attained and the processes employed.

Despite active public participation being a well-established approach in the decision-making processes of local and national authorities, the evidence collected underscores that research has paid limited attention to its implications for air quality.

Future studies should delve deeper into this subject, documenting the experiences cultivated at both the national and local levels and evaluating their relevance in terms of their effectiveness in influencing urban air quality conditions.

National and local authorities could adopt a multi-stakeholder approach, based on categories of subjects representing different interests, as a driver to analyse this topic and to provide innovative suggestions for scholars and policymakers. Our research has shown a lack of literature considering market-based measures for reducing air emissions. Future studies could more closely examine the impact of market policies on atmospheric pollution.

As mentioned, this review is part of a larger project currently in the initial stage. The review provides indications useful for understanding the effectiveness of policies and practices adopted in other contexts. In this sense, effective policies and practices can be discussed with stakeholders, enhancing awareness of the potential outcomes. The paper's added value is linked to its innovative use of a literature review.

The literature review is generally used to identify scientific gaps and to establish the rationale for new investigations (Creswell and Creswell, 2009). This paper presents a collaborative approach with the aim of providing practitioners, in this case, policymakers and administrators, with information to frame their own situation in a broader and international context and take informed actions.

The use of the literature review, as a scientific analytical method has been improved to empower non-academics with the tools to translate theories into policy decisions. In this context, addressing a local challenge may involve engaging a research team to guide the local authority in formulating and comparing their request within a broader scientific and political framework. Furthermore, through this research, we offer guidelines on policies that can be implemented not only in a local context, but that can be extended for all national and international administrations.

Focusing on the research-identified limitations, the administration's decision to engage stakeholders aims to shift away from the predominantly short-term focus in political decisions and underscores the commitment to implementing enduring, consensus-based policies. Understanding the effects of adopted policies and strategies on the international level, the environmental councillors need to encourage the local stakeholders' commitment to implementing innovative solutions.

While the stakeholder engagement process has not yet commenced, it remains feasible to view the role of scientific contribution as a means to encourage local actors to aspire to loftier objectives. Finally, another potential research perspective could explore the relationship between urban area pollution and the 2030 Agenda's sustainable development goals. The results of the previously adopted policies have played a significant role in achieving objectives within the contexts of SDGs 11 and 13 of the 2030 Agenda.

Consequently, future research should further investigate the nature of this relationship by identifying suitable instruments to measure the actual impact of policies in these domains and, consequently, their contribution to achieving the set targets.

Furthermore, we believe that the issue of energy is central to reducing atmospheric emissions, and in future administrations, policies that encourage and favour the use of renewable energies could be introduced to reduce environmental impact, achieve self-sufficiency, and reduce dependence on energy imports from abroad.

We believe that this document will promote progress in empirical studies, research developments, and practical applications in this area, aiding in the identification of strategies to address air pollution issues in urban areas.

The inability to attain a homogeneous and comparable picture of the conducted research limits our paper. Each analysed article outlines the specific identification of one or more pollutants in various geographical areas at different time periods. Further, each study examines a specific relationship between the geographic area, climate, reference period, and urban development. Finally, there is a lack of collaboration among local, regional, national, and international authorities to establish coordinated strategies for tackling and mitigating urban pollution, encompassing policy requirements as well.

The developed algorithm also has some limitations. It has detected a smaller number of papers focused on African and South American countries when compared with European and Chinese case studies. In this sense, it is likely that the algorithm has not comprehensively captured entire body of literature. Nevertheless, the findings can serve as a proxy for the current focus of academic research and the accessibility of data within these domains. In a similar context, the article has overlooked references pertaining to the matter of environmental and climate justice, which is directly linked to citizens' exposure to air pollution (Bouma et al., 2023). This issue should be addressed by urban policies. Different wording choices or the development of a systematic review would probably have resulted in a broader range of contributions. Nonetheless, this review was specifically crafted to address an administrative requirement, offering a distinct opportunity for guiding the decisions of a local authority. In this context, the role of academic research in driving public sector transformations is evident but remains a challenge for future climate-change-focused planning endeavours.

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