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One Atmosphere: Integrating Air Pollution and Climate Policy and Governance

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Abstract: Few challenges pose a greater threat to a healthy planet and people than air pollution and climate change. Over the past three decades, research has demonstrated that integrated solutions to air pollution and climate change can yield co-benefits that support cost-effective, coherent policies. However, research on co-benefits has yet to generate policy responses consistent with this promise. This paper argues that realizing this potential requires more rigorous research on how governance affects the opportunities and incentives to align the interests of government agencies, scientists, and other stakeholders at multiple levels. The article proposes a "One Atmosphere approach" consisting of three building blocks to strengthen that alignment: (1) continually incorporating and strategically timing the introduction of integrated visions; (2) reforming governance arrangements to encourage interagency collaboration and multi-stakeholder cooperation; and (3) supporting integrated visions and institutional cooperation with standardized metrics and assessment methods. This article is also the introduction to the Special Issue 'One Atmosphere: Integrating Air Pollution and Climate Policy and Governance', aimed at fostering the multidisciplinary dialogue needed for more integrated air pollution and climate change policies.

Keywords: co-benefits; integrative policy; climate change; climate policy; air quality policy; SLCPs; co-impacts; governance

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1. Introduction

Even as COVID-19 forced economies and lives to close down over the past year, it opened eyes to some of the environmental benefits of disruptive economic and lifestyle changes. Among the positive disruptions that the pandemic made most clear were the sharp reductions in greenhouse gases (GHGs) and air pollution many countries and cities experienced during the lockdowns [1,2]. However, abruptly halting socio-economic activity is not a sustainable solution to air pollution or climate change. Rather, the most sustainable responses to "wickedly complex" planetary crises like air pollution and climate change capitalize on these problems' common causes and related effects to arrive at integrated solutions. These solutions are so-named because they remedy multiple problems with a single set of interventions.

Few problems are better suited for integrated solutions than climate change and air pollution. This potential, in part, reflects the fact that fossil fuel combustion contributes to the emissions of greenhouse gases (GHGs) responsible for warming as well as air pollution. The potential for integrated solutions also exists, in part because short-lived climate pollutants (SLCPs), notably black carbon and methane, contribute to air pollution at the same time as near-term climate change. Policies mitigating near-term and long-term climate change while improving public health, labor productivity, and crop yields are said to deliver "co-benefits"—or multiple benefits that mitigate climate change and meet other development priorities. Maximizing the co-benefits from actions that mitigate climate change and achieve other development priorities can allay the cost concerns that often discourage policymakers from acting on climate change—and, to a lesser extent, air pollution.

The recognition of this potential has influenced the language of and provisions in numerous policy frameworks and initiatives. Both the Paris Agreement and the Sustainable Development Goals (SDGs), for instance, call for governments to integrate climate and other sustainable development concerns [3]. The Climate and Clean Air Coalition (CCAC) was formed in 2012 to motivate countries to integrate the short-lived climate pollutants (SLCPs) into climate and other relevant policies [4]. The Convention on Long Range Transport of Atmospheric Pollution (CLRTAP) and its Gothenburg Protocol included a science-based objective for reducing particulate air pollution in order to provide benefits for human health and the environment and mitigate near-term climate change [5]. In addition, a growing list of national and local policies account for the co-benefits from working on climate and air pollution concerns at the same time.

This progress nevertheless falls short of the suite of reforms needed to limit dangerous climate change and ensure clean air for all [6]. In fact, achieving these goals requires bridging an under-discussed divide between research on co-benefits and the integrated policies meant to achieve them. Part of the reason for this disconnect is that much of the co-benefits research concentrates on modelling how much different mitigation measures generate benefits and/or trade-offs for/with climate change, air pollution, health, and other development concerns [7,8]. Typically, such studies recommend that governments adopt policies promoting technological and behavioral changes capable of maximizing estimated benefits. Such assessments are necessary inputs into policy processes, but are not sufficient to ensure the governance arrangements shaping those processes deliver the outcomes their modeling recommends. A more rigorous analysis of how governance affects the opportunities and incentives for different government agencies, scientists, and other influential stakeholders to cooperate on integrated solutions would greatly enrich these studies.

This Special Issue "One Atmosphere: Integrating Air Pollution and Climate Policy and Governance" aims to bring governance into co-benefits research. To make governance more central to this research, this paper argues that policymakers should adopt a "One Atmosphere approach" consisting of three building blocks: (1) continually incorporating and strategically timing the introduction of integrated visions; (2) reforming governance to encourage interagency collaboration and multi-stakeholder cooperation; and (3) supporting integrated visions and institutional cooperation with standardized metrics and assessment methods. Putting these building blocks in place requires not only more attention to governance but a constructive exchange between natural and social sciences on how integration can be achieved in policy and practice [9]. This Special Issue holds firm that such a multi-disciplinary dialogue is critical to making integrated solutions to climate change and air pollution a reality.

This introductory article "sets the scene" for the Special Issue. Methodologically, it can be regarded as an overview paper and an analysis of the state of integration of climate and air quality policies and governance. It builds on the examination and interpretation of existing academic and non-academic work, as well as the authors' engagement, experience, and previous research within the field.

In the first part, the article traces the evolution of work on co-benefits. It further reviews how international, regional, and national policy frameworks and initiatives have, often implicitly, provided support for only a single perspective on co-benefits (e.g., the climate benefits of development policies) without recognizing complementarities with others. In the last part, the article details how three previously mentioned governance building blocks could help policymakers leverage integrated solutions and work toward a One Atmosphere approach in diverse contexts.

2. Air Pollution and Climate Change: Making the Connections

2.1. The Evolution of Perspectives on Co-Benefits

A useful starting point for a discussion of governance for more integrated solutions are the multiple or co-benefits that result from mitigating climate change while controlling air pollution. The Intergovernmental Panel on Climate Change (IPCC) defines co-benefits as "the positive effects that a policy or measure aimed at one objective might have on other objectives, thereby increasing the total benefits for society or the environment" [10]. As this broad definition implies, the term co-benefits encompass a wide array of "positive effects" that can be achieved from a range of interventions in equally diverse settings. This section distinguishes between four perspectives on co-benefits, clarifying the different benefits, interventions, and contexts featured in the four views (see Table 1).

Table 1. Four perspectives on co-benefits.

Perspectives	Focus	Primary Contexts	Policy Interventions	Period When Research Began
Frame 1: Development Co-benefits	Non-climate benefits (e.g., air quality and health) of climate policies	Developed countries	Climate policies (especially carbon taxes)	Early 1990s
Frame 2: Climate Co-benefits	Climate benefits of development policies	Developed countries	Development policies and climate finance mechanisms	Early 2000s
Frame 3: Air Pollution Co-benefits	SLCPs, i.e., individual pollutants that contribute to air pollution and global warming (e.g., black carbon, methane, tropospheric ozone)	Both developed and developing countries	Air pollution policies and some sectoral policies	Early 2010s
Frame 4: Co-impacts	Multiple positive and negative effects (co-impacts) for climate change, air pollution, and many other development objectives	Both developed and developing countries	Sustainable development strategies and some sectoral policies	2015–present

Approximately 30 years ago, the first climate-first co-benefits perspective focused on the (sustainable) development benefits from climate policies in 'developed countries' [11,12]. This view grew from a desire to persuade developed country policymakers that investing in GHG mitigation could bring air quality and health benefits capable of lowering the costs of controlling climate change. Many of these initial co-benefits studies employed energy, air pollution, and health models to estimate local air quality and health improvements that were more short-term, local, and certain than what were perceived as long-term, global, and uncertain GHG benefits [13,14]. Moving forward, the work on co-benefits would build on this initial view by considering applications outside of developed country climate policies [15,16].

The second perspective gained currency two decades ago by concentrating on co-benefits in 'developing countries' [17,18]. This development-first perspective was motivated by research that mirrored previous modeling studies but showed that air quality and health improvements in developing countries were typically greater due to the exposure of often denser populations to more polluted air [17–20]. This shift in perspective also implied developing countries could pursue climate co-benefits from domestic sectoral policies meant chiefly to achieve other development objectives [21]. Co-benefits in developing countries could also be achieved with the support of international climate finance mechanisms such as the Clean Development Mechanism (CDM) or the Green Climate Fund [22].

A third air pollution perspective on co-benefits originated from a body of research that concentrated on SLCPs such as black carbon, methane, and tropospheric ozone. SLCPs are relatively short-lived in the atmosphere and are, or contribute to the formation of, air pollutants. These studies demonstrated that mitigating SLCPs could limit near-term warming (i.e., within the next decades) while simultaneously protecting health and delivering other benefits. In contrast to the two previously discussed viewpoints, this work highlighted the potential benefits from actions concentrating on small-scale sources of SLCPs (such as diesel engines, brick kilns, and rice paddies), which were frequently different from and therefore complementary to larger-scale energy-intensive sources that were the focus of other co-benefits perspectives [23]. Scientists stressed that strategies targeting co-benefits for the mitigation of both SLCPs and long-lived GHGs were needed to achieve ambitious climate targets [10].

The most recent perspective highlights that policy measures usually have multiple positive and negative effects or co-impacts for climate change, air pollution, and many other development objectives [24–28]. An example illustrating these multiple effects is the closure of coal-fired power plants. The shutdown of these plants could result in job losses, despite other environmental and societal gains from controlling pollution and climate change. Expanding the system boundaries of the analysis to include concerns such as jobs could allow for mapping the benefits flowing from the different interventions to the overarching goals such as improved well-being [15]. Packaging different policies in wider sustainable development strategies could maximize complementarities and minimize conflicts across the different development objectives, which would become clearer with a greater emphasis on co-impacts [29].

2.2. Surveying the Policy Landscape

International, regional, national, and local policy frameworks can help promote the integration between climate and air pollution. Though studies note this promise, the global and regional policy frameworks potentially supporting that integration often struggle to realize it [30]. This shortfall is partially attributable to the evolution of institutions and political pressures that have limited the scope of these frameworks to single impacts and one of the above reviewed co-benefits perspectives (e. g. focus on either climate or air quality), while precluding recognition of complementarities with others (see Table 2). This tendency has resulted in the policy landscape evolving into a patchwork of institutions and initiatives that dissolve some divisions between air pollution and climate change even as they create new divides in their place—for example, a limited understanding of how climate finance mechanisms could support the mitigation of SLCPs.

Table 2. Degree to which key processes support different views on co-benefits. 'XX' indicates that the indicated perspective is particularly strong in the given context and 'X' demonstrates only a moderate manifestation.

Process/Initiative	Frame 1: Development Co-Benefits	Frame 2: Climate Co-Benefits	Frame 3: Air Pollution Co-Benefits	Frame 4: Co-Impacts
UNFCCC	X	XX	X	X
SDGs	X	X		XX
CCAC	X	X	XX	
CLRTAP			XX	
Arctic Council			XX	
ASEAN Haze Agreement			X	
EANET			X	
Latin America Air Pollution Initiatives			X	

2.2.1. Global Agreements and Initiatives

The United Nations Framework Convention on Climate Change (UNFCCC) is the highest-profile international climate agreement promoting some degree of integration between climate change and air pollution. At the most general level, this connection is evident in repeated references in the UNFCCC and related decisions to mitigating climate in the context of sustainable development. This language was initially operationalized in the project-based finance mechanism under the Kyoto Protocol known as the Clean Development Mechanism (CDM). One of the CDM's two main objectives was to help developing countries achieve sustainable development objectives such as cleaner air and improved health. Many CDM projects made good on this promise—though there was not as much attention to systematically assessing air pollution and other impacts as GHG reductions [22]. The Green Climate Fund, a newer addition to UNFCCC climate finance architecture, also calls for proposals to highlight environmental co-benefits, including air quality improvements, in the wider programmes it helps finance. However, there is not a systematic analysis of these air quality or downstream health effects [31].

Another area where there has been traction in the UNFCCC involves the air pollution or SLCP perspective. Among the six GHGs the UNFCCC covers, methane is also an SLCP and a precursor of the air pollutant tropospheric ozone. Although the Kyoto Protocol did not recognize methane's effect on air quality, the Paris Agreement offers broader framing that refers to "greenhouse gas emissions" (Article 4(1)) without specifying particular gases, and in principle allows for the inclusion of other pollutants such as black carbon [32]. Further, since 2018 the IPCC has held meetings on the integration of short-lived climate forcers (SLCFs) into the international climate regime that could have implications for reporting and national actions [33]. In addition, since countries submit their own mitigation pledges in the form of Nationally Determined Contributions (NDCs) to the UNFCCC as part of the Paris Agreement, these pledges can include air pollutants (such as black carbon) that warm the climate—though only three countries have addressed black carbon in the first round of NDCs submitted in 2016 [34].

A further international framework that could support greater integration between climate change and air pollution is the 2030 Agenda on Sustainable Development and its 17 Sustainable Development Goals (SDGs). The global community agreed to the SDGs and its supporting 169 targets (beneath the 17 goals), which are intended to offer countries an integrated and indivisible framework for development over a 15-year period. The SDGs include one goal focusing exclusively on climate change (SDG 13) and health (SDG 3) as well as targets related to air pollution under the health, sustainable cities (SDG 11), and responsible consumption and production (SDG 12) goals. Co-benefits between climate change and air pollution have also been included in national SDG strategies and plans as well as Voluntary National Reviews (VNRs) that approximately 40 countries present each year during an annual meeting called the High Level Political Forum [35]. Similar to the NDCs, the VNRs are a country-driven effort to contribute to a global process but are distinct in that they cover a wider range of objectives than the NDCs.

In addition to these regulatory frameworks, initiatives with a more voluntary character can push the integration between air pollution and climate change. An example for such a global initiative is the Climate and Clean Air Coalition (CCAC). Formed in 2012, the CCAC has grown to more than 120 state and non-state partners committed to mitigating SLCPs. The United Nations Environment Programme (UNEP) serves as the CCAC secretariat and helps partners work with solution-specific hubs that allocate resources for SLCP projects in particular countries and regions [4]. With its focus on SLCPs, nearly all of the CCAC activities aim to advance an integrated approach to air pollution and climate change (chiefly consistent with framing co-benefits from an air pollution perspective); however, they also consider benefits in other areas, such as health, food security, or improved livelihood (co-impacts) [36]. As part of its activities, the CCAC has supported the development of a series of SLCP national action plans in more than 20 countries. Some of these plans and other CCAC activities have been linked to the process under the UNFCCC, such as the introduction of SLCPs into the countries' NDCs. For instance, with support from the CCAC, Mexico has included black carbon in its NDC. At the same time, one of the main reasons the CCAC was formed was to tackle those pollutants that are not covered by the UNFCCC.

2.2.2. Regional Agreements and Initiatives

Although national and local governments are chiefly responsible for regulating air pollution, several regional instruments and frameworks have emerged to address its transboundary effects [37]. These regional air pollution agreements exemplify another set of frameworks for potentially promoting the integration of air pollution and climate change.

The longest running regional air pollution agreement with this potential is the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and particularly the most recent of its eight protocols, the Gothenburg Protocol. Covering commitments from the European Union, Canada, and the United States, the original 1999 Gothenburg Protocol addressed tropospheric ozone pollution (*by including emission ceilings for tropospheric ozone precursors, namely, nitrogen oxides and volatile organic pollutants. Note that tropospheric ozone is a secondary air pollutant, meaning that it is not emitted directly; it is formed in the atmosphere* via *photochemical reactions of its precursors*), and its 2012 amendments include a science-based goal of reducing black carbon. Despite its relevance for both air quality (as a precursor to tropospheric ozone) and climate, the CLRTAP has stopped short of directly addressing methane emissions, opting for language in its long-term strategy specifying that the ongoing review of the Gothenburg Protocol "should consider" steps to reducing emissions of methane as an ozone precursor [38].

In addition, the Arctic Council has increasingly focused on climate and especially SLCP-related problems. Arctic country members and associated constituencies such as indigenous peoples' associations, who are especially affected by the environmental changes in the region, have implemented work streams and expert groups on SLCPs, especially black carbon and methane, are listed among its priorities [39].

There are also several regional agreements and initiatives in Asia with the potential to strengthen air pollution and climate integration. The ASEAN Agreement on Transboundary Haze, for instance, targets reductions in the burning of forests and biomass that could also help reduce emissions of black carbon—though the agreement does not reference climate change. The East Asia Acid Deposition Network (EANET) has focused on improving the monitoring of pollutants that contribute to acid rain and deposition in North and Southeast Asia, but might include $PM_{2.5}$ in future reforms [40]. The Asia Pacific Clean Air Partnership (APCAP) hosts a science panel of leading experts on air pollution in Asia that provides advice to countries and convenes a joint forum to act as an umbrella for all of the key air pollution initiatives in the region (including EANET and the ASEAN Haze Agreement) [3]. The long-range transport of air pollutants in Northeast Asia (LTP) is a two-decade old initiative with a scientific emphasis on improving the monitoring and modeling of air pollution in Asia and the Pacific [41]. Last but not least, the Asian Subregional Programme for Environmental Cooperation (NEASPEC) is an intergovernmental cooperation framework addressing environmental challenges in Northeast Asia, including air pollution. Working chiefly in Mongolia and Russia, it has focused on coal fired power plants in the past. NEASPEC more recently created the North-East Asia Clean Air Partnership (NEACAP) to promote science-based, policy-oriented cooperation on air pollution [42] Due in part to political sensitivities, there are few explicit references to climate change in the relevant documents, operational rules, and work programmes covered by the above agreements and initiatives. Nonetheless, there is potential for these agreements to facilitate increased integration between air pollution and climate change concerns as they help exchange knowledge and experiences between governments, and awareness of the potential for co-benefits continues to increase.

There have also been regional efforts to tackle the transboundary effects of air pollution in Latin America. In 2009, The Forum of Ministers of Environment of Latin America and the Caribbean established the Intergovernmental Network on Atmospheric Pollution, mandated to facilitate cooperation and capacity building and coordinate regional and subregional initiatives to manage atmospheric pollution in the LAC region. Through this cooperation, the Forum of Ministers adopted a Regional Action Plan for Intergovernmental Cooperation on Air Pollution for Latin America and the Caribbean, established in 2014. The Action Plan is the first ever regional air pollution agreement covering the LAC region and includes explicit recognition of SLCPs in terms of both air quality and climate change policies and the regions' countries support each other voluntarily and share information to identify and assess sources of pollutants and their impacts on human health and the environment, including the climate system. Since its adoption, the Action Plan and Network have languished due to limited resources and competing regional priorities, but in February 2021, the Forum of Ministers called for the Network to be re-established and the Action Plan to be updated by the end of 2021 [43].

Many countries and some cities have also incorporated a more integrated perspective in climate, air pollution, and sustainable development. Notable examples include China's pathway towards improving air quality, which in parallel achieves significant GHG reductions and further co-benefits [44–47]; India's references to co-benefits in its national climate change strategies [48]; the recognition of links between air pollution and climate change in Mongolia's Voluntary National Review; and the publication of the SLCP action plans in countries ranging from Ghana to Mexico to the Philippines. In addition, significant action is taking place at the local level and cities such as Santa Rosa have considered incorporating co-benefits into their climate plans.

3. Strengthening the Science–Policy Interface

The previous section showed that some global and regional agreements and initiatives have recognized and provided support for co-benefits from more integrated policies. On balance, however, the regional and international policy landscape is itself fragmented. The global and regional fragmentation has arguably limited integration between air pollution and climate change at the national and local levels. A related reason for this fragmentation—and for co-benefits not gaining traction within countries—is the weakness of national science–policy interfaces [26,49–51]. Researchers have attributed this weakness to divisions within both different scientific disciplines as well as policymaking processes and governance arrangements [26]. This section discusses the gaps between the atmospheric, climate, and social sciences and then turns to a similar disconnect in policymaking processes and governance arrangements. It closes by recommending reforms that can help bridge these divides.

3.1. Divisions in Science

One reason research may not translate into policy is the inherent complexity of the interrelated effects on air pollution and climate science. This requires researchers to acquire a more holistic perspective that extends beyond a particular disciplinary expertise. To illustrate, while pollutants such as black carbon contribute to near-term warming, black carbon is a component of fine particulate matter, which also contains other components, some of which have a cooling impact such as sulfates. Because warming and cooling pollutants are emitted from the same sources, strong air pollution control scenarios could lead to a net warming—but simultaneous stringent climate mitigation, including methane mitigation, could alleviate this warming [52]. Hence, crafting a policy that curbs warming requires an understanding of the net impacts from all co-emitted pollutants. A related illustration of this difficulty involves the growing understanding that particulate matter pollutants affect cloud formation which, in turn, influences warming [53]. This adds complexity when evaluating the aggregate effect of particulate matter on climate. Perhaps most centrally, the effects of more GHG- and SLCP-centered perspectives on co-benefits have not received as much attention as needed given complementarities for climate change, air quality, and other priorities—issues often operating at varying temporal and spatial scales.

Another set of divisions separates the climate and atmospheric scientific communities. Some climate scientists still take a "climate-first perspective" that downplays the importance of co-emitted air pollution, while the air pollution community can similarly constrain the scope of their inquiry. This is partially due to practical constraints: climate models and air pollution models are typically complex and computationally intensive. Adding even more complexity to these models requires expertise and increased computational resources, which may not be justified depending on the research goals. Nonetheless, an implication of these often inadvertent disciplinary blinders is that some models are better suited to climate change or air pollution, but not both. In a similar vein, many models leave out benefits or impacts outside of air pollution and climate change that may weigh more heavily in policy decisions, such as job creation and loss.

Last but not least, as implied in the Introduction, some researchers have noted the lack of engagement of policy-related disciplines in the work on integrated solutions to air pollution and climate change [26]. In highlighting this gap, they point out that this research draws upon a combination of natural sciences and energy modelling; however, it does not draw as extensively on insights and analytical tools from social scientists and humanities to determine how the results of that modeling enter into policies. Fortunately, some observers such as Mayrhofer and Gupta (2016) have provided reviews of the relevant literature and suggest that sociologists, geographers, anthropologists, lawyers, and political scientists could add valuable inputs in this regard [16]. The next subsection begins to draw on the insights from governance and policy research to better understand those possible contributions.

Perhaps the most important division sits at the intersection of science and governance and involves limited engagement of policymakers with scientists. Scientists may have limited channels to share recent research and data with policymakers. This disconnect is likely to be most problematic in an area where there is a frequent and consistent need to update policymakers on new findings. Research on the interactions between climate change and air pollution exemplifies such a dynamic area of inquiry.

3.2. Divisions in Governance

Divisions between air pollution and climate change are not limited to science and research, but also influence policy and governance. The most readily apparent divisions are horizontal in nature, i.e., the sometimes "siloed" separation between administrative departments responsible for air pollution and for climate change. This horizontal division has its roots in the historical evolution of air pollution and climate change as two (perceived) separate environmental problems. In the United States and Western Europe, air pollution gained attention as a negative side effect of industrialization during the 1950s due to high-profile episodes such as the London Smog of 1952 [54] and the Donora, Pennsylvania Smog of 1948 [55]. In Japan, air pollution emerged as a concern during the late-1960s and early 1970s when Yokkaichi asthma was one of the big four environmental crises that triggered major shifts in national environmental policies and institutions [56,57]. Anthropogenic climate change, on the other hand, first emerged as a concern in the late 1970s [58,59] and did not gain a foothold in policy until the establishment of the Intergovernmental Panel on Climate Change (IPCC) and UNFCCC more than a decade later.

For many countries, these different timelines have meant that departments responsible for air pollution were already established when climate change was introduced as a "separate" issue. Given this institutional evolution, the responsibility for climate change was typically assigned to its own unit within government ministries and agencies, while budgeting, reporting, monitoring protocols, and other standard operating procedures differed across administrative units. Even if different agencies, divisions, or enlightened individuals are willing to work past these differences, institutional divisions may further diminish human resource and financial capacities to do so.

A related possibility is that a power imbalance between different divisions—for example, if the climate division receives more funding than the air quality division or vice versa—could reinforce myopias and sectionalism. This siloing can even create a competitive relationship wherein different divisions compete for financial resources or political support for their own particular set of issues. At worst, different agencies may turn inward to protect their own areas of work, setting off difficult-to-resolve interagency turf wars. Inter-institutional competition and coordination challenges are likely to be greatest in countries where capacities to tackle even one issue are already limited [60].

Often the lack of horizontal integration is aggravated by a lack of vertical integration or the separation between decision making at the international, national, and subnational levels. Because air pollution and climate change operate on different geographic scales, air pollution has traditionally been addressed by national and local policies. This division of labor has proven effective in many contexts: a significant number of countries have achieved improvements in air quality since the 1970s. In contrast, climate change has been perceived chiefly as a global issue: the long-lived nature of CO_2 and other well-mixed GHGs means that local emissions result in global rather than local impacts. This is, of course, the reason that the UNFCCC, Kyoto Protocol, and Paris Agreement are the main institutional homes for climate policy: climate mitigation requires global collective action.

This spatial dichotomy—of air pollution as a local problem vs. climate change as a global problem—has nonetheless become increasingly blurred. This is partially due to scientific advancements, which have highlighted the important role of transboundary air pollution as well as the impacts that SLCPs can have on regional as well as global climate [61]. The fading of vertical divisions is also attributable to more cities and subnational governments capitalizing on their relatively greater flexibility to adopt innovative climate solutions [62]. Efforts from national governments to provide the financing and other enabling reforms for spreading and scaling local "good practice" climate solutions are another encouraging sign of multi-level integration [63]. However, working across multiple levels on climate and air pollution still tends to be the exception more than the norm. Perhaps even more so than horizontal cleavages, issues related to budgeting, reporting, and monitoring protocols and standard operating procedures can dissuade agencies at different levels from vertical cooperation on multiple issues at once.

In addition to the within-government challenges, a failure to meaningfully engage and include civil society, non-governmental organizations, and the private sector can limit integration across related policy areas. More inclusive institutions and decision-making processes, though often requiring more time and resources, could generate more support for integrated solutions. This is particularly true if that process uncovers a more diverse collection of benefits and creates a stronger sense of ownership among a broader group of stakeholders and constituents.

4. What Would a One Atmosphere Approach Look Like?

The review of global and regional agreements and initiatives as well as the discussion of divisions within and between science and policy suggest that advancing integrated solutions requires addressing several need areas. These include a greater effort to work across different international and regional climate and air pollution agreements. For instance, those focused on air pollution and SLCPs could engage more with those involved in the UNFCCC processes. They also entail researchers working across scientific disciplines. For example, climate scientists could be given more opportunities to interact with researchers that see co-benefits as fitting within a broader sustainability or co-impacts perspective.

While greater integration of international and regional processes and relevant science are needed, arguably the most important reforms involve governance arrangements and decision-making processes at the national level. This section describes the main building blocks of a One Atmosphere approach (see Figure 1) to outline key national level reforms: (1) strategically timing and continually incorporating an integrated vision into decision-making processes; (2) gradually opening opportunities for multi-level and multi-stakeholder cooperation; and (3) supporting that vision and cooperation with standardized metrics and assessment methods.

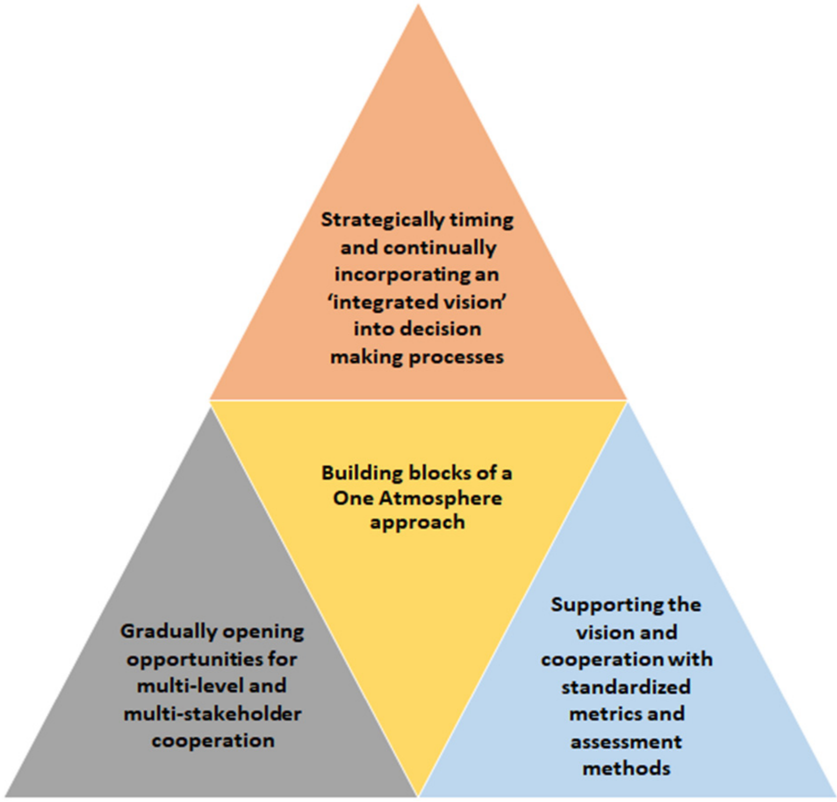

Figure 1. Building blocks of a One Atmosphere approach.

4.1. Continually Incorporating and Strategically Timing the Introduction of Integrated Visions

Arguably the first step in translating a more integrated understanding of climate change and air pollution into policies are integrated visions. More integrated visions help demonstrate the interconnections between climate, air quality and other sustainable development priorities; they will also likely elicit greater support if they explicitly identify which policies and measures deliver which co-benefits. They should not, however, stop at identifying the featured policies and benefits. Instead, they should be placed in a broader, opportunity-oriented narrative that illustrates which policies bring which benefits to which stakeholders [64]. The vision and narrative that clearly demonstrate both benefits and beneficiaries of particular actions are likely to boost support for decisions needed to put that vision into motion.

Another way to generate support for greater integration is to continually introduce and update the vision during relevant decision-making processes. The success of Nigeria's National Action Plan on SLCPs was partially attributable to efforts to build that vision into different stages of decision making [65]. More concretely, in Nigeria an integrated vision was presented in the initial data gathering and scientific consultations, then was highlighted as the data and science were employed to identify benefit-maximizing policy and measures, and was subsequently shared during the multi-agency coordination that set the stage for the formal adoption and implementation of the National Action Plan on SLCPs [65,66]. The consistent use of this shared vision can strengthen ownership of the outcomes of the process.

A related suggestion for building policymaker and political support involves the timing of the introduction of an integrated vision. In many cases, a severe crisis or an international event can open a window of opportunity for significant policy changes. For example, the Chinese governments made considerable efforts to strengthen air pollution policies in the lead up to the 2008 Beijing Olympics and then strengthened related policies again in the wake of sharp increases in PM2.5 in 2012 and 2013. Crises, such as the recent COVID pandemic or exogenous shocks can bring the problem to the attention of the public and may limit the influence of powerful industries and interests that would have a financial stake in blocking substantial reforms. Facing such exceptional circumstances, policymakers might also be more receptive to new directions in policy, and adopt more integrated, co-impact centered measures that address both air pollution and climate change at the same time. These political considerations suggest that the timing of the introduction of a new vision may be as important as their substantive content.

4.2. Reforming Governance to Encourage Interagency Collaboration and Multi-Stakeholder Cooperation

An additional step forward involves enhancing the horizontal integration between climate and air pollution. Greater cooperation, coordination, and information exchange are foundational elements of a One Atmosphere approach. However, this does not necessarily mean that every government should immediately consolidate their current climate and air pollution divisions into a single supra unit. Such an abrupt shift could be impractical in contexts where the capacity to work on a single issue is already limited. It may also be undesirable to staff who perceive a sweeping overhaul to be threatening to their budgets or job security. Such modest shifts could include interagency task forces, staffing rotations that build multi-disciplinary expertise, joint capacity-building activities, standardized reporting protocols, and tagging public budgets for multiple goals.

A related approach to horizontal integration could focus on building trust and creating understanding by working together on a strategic policy or plan. Concentrating on a particular policy or plan could enable staff within relevant agencies/divisions to identify context-appropriate reforms that pave the way for greater integration in other sets of policies and plans. For instance, the decision for Ghana to install a special authority to coordinate SLCPs that functions as the focal point for cooperation among government institutions as well as other stakeholders grew from an effort to develop a National SLCP Action Plan [67]. The proposed policy or plan that is used to build this trust and cooperation is likely to vary across countries. In some contexts, working on an overarching SDG plan may help agencies tasked with climate change and air pollution portfolios identify mechanisms facilitating cooperation. In others, cooperation on a NDC may be a more workable entry point. In the above examples, such as Nigeria and Ghana, the opportunity to collaborate in one concrete area leads to support for some of the suggested modest institutional changes.

Yet another way to build support for a One Atmosphere approach is to enhance vertical integration. This can entail helping to align climate and air pollution policies at different levels of decision making, from the national to the local governance level. In practice, this may mean setting broader enabling policies at the national level that encourage cities and local governments to implement innovative co-benefit solutions. For example, national governments may create incentives for cities to improve their inspection and maintenance programs for heavily polluting vehicles. Fiscal transfers that help local governments pilot and then spread successful examples of local innovation can inspire other governments to follow suit.

Working across and between levels of government may not be the only important step; the inclusion of diverse stakeholders should complement that step. Many of the integrated solutions will impact jobs, energy costs, and livelihoods. Actively engaging with affected communities, communicating benefits but also soliciting concerns about uneven distributional impacts, can help account for these effects. Mechanisms that bring in civil society and affected publics can enrich policymaking and bolster implementation while also anticipating and managing trade-offs [65]. This can be achieved through multiple channels, ranging from community meetings to public comment (and response) periods to e-governance initiatives (such as government websites that encourage citizen input and interactive exchanges). For example, in Nigeria, the development of the National Action Plan to reduce SLCPs was set in an extensive multi-sectoral consultive process. Key stakeholders were included in a mix of informal and formal meetings, e.g., peer-review workshops and advisory groups, in order to strengthen acceptance and gather broad support for the SLCP mitigation measures proposed in the plan [65].

Of all of the areas, engagement of the scientific community is arguably the most critical. Consistent integration of science and other experts can build the mutual understanding and trust essential for more integrated approaches to policymaking. Some studies make this point by underlining that policymakers need to be continually engaged in the modelling and assessment process [26]. Others note that institutional and structural changes, including formal scientific advisory meetings and a regular set of less formal consultations, are crucial additions to the policymaking landscape. As with many of the reforms, efforts to integrate science into decision-making processes can help strengthen institutional cooperation and vice versa. In all of the above cases, there is a risk that the suggested reforms can prolong decisions. Thus, the possible advantages of the suggested reforms need to be weighed carefully against the increased transaction costs of arriving at a consensus.

4.3. Supporting Integrated Visions and Institutional Cooperation with Standardized Metrics and Assessment Methods

Common metrics, methodologies, and improved modeling approaches are an important enabler of a One Atmosphere approach, as they allow communities to develop a common understanding of problems and create the conditions for policy coherence. This will require increased collaboration among climate and atmospheric scientists as well as effective communication at the science–policy interface to ensure the common approaches deliver policy-relevant information. Standardized sets of data support assessment of the impacts and benefits of different policy options. This can avoid and mitigate tradeoffs between climate, air quality, and other development policy goals, while achieving co-benefits. For example, national emissions inventories that include not only greenhouse gases but all climate-forcing and air pollutants (e.g., black carbon and ozone precursors) unlock the ability of policymakers and planners to assess co-emitted air pollutants and related public health and development impacts. Recognizing the importance of integrated national inventories, in 2019 the IPCC agreed to develop a methodology report for including short-lived climate-forcers in national inventories [68].

In 2019, Ghana published its 4th National Inventory Report to the UNFCCC and included emissions of ozone precursor gases, SLCPs, and air pollutants. Although only required to report emissions of greenhouse gases, Ghana noted that the additional substances are crucial because they "enhance the utility and relevance of the results beyond climate change to the impacts of SLCPs and air pollution on human lives, agriculture productivity, ecosystems, and sustainable development" [69]. However, common data, while a necessary prerequisite for integrated management, are not a guarantee that such approaches are implemented. Implementation prospects increase, when policymakers have ownership of the data and understand the models and tools that can use the data to shape policy. One good example of this is the LEAP Integrated Benefits Calculator (IBC) tool, which is used for national action planning on SLCPs and can strengthen connections between data and policymaking. It calculates the benefits that can result from the implementation of SLCP mitigation strategies on a country level [70]. These benefits include health benefits, ozone impact on crops, and global temperature change [70].

Further, models and scenarios should continue to be improved to better support a One Atmosphere approach and the needs of policymaking. Concretely, this could include the consideration of qualitative impacts and data into the assessments, a more general reduction of complexity and the development of simplified models, the integration of insights from practical case studies and experiences [26], as well as local scale co-benefits analyses that can inform specific policy circumstances [71]. This would support policymakers in taking up information released by science and strengthen knowledge that can directly complement policymaking.

Also, separate administration of climate and air quality topics can require more coordination, communication, and information efforts. The decarbonization of the economy will generally reduce emissions of both CO_2 and air pollutants. However, if emissions data are collected by two different government divisions, they may be inconsistent. Emissions data management needs to be coordinated and possibly harmonized. Insufficient flow of information from one division to the other may lead again to conflicting policies, and a different accounting of emissions reductions.

While common and integrated metrics, methodologies, and improved modeling approaches will not guarantee a One Atmosphere approach is achieved, the lack of integration can serve as a powerful barrier or disincentive to multiple-benefit policymaking. For example, the decision by European governments in the 1990s to introduce tax incentives to encourage drivers to shift from petrol to diesel vehicles has produced such negative implications. The financial incentives were put in place because of potential long-term climate benefits of lower CO_2 emissions per liter from diesel, but without accounting for the near-term air quality and public health impacts, and despite the existing knowledge that diesel vehicles produced more NOx and particulate emissions than petrol.

5. Reflections and Way Forward

Climate change and air pollution are two of the most critical sustainability challenges facing society today. They are closely related: the major sources of CO_2 emissions are the most significant sources of air pollution. Integrated approaches on policymaking for climate and air quality can not only yield manifold co-benefits ranging from health to energy and food security, but they also can enable policy decisions that are more cost effective and coherent and that increase efficiency. Integrated approaches can prevent poor decision making based on incomplete information and help build confidence and support for mitigation actions and justify the allocation of resources.

Integrative policymaking is gaining traction as policymakers in many regions of the world are becoming more aware of a co-benefits-based perspective. Most notable are international initiatives such as the Climate and Clean Air Coalition, which has a focus on multiple benefits; however, international, regional, and national frameworks also represent opportunities to include all climate, air quality, and development impacts (and benefits).

Yet, when compared to the amount and variety of co-benefits science promises, and whose harvesting available scientific methods and technologies would allow, policymaking is still lacking. The co-benefits approach has not been applied in governance practices sufficiently. While part of the problem can be found in the science–policy–civil society interface, such as in communication and information deficits, other challenges lie in the lack of interdisciplinary approaches and of research rooted in the social sciences that analyzes governance circumstances or behavioral conditions specifically. Additionally, a glimpse into political practices shows that many governance routines are not conducive to integrative and co-benefits-oriented policymaking. These governance related aspects require more research and would benefit from case studies that show examples of how integration and multiple benefits can be realized.

Further, this paper proposes a One Atmosphere approach with a few practical recommendations. First, an integrative vision that takes into account multiple co-impacts and is placed in a broader, opportunity-oriented narrative can not only build the basis for a more sustainable policy, but it can also gain stronger support from stakeholders. Crises or international events such as the recent COVID pandemic may represent a window of opportunity for introducing integrated co-benefits-based perspectives.

Second, governance reforms, including greater cooperation, coordination, and information exchange, are a first step towards integrative policymaking. They do not necessarily have to imply the consolidation of climate and air pollution governmental agencies, but modest changes can be essential. For example, stronger vertical integration at different levels of decision making can reveal synergies if national policies also enable cities and local governments to implement innovative co-benefit-based solutions. Also, continuous stakeholder consultation is essential to guarantee the information flow among all constituents and gain support for the integrated policy approaches.

Third, common metrics, methodologies, improved modeling approaches, and standardized sets of data not only guarantee the effective assessment of the impacts and benefits of different policy options, but they also help to mitigate tradeoffs between climate, air quality, and sustainable development requirements. Models could be simplified and tailored according to the needs of policymaking, for example, through including qualitative data into the assessments, gained from insights from practical case studies and experiences.

However, practical experience with integrative policymaking has shown that national and local circumstances vary significantly with respect to their political structures, economic capacities, or development priorities and therefore there is no "one-size-fits-all" One Atmosphere approach. A One Atmosphere approach will need to be adopted according to each jurisdiction's needs. For such individual solutions, stakeholder involvement, policy entrepreneurs who push for integration, and international institutions that can provide technical and monetary assistance and guidance are crucial.

That being said, a cautious note can be made about the term "integration". Integration has recently become somewhat of a "buzzword" in politics and policy. More integration, both horizontal, across policy fields, and vertical, across government levels, also means increased complexity. For governance, this is also tied to a risk of overburdening policies and policymakers. In a similar manner, international and regional frameworks, such as the UNFCCC or CLRTAP have their limits, as they will not be able to include solutions to all possible co-impacts and development needs, also in order to avoid too many overlaps with existing regulations.

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