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The co-impacts of climate action in cities

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Abstract

As more cities embark on climate-neutral trajectories, it is important to understand how actions will impact all stakeholders in a city: citizens and industry, as well as government agencies operating at the regional and national level. Here we offer an overview of scientific literature exploring the co-impacts of climate action in urban settings, both positive and negative. Additionally, we introduce a classification framework for structuring such co-impacts in Swedish cities. Our study reveals a predominant focus in the literature on the positive effects of climate action, neglecting potential adverse impacts. We find a pressing need to specify which city actors stand to benefit from specific climate interventions and which may be adversely affected. By understanding and addressing these impacts, cities can enhance the social acceptability of climate plans, facilitating their quicker implementation.

Keywords

Climate-neutral cities; co-impacts; climate action; governance

1. Introduction

Rising greenhouse gas emissions create unliveable conditions in cities worldwide, ranging from floods to heat waves, droughts and unbearable air pollution levels. Under the EU Mission for Climate-Neutral and Smart Cities, 112 cities pledged to become climate-neutral by 2030, i.e., achieving net-zero emissions or reducing emissions through behavioural change and energy efficiency investments and balancing the remaining emissions released to the atmosphere with negative emission solutions (European Commission, 2022). In Sweden, the Viable Cities Strategic Innovation Programme (SIP) aims at "Climate Neutral Cities 2030 with a good life for all within the boundaries of the planet" and supports at present 23 cities, representing 40% of the Swedish population (Viable Cities SIP, 2024).[1]

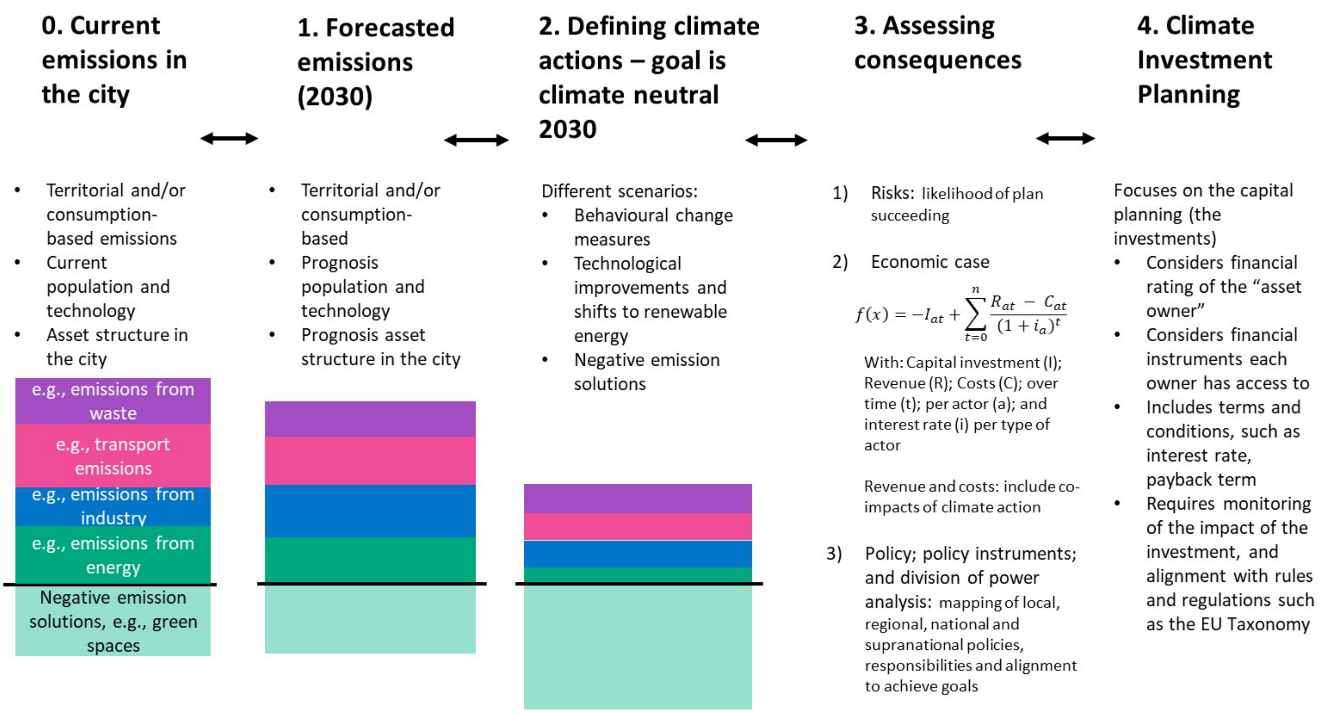
The methodology designed to meet climate neutrality under both the EU and Viable Cities programs consists of three components: (1) cities agree to a climate city contract that details their commitment to achieving climate neutrality by 2030; (2) cities design a climate action plan describing the measures to achieve climate neutrality; and (3) cities put forward a climate investment plan detailing how the capital needed for their climate action plan will be raised and allocated to decarbonize physical assets and build out infrastructure in support of climate neutrality within the city. Climate actions can be behavioural change measures, such as lowering indoor temperature or cycling and walking instead of using private vehicles; technological improvements and shifts to renewable energy, including investments in solar and wind energy, and upgrading appliances; and negative emission solutions, such as building carbon sinks, green spaces, and carbon capture and storage technologies.

Figure 1 shows the iterative approach for designing climate action and investment plans. The approach consists of five steps: understanding current emission profiles and sources of emissions; forecasting emissions to 2030; designing climate actions in line with the 2030 climate neutrality target; assessing the consequences of the climate action plan (i.e., the risks associated with the plan, the economic case for the plan, and the policies governing the plan); and finally the design of an investment plan that details the financial instruments, terms and conditions of the investments put forward in the climate action plan.

Throughout this process, substantial attention is given to the local context in which the climate action plan is developed. For example, in Step 0, an inventory of all assets in the city is made, including an overview of the owners of these assets. An assessment is also made of the emissions across sectors, allowing to identify where climate action is needed. In Step 3, following the design of the climate action plan, further consideration is given to the local ecosystem: here, the aim is to uncover who will be impacted by the climate action in the city, what level of support they can, and want to, provide for the climate action plan, and whether any incentives are required to stimulate support for the climate action plan. Without the sign-off from all actors in the city (citizens, industry, supraordinate government levels, civil society and financial actors), the implementation of the climate action plan will fall short.

1 As of 2025, Klimatneutrala städer 2030 | Viable Cities works with 48 cities.

Figure 1. Overview climate action and investment planning methodology



Source: Vanhuyse (2023)

1.1 Addressing co-impacts

In this working paper, we introduce research on the co-impacts of climate action, with a specific focus on cities. Co-impacts of climate action are the positive and negative, intended and unintended consequences that may arise from climate action policies (Markkanen & Anger-Kraavi, 2019). We do so for several reasons.

First, conversations on climate action in cities often highlight the positive consequences but fail to consider negative, oftentimes unintended consequences, in particular related to equity and equality (Luderer et al., 2019; Markkanen & Anger-Kraavi, 2019; Mayrhofer & Gupta, 2016; Sovacool et al., 2019; Vanhuyse et al., 2022; Wuyts & Marin, 2022). The term co-benefits has also been linked to incremental measures, which do not address the root causes of climate change (Mayrhofer & Gupta, 2016; Puppim de Oliveira, 2013). More ambitious policies could be warranted, in particular following an assessment of equity considerations: much research has found that polluting industries and highways are oftentimes located in poorer areas, and green spaces ample in richer areas (Bulkeley et al., 2014; Gould & Lewis, 2012; Kabisch & Haase, 2014; Wolch et al., 2014).

With our overview, we aim to draw attention to potential drawbacks of climate action in cities and point out how climate action could negatively impact communities. This broader approach also aligns with discussions on enhancing urban resilience against the impacts of climate change, extending beyond mere decarbonization policies (Boyd et al., 2022; Pont et al., 2021).

Moreover, considering the full scope of impacts is essential for minimizing the risk of policy backlash and ensuring sustained public support. In addition, it enhances policy efficiency (Grafakos et al., 2020) by identifying synergies and helps prevent distorted policymaking and goal misalignment (Alfredsson & Karlsson, 2016).

Finally, we aim to provide some insight into the classification and potential quantification of co-impacts, which is challenging (Puppim de Oliveira, 2013; Puppim de Oliveira et al., 2015), informing the co-impacts calculation in the Viable Cities Finance Dashboard (Vanhuyse et al., 2023). This dashboard supports Swedish municipalities with their climate action and investment planning, by showcasing the emission reductions possible following the selection of climate action measures and calculating the Net Present Value of the selected climate action measures. In the Net Present Value calculation, co-impacts are considered, alongside capital expenditure, operational expenditure, savings and revenue (see Vanhuyse, 2023, for the methodology; and Vanhuyse et al., 2023, for the dashboard user guide).

In Section 2, we briefly describe how the concept of co-impacts has evolved over time. Then, based on a literature review, an analysis of 23 cities' climate plans and a workshop with Swedish cities, we summarize the co-impacts found in these documents in Section 3. We end with some concluding remarks in Section 4.

2. Evolution of the concept

The concept of co-benefits has evolved over time. Starting with "secondary benefits", the IPCC defined these in the 1990s as "reductions in other pollutants jointly produced with greenhouse gases and the conservation of biological diversity" and "improved air quality, better protection of surface and underground waters, enhanced animal productivity, reduced risk of explosions and fire, and improved use of energy resources" (IPCC, 1995, pp. 50; 52), and "co-benefits" or "ancillary benefits" in the early 2000s (IPCC, 2001). More recently, the IPCC defined co-benefits as "the positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare" (IPCC, 2014, p. 121). It focused solely on the positive implications of climate policy on other societal goals.

Recent reports on climate action in cities highlight the importance of co-benefits in a positive light, with sustainable behaviours and energy efficiency being two of the most cited (Bachra et al., 2020). Johanson's analysis of 33 climate action plans from 27 C40 cities found that most references related to exposure, followed by equity, health co-benefits and health effects. However, these overviews reveal a lack of comprehensive analysis of potential adverse effects following climate action. Because cities are dynamic and diverse, co-benefits and mitigation actions vary by city priorities. Therefore, deeper analysis is needed to understand who benefits and the potential negative impacts. (See also Ürge-Vorsatz et al., 2014, for a reassessment of the terminology and recommendations for frameworks to incorporate climate action co-benefits into economic outcomes and more.)

Table 1. Examples of co-benefits in cities' climate, transport and infrastructure projects reported in city documents and other literature

City, country	Co-impact	Source
Adelaide, Australia	• Costs savings to residents • Improved energy affordability for residents and business reported • Improved liveability	(Bachra et al., 2020)
Copenhagen, Denmark	• Transport costs • Security • Comfort • Branding of the city – positive reputation • Tourism potential • Transportation times • Public health	(COWI and Københavns Kommune, 2009)
Helsinki, Finland	• Health benefits • Air quality improvements • Noise reduction	(City of Helsinki, 2018)
Indianapolis, US	• Equity • Health benefits • Net job creation • Potential to reduce greenhouse gas emissions	(City of Indianapolis, 2019)
Kampala, Uganda	• Cost savings for residents • Creation of green jobs • Air quality improvements	(Bachra et al., 2020)
León de los Aldama, Mexico	• Improving air quality	(Bachra et al., 2020)
New York, US	• Reduced air pollution related deaths • Reduced healthcare spending	(Johnson et al., 2020)

In this working paper, we consider all co-impacts, including negative, perhaps unintended, consequences of climate action in cities, given that transition processes have been found to often have negative consequences as well (see, e.g., Markkanen & Anger-Kraavi, 2019, for a review of social impacts; Luderer et al., 2019, and Sovacool et al., 2019, on decarbonization; Vanhuyse et al., 2022, on circular economy transitions). Our definition of co-impacts from climate action in cities is any positive or negative, intended, or unintended consequence on "people, planet and profit", resulting from tackling greenhouse gas emissions in cities. This incorporates both territorial emissions (i.e., the ones produced within the geographical boundary of the city) as well as consumption-based emissions, where the final point of consumption is considered and not the production point of the greenhouse gas emissions.

Expanding the scope to incorporate also negative impacts of climate action at the city level aims to raise awareness on equity considerations of climate action, and helps to pinpoint potential resistance against climate action.

3. Literature review of co-impacts in cities

Here we provide an overview (Table 2) of the most reported co-impacts of climate action in cities from our qualitative scientific literature review, organized according to a review of the climate action plans of the 23 Swedish cities that are part of Viable Cities (Appendix 1).

Our scientific literature review was not systematic, but instead consisted of a search in Scopus, using the following search string on article title, abstract and keywords:

> "city" OR "cities" OR "urban" OR "municipal" OR "local government"
> AND
> "Co-impact*" OR "co-benefit*"
> AND
> "climate action"

This resulted in a corpus of 53 articles, which were screened for relevance. Furthermore, targeted searches were conducted on specific climate action strategies outlined in the climate action plans of 23 cities. These searches encompassed various initiatives, including but not limited to car-free days, congestion charges, reduced parking spaces, densification, urban farming and green spaces. We acknowledge that a more systematic mapping could be warranted, potentially even measuring the effect of each climate action in a meta-review, to inform decision-makers of the weight of each action. However, due to the difficulties in quantifying co-impacts (Puppim de Oliveira, 2013; Puppim de Oliveira et al., 2015), that might not lead to a robust assessment.

In addition, we reviewed the climate action plans of the 23 cities that are part of SIP (Appendix 1). This review categorizes seven main action areas (buildings; consumption, material use and waste management; energy; finance and management; land use and urban planning; negative emission solutions; and transport) and common measures and policy instruments (e.g., decarbonizing transport and retrofitting buildings.) which the municipal government, citizens and/or industry can implement. Measures related to agriculture are allocated to the land use and urban planning category as there were few examples of agriculture within the city. Industrial actions were allocated to different categories, including buildings (construction); material use and waste management (manufacturing); and transport (heavy machinery and logistics). Some climate action measures are less covered (e.g., mining, fossil fuel plants) as the focus of this brief is urban environments and not rural areas.

Co-impacts are organized according to the Triple Bottom Line (Elkington, 1994), into "people, planet and profit" categories. The planet impacts category entails contributions to other environmental goals, such as reducing water and soil pollution. For this, the planetary boundaries system (Steffen et al., 2015) was chosen, given its comprehensiveness, and it can be applied to cities. More specifically, the framework defines a safe operating space for human communities to flourish and prosper, within a set of nine planetary boundaries of biophysical processes that regulate the stability of the Earth's conditions that have been beneficial for human development over millennia.

The people category accounts for social impacts, such as health improvements or protection, job creation and impacts related to civic participation, fears and aspirations, and overall equity and equality (see, e.g., Vanclay et al., 2015 for an overview of social impacts). And the profit category entails economic consequences, including macroeconomic indicators such as Gross Domestic Product (GDP) and innovation (Slaper & Hall, 2011). While we acknowledge the critique put forward that GDP and profit motives may conflict with staying within planetary boundaries (see Haberl et al., 2020), this categorization was chosen because it aligns with the prevailing circumstances in cities. Specifically, policymakers often prioritize economic benefits (Bedsworth & Hanak, 2013; Carter & Culp, 2010; Chu, 2016). Consequently, we contend that driving action requires crafting compelling arguments tailored to these economic realities (de Nazelle et al., 2021). Geopolitical impacts were allocated to the profit category, and these include energy security and resource depletion, as stability related to these sectors should contribute positively to the economy.

Following Karlsson et al. (2023), we recognize that concepts such as "reduced air pollution" and "improved health" are closely interconnected, yet they are assigned to separate categories within the framework (planet and people, respectively). Job creation, in turn, can be allocated to the categories of people and profit. It is important to acknowledge the overlaps and interdependencies between these categories to ensure a more comprehensive understanding of the co-impacts of climate action in cities. Co-impacts were categorized as unclear when the empirical results in the scientific research were inconclusive.

In Table 2, we summarize the positive and negative impacts of climate action, as well as areas where the impacts remain unclear. Our review highlights that the existing literature predominantly focuses on the positive effects of climate action in cities, often overlooking potential adverse effects. The emphasis is primarily on health-related benefits and environmental improvements.

Additionally, as shown in the table, we found a significant gap in the literature concerning the identification of specific actors within the city who are positively or negatively impacted by climate action, and the distributional aspects within stakeholder groups. Notably, there is insufficient consideration of spatial planning (the context of climate action implementation) and social consequences (who bears the burden or enjoys the benefits).

In the following section, we present selected climate action strategies from Table 2 that are frequently highlighted in Swedish climate action plans for their potential to deliver multiple benefits. We also discuss their associated trade-offs, as reported in the scientific literature.

Climate actions in cities contribute to reducing greenhouse gas emissions, improving air quality, decreasing material consumption, and enhancing land use efficiency. Key strategies, such as energy-efficient buildings, renewable energy adoption and sustainable transport, alongside urban planning measures such as limiting urban sprawl and promoting densification, play a critical role in enhancing urban sustainability. However, these strategies also present various challenges.

Two examples highlight the importance of balancing climate action strategies with careful planning to mitigate potential adverse effects. Urban densification – one of the most commonly implemented climate action strategies in Swedish cities – illustrates such challenges. If not carefully planned, densification can exacerbate the urban heat island effect by reducing green spaces and surface permeability, leading to increased cooling demands and associated health risks. Additionally, a reduction in permeable surfaces can elevate flood risks.

Another widely adopted climate action by local governments in Sweden is the promotion of natural materials, such as timber, in construction. While this approach has the potential to reduce emissions, it also raises concerns about environmental impacts, particularly deforestation.

Climate actions also significantly impact social well-being by improving public health, reducing air pollution, and promoting physical and mental health. However, these benefits are not always equitably distributed. Economic disparities can limit access to green technologies and sustainable transport, which are often unevenly available across a city. In Sweden, densification is promoted in climate plans to foster social sustainability by strengthening community bonds and interactions (see Pont et al., 2021). However, research suggests that it may inadvertently lead to adverse effects, such as reduced wellbeing, fewer social interactions, weakened community ties, increased epidemic risks, and greater heat vulnerability.

Lastly, the economic impacts of climate actions have also been highlighted, albeit to a lesser extent in the reviewed literature. Several studies emphasize reduced public health expenditures resulting from improved air quality and increased physical activity due to active transportation. Moreover, climate policies aimed at facilitating the transition to a circular economy have been argued to yield potential economic advantages. These include reduced dependence on global supply chains, positive contributions to GDP and innovation, and the creation of new employment opportunities in sectors such as reuse, repair and recycling. However, such initiatives may pose challenges to traditional "linear" economic models, underscoring the necessity of ensuring a just and equitable transition. Some scholars have also expressed concerns about the quality of jobs within the circular economy, questioning whether job creation is truly a co-benefit of the transition (Clube, 2022; Vanhuyse et al., 2022).

Overall, while climate action offers substantial benefits across environmental, social and economic dimensions, careful planning and holistic approaches are necessary to mitigate potential adverse effects and ensure equitable outcomes.

Table 2. The co-impacts of climate action in cities

Climate action strategy	Planet	People	Profit
Buildings – focus on reducing energy consumption and greenhouse gas emissions associated with the construction, maintenance and operation of buildings			
Retrofitting existing buildings or building new green buildings	**Positive** • Improved air quality • Reduced energy consumption • Reduced greenhouse gas emissions **Unclear** • Impact of material consumption (retrofitting) • Waste management from construction/ retrofitting	**Positive** • Reduced internal and external noise • Improved health: reduced vulnerability to extreme heat events, reduced winter mortality, increased thermal comfort, improved indoor air quality, improved mental health • Energy cost reductions for people living in fuel poverty • Improved educational equality, as poor housing quality impacts educational achievement, affecting job prospects and increasing poverty risk **Unclear** • Equality – increased housing or rental prices • Could improve nutrition and household relationships by addressing fuel poverty **Negative** • If retrofitting is done improperly, it may increase the risks from indoor air pollution, damp or summertime overheating.	**Positive** • Energy cost savings • Increased property value • Operational cost reduction • Job creation and business opportunities **Unclear** • High initial investments • Return on investment timeline
Increase use and production of natural building materials (timber and wood)	**Positive** • Reduced emissions from carbon sequestration through use of wood in construction • Reduced construction and operational emissions, including those from heavy vehicles • Reduced carbon dioxide (CO_2) in material production • Lower strain on freshwater resources during material production • Enhanced air quality throughout the production process • Reduced ecological toxicity • Reduced ozone depletion from the production process **Unclear** • Reduced smog potential • Reduced acidification potential • Concerns about potential deforestation and the depletion of global forest resources, particularly primary forests	**Positive** • Improved health from the use of natural building materials in buildings (e.g., decrease in blood pressure, reduced skin conductance, greater short-term memory, and decrease in negative emotions, improved autonomic nervous system, respiratory and visual systems and reduced tension and fatigue) • Minimized noise and dust pollution on-site construction • Better thermal conductivity due to high air tightness	**Positive** • Cost savings due to reduction of on-site labour and speed of construction • Growth in the green building market **Unclear** • Increased costs, as challenges related to durability; fire risks relative to conventional building materials; negative impacts of climate change on timber buildings, such as the risk of rot decay, increasing mould problems and the possibility of the spread of termites • Cost of material • Skilled labour shortage

Table 2. cont.

Climate action strategy	Planet	People	Profit
Consumption, material use and waste management – focus on reducing environmental impacts and promoting sustainable practices			
Circular economy strategies, including the sharing economy (furniture, textiles, sports equipment) and improving waste collection systems	**Positive** • Reduced material and energy use • Reduced greenhouse gas emissions • Land use minimization (e.g., through better waste management) • Reduced contamination of soil and waterways (e.g., through better waste management) **Negative** • Rebound effects, e.g., increased transport • Energy and material use during the recycling process • Environmental waste due to material degradation during the recycling process (e.g., batteries)	**Positive** • More affordable products • Creation of new forms of employment **Unclear** • Impact on personal and property rights, in particular on the sharing economy (e.g., who owns the goods and how is insurance shared) • Impact on health, e.g., through material degradation • Cultural resistance to change in some communities **Negative** • Access to services, e.g., when they are spatially located in an area where people have limited access • Quality of employment generated	**Positive** • Lower dependency on supply chains • Contribution to GDP and innovation • Municipal cost savings (due to high cost of waste and landfill management) • New business opportunities (e.g., reusing, repairing and recycling) **Negative** • Job losses – in "linear" sectors
Change in diet (e.g., reducing the intake of food from animal sources, reduction of red and processed meat)	**Positive** • Reduced sludge, and land and waterway contamination • Reduced land use • Reduced greenhouse gas emissions from livestock • Reduced water, energy, and land consumption (increase in plant-based diet)	**Positive** • Diets with low greenhouse gas emissions can have significant potential co-benefits for health, potentially reducing the risk of various diet-related diseases **Negative** • Equity in policy – strategies for promoting low-emission foods must be inclusive across all socio-economic groups • Food quality – not all low-emission foods are nutritious • Nutrient concerns – vegan diet, if not carefully planned, may lack vital nutrients like B12, choline and calcium	**Positive** • Reduced reliance on imports (animal feeds) • Emerging opportunities in plant-based diet market **Unclear** • Impact on the economy and GDP

Table 2. cont.

Climate action strategy	Planet	People	Profit
Energy – focus on transitioning to renewable energy sources, improving energy efficiency, and reducing energy consumption			
Increased production and uptake of renewable energy (e.g., wind, solar, hydrogen, biofuel)	**Positive** • Improved air quality • Reduced greenhouse gas emissions • Reduced extraction and use of fossil energy **Unclear** • Material use and end-of-life disposal of technologies • Land use requirements – on existing infrastructure or new exploitation • Water and energy use for energy production **Negative** • Increase in the extraction of critical raw materials	**Positive** • Improved health • Stabilize energy expenditure for households **Unclear** • Affordability of technologies at household level • Equality – location of these technologies (which neighbourhood renewable technologies are implemented in, and who benefits or bears the burden of the technology) • Rights questions – extraction of critical raw materials • Land use change for biofuels could raise food costs and affect food security, altering agricultural practices and availability	**Positive** • Reduced reliance on oil and gas imports • Stabilizes energy budgeting and reduces vulnerability to geopolitical events • Potential GDP contribution through energy exports • Decreased costs associated with air pollution damage • Job opportunities • Financial savings • Long-term cost-effectiveness of initial investments **Unclear** • Challenges in the supply chain to ensure stable growth in the renewable energy sector **Negative** • Comparatively high initial investment needed • Increasing variable renewable energy in the grid poses challenges to maintaining secure energy supply • Land use change for biofuels could impact food security negatively
Installing district heating and cooling systems (including heat pumps) and phasing out fossil fuels	**Positive** • Improved air quality • Reduced greenhouse gas emissions • High efficiency gains due to centralized management and advanced technologies. • Reduced material consumption due to the adoption of the district heating system **Negative** • Increased land use and construction emissions from the infrastructure development	**Positive** • Cushion against heating costs • Improved health	**Positive** • Cost savings **Unclear** • Job creation and business opportunities (e.g., reduced maintenance of pipelines could lead to job loss)
Pricing – increased energy prices aimed at reducing consumption of energy	**Positive**: • Reduced energy and material consumption • Reduced greenhouse gas emissions	**Unclear** • Equality – impact of price hikes on lower socio-economic groups	**Unclear** • Impact on the economy and GDP
Application of the Best Available Technologies, including energy-efficient appliances,	**Positive** • Improved air quality • Reduced energy consumption • Reduced greenhouse gas emissions **Unclear** • Environmental cost of production and e-waste disposal	**Positive** • Health improvements **Negative** • Accessibility and affordability issues	**Positive**: • Long-term cost savings • Market growth for energy-efficient products • Increased productivity by reducing absenteeism and improving the health and wellbeing of workers. • Energy security due to reduced reliance on oil and gas imports **Negative** • High initial investment

Table 2. cont.

Climate action strategy	Planet	People	Profit
Finance and management (managing the municipal government) – focus on allocating resources towards sustainable practices and investing in green infrastructure			
Investing (i.e., placing capital) in climate-neutral and climate positive funds (divesting from fossil fuels)	**Positive** • Depending on the focus of the fund: all planetary boundaries • Decrease in activities related to environmental degradation	**Positive** • Improved health • Enhance community resilience • Job creation	**Positive** • Innovation • Impact on the economy and GDP • Cost savings due to reduced pollution damage **Negative** • Rapid shift may affect the jobs in fossil fuel industry
Land use and urban planning – focus on designing cities and managing land to minimize environmental impact, incorporating green spaces, and energy-efficient urban design			
Removing parking spaces	**Positive** • Land use minimized	**Positive** • More affordable housing	**Unclear** • Impact on the economy and GDP (depending on land use)
Densification of buildings	**Positive** • Land use minimized. • Reduced greenhouse gas emissions **Unclear** • Urban areas exhibit reduced overall biodiversity compared to rural areas. Yet, while higher local density negatively impacts biodiversity, it may have positive effects on a regional scale **Negative** • Increased risk of urban heat island effect due to lower permeability, population density and lower tree canopy cover • Problems related to water management due to scarcity of permeable surfaces for surface water runoff • Increased levels of dissolved inorganic nitrogen fluxes • Urban development and higher population densities poses a threat to the provision and quality of recreational (green) areas	**Positive** • Improved health due to increased active travel • Property value is positively affected by density (positive for owner-occupiers) **Unclear** • Traffic safety and decreased risk of injury • Increased population density correlates with a surge in housing prices potentially having an impact on low-income households **Negative** • Higher risk of epidemics and heat vulnerability • Most studies using life satisfaction indicators indicate densification negatively impacts wellbeing • Despite expectations, social interaction is negatively linked to density, with fewer neighbourly interactions in high-density areas • Reduced sense of 'community,' including perceptions of safety and stability	**Positive** • Higher productivity and innovation due to economy of scale • More public finances due to lower per-capita cost of offering services

Table 2. cont.

Climate action strategy	Planet	People	Profit
Negative emission solutions – focus on technologies and nature-based solutions that actively remove and sequester carbon dioxide from the atmosphere			
Technological solutions, such as Carbon Capture and Storage (CCS)	**Unclear** • Impact on the environment (with the storage of the carbon) • Reduction in atmospheric CO_2 level	**Positive** • Improved health from the CO_2 reduction • Creation of new jobs **Negative** • Nuisance from the CCS installations, e.g., the installation of more pipes to store the carbon somewhere could create an issue with acceptability	**Positive** • Innovation
Nature-based solutions, including increased green space	**Positive** • Improved air quality • Noise reduction • Reduced urban heat island effect • Enhanced biodiversity • Improve water quality by reducing soil erosion and preventing pollution runoff **Unclear** • Carbon markets may incentivize the establishment of high-density tree plantations, which can lead to ecological imbalances and exacerbate the risk of drought-induced conditions and wildfires.	**Positive** • Improved health due to Increased physical activity • Improved mental health, reduced anxiety and stress • Increased social engagementAesthetic benefits, enhancing the quality of life for nearby communities • Protect culturally significant sites and structures, preserving heritage and identity **Unclear** • Concerns arise regarding the disproportionate impact of CO_2 removal efforts on vulnerable communities, emphasizing the need for equitable distribution of benefits and risks across all sectors and communities.	**Positive** • Attracting tourism • Reduced cost due to improved health **Negative** • Urban trees, while often improving air quality, can also trap traffic-related pollution, potentially worsening local air quality.
Enhancing urban food systems (urban farming, community gardens and allotments)	**Positive** • Reduced food waste • Improved air quality • Stormwater retention **Unclear** • Fertilization levels, and impact on biodiversity (depending on farmed crop and farming system) • Effect of reduced food waste (if food waste to energy) • Biodiversity impacts	**Positive** • Improved health through, e.g., reductions in depression, anxiety, satisfaction, quality of life, sense of community and through improved nutrition and lower body mass index • Cost savings for citizens **Unclear** • Equality – environmentally friendly food can be more expensive	**Positive** • Local sufficiency • Contribution to GDP

Table 2. cont.

Climate action strategy	Planet	People	Profit
Transport – focus on creating a more sustainable and low-carbon transportation system			
Shift from private motorized transport towards public and active transport (e.g., cycling and walking), including through the build out of walking and cycling pathways, and public transport systems).	**Positive** • Improved air quality • Reduced carbon emissions • Land use minimized (freeing parking spaces) • Potential to recycle old cars – reduced material consumption • Reduced noise pollution • Improved urban landscape	**Positive** • Improved health due to reduced obesity, improved wellbeing, less respiratory diseases and increased physical activity • Economic savings due to active travel • Reduced traffic injuries • Reduced congestion • Activation of public space • Enhanced social connectivity • Enhanced equity due to improvements in air quality, particularly in socio-economic challenged areas, can positively impact child cognition, potentially boosting educational outcomes **Unclear** • Impact on health inequalities: limited research on the distribution of health benefits and risk across space and population groups. Increased cycling can have varying health benefits due to dispersed spatial risk (e.g., concentration of PM2.5 and crash risk) • Work-life balance (positive if combined with working from home; potentially negative if public transport system not functioning) **Negative** • Walkers and cyclists' exposure to air pollution • Accessibility for people with disabilities	**Positive** • Healthcare savings and productivity (e.g., reduced sick days) • Labour market – increased accessibility, especially for business trips and travellers)
Restricting car use within cities (e.g., car-free days, zones or parking management).	**Positive** • Noise reduction • Reduced carbon emissions • Improved air quality	**Positive** • Health improvement • Reduced construction cost creating opportunities for more affordable housing • Reduced traffic injuries • Reduced congestion • Enhanced equity due to improvements in air quality, particularly in underserved areas, can positively impact child cognition, potentially boosting educational outcomes	**Unclear** • Impact on the economy and GDP • Reduced cost from injuries **Negative** • Converting a neighbourhood to a low traffic zone could cause about half of the traffic to divert to other routes, leading to exposure disparities in outdoor air pollution level.
Sharing initiatives **(Shared mobility and smart working)**	**Positive** • Improved air quality • Land use minimized (freeing parking spaces) • Efficient use of vehicles • Reduced carbon emissions	**Positive** • Cost savings (associated with vehicle ownership) **Unclear** • Equality – providing access to socio-economic challenged families to a motorized vehicle when needed • Equality – no access to certain schemes (e.g., public bicycle sharing initiatives) in socio-economic challenged neighbourhoods while more highly educated and young people are represented	

Table 2. cont.

Climate action strategy	Planet	People	Profit
Transport – focus on creating a more sustainable and low-carbon transportation system [cont.]			
Electrification of transport, including private vehicles, public transport, logistics and heavy machinery	**Positive** • Noise reduction • Reduced carbon emissions • Improved air quality **Negative** • Material consumption (e.g., batteries) • Increased demand for electricity • Electric vehicles still contribute to non-exhaust emissions (e.g., brake and tyre wear, road surface wear, and resuspension of road dust).	**Positive** • Improved health due to improved air quality **Unclear** • Affordability of the electrified vehicle	**Positive** • Innovation • Economic opportunity in green technology **Unclear** • Energy provision and geopolitical connection • Contribution to GDP
Pricing mechanisms – increased (e.g., price of parking; congestion charge)	**Positive** • Improved air quality • Reduced noise pollution • Reduced carbon emission	**Positive** • Improved health due to reduced air pollution and increased physical activity • Improved traffic safety • Equality – decrease in absences of students with low economic status in schools due to improved air quality (better overall health and better attendance) • Improved traffic flows less congestion **Unclear** • Equality – impact of price hikes on lower socio-economic groups • Health impacts from increased active travel	**Positive** • More public finance • Savings because of related health impacts from reduced air pollution **Unclear** • Some studies suggest that there is negative effect on labour market because it reduces accessibility, yet others point to the opposite: that it increases accessibility especially for business trips travellers. • Effects on retail

Sources: (Abed et al., 2022; Aunan et al., 2006; Backholer et al., 2021; Barthel & Isendahl, 2013; Barton & Pretty, 2010; Bedsworth & Hanak, 2013; Bergman et al., 2010; Bernstein et al., 2010; Blanchard et al., 2023; Börjesson & Kristoffersson, 2015; Brochu et al., 2022; Buonocore et al., 2016; Bush et al., 2007; Butt et al., 2018; Capon et al., 2009; Casey et al., 2008; Clucas et al., 2018; Coutts et al., 2010; Creutzig et al., 2012; Daunfeldt et al., 2009; De Borger, 2009; de Hartog et al., 2010; Duncan, 2011; Farzaneh et al., 2019; Ferreira et al., 2017; Ferrero et al., 2016; Fishman, 2016; Fisk, 2000; Fuller et al., 2011, 2011; Gibson, 2013; Gittleman et al., 2017; Glazener et al., 2022; Glazener & Khreis, 2019; Glotz-Richter, 2016; Gössling & Choi, 2015; Grabow et al., 2012; Grahn & Stigsdotter, 2010; Guitart et al., 2012; Hallström et al., 2015; Harlan & Ruddell, 2011; Hartig, 2008; Himes & Busby, 2020; Hoeben et al., 2023; Holm et al., 2012; Jennings et al., 2020; Johansson et al., 2009; Kaplan & Kaplan, 2003; Kendrovski & Schmoll, 2019; Kent, 2014; Kleeman et al., 2013; Krishnamurthy & Ngo, 2020; Kuo, 2001; Lampard et al., 2023; Larsson et al., 2011a,b; Litman, 2011; MacNaughton et al., 2018; Maizlish et al., 2013; Mölenberg et al., 2019; Monni & Raes, 2008; Nowak et al., 2006; Ogilvie & Goodman, 2012; Pont et al., 2021; Rabbitt & Ghosh, 2013; Rojas-Rueda et al., 2011, 2011; Rose et al., 2019; Saidur et al., 2011; Sakieh et al., 2017; Shakya, 2016; Sharifi, 2021; Silva et al., 2022; Soga et al., 2017; Song et al., 2007; Springmann et al., 2016; Sugar & Webb, 2022; Taboada et al., 2021; Taylor & Howden-Chapman, 2021; Tsoutsos et al., 2005; Tupenaite et al., 2023; Ulrich, 1981; Vandenberghe & Albrecht, 2018; Villeneuve et al., 2012; Wiser et al., 2016; Wolch et al., 2014; Wolkinger et al., 2018; Woodcock et al., 2009, 2014; Xia et al., 2015; Yin et al., 2018; Yip et al., 2013; Zhang et al., 2017)

4. Concluding remarks

In this working paper, we summarize research on the co-impacts of climate action in cities. We found multiple positive consequences of climate action in cities, in particular through reduced air pollution, more active travel that does not create emissions, and improved health. Yet insufficient consideration of spatial planning and of the social consequences of who bears the burden or enjoys the benefits of climate action could lead to unjust and incremental improvements only, instead of transformative climate action.

We therefore recommend a solid analysis of the co-impacts, including potential adverse effects, of climate action, including incorporation of socio-economic and spatial analysis. In addition, the evidence base on the quantification of co-impacts should be improved, allowing policymakers to consistently assess these in policymaking.

Appendix 1. List of cities and documents analysed

City	Document(s)	Reference(s)
Borlänge	• Miljöstrategi 2021-2030	(Borlänge, 2021)
Borås	• Energi- och klimatstrategi • Miljöprogram • Klimatrapporten	(Borås, 2020) (Borås, 2022) (Borås, 2018)
Enköping	• Hållbarhetspogram Myran • Enköpings kommuns hållbarhetslöften	(Enköping, 2019) (Enköping, 2023)
Eskilstuna	• Fördjupning av fokusområden klimatpogram Eskilstuna	(Eskilstuna, 2021)
Gävle	• Miljöstrategiskt program 2.0	(Gävle, 2020)
Göteborg	• Göteborgsstad miljö och klimatpogram • Fossilfritt Göteborg – vad krävs?	(Göteborgs Stad, 2021) (Miljöförvaltningen, 2018)
Helsingborg	• Klimat och energiplan för Helsingborg	(Helsingborg, 2018)
Järfälla	• Klimat och energiplan • Miljöplan 2023–2030	(Järfälla, 2020) (Järfälla, 2022)
Kalmar	• Handlingsplan – Fossilbränslefri kommun 2030	(Kalmar, 2019)
Karlstad	• Handlingsplan för energi och klimat	(Karlstad, 2023)
Kristianstad	• Klimat- och miljöplan 2023–2027	(Kristianstads kommun, 2023)
Linköping	• Klimat- och energiprogram för Linköpings kommun 2022–2030	(Linköping, 2022)
Lund	• Klimatneutrala lund – att göra • Lunds kommuns program för ekologisk hållbar utveckling	(Lunds kommun, 2021) (Lunds kommun, 2022)
Malmö	• Malmö energistrategi 2022–2030 • Malmö trafik och mobilitetsplan • Malmös mötes och rese policyplan • Kretsloppsplan 2021–2030	(Malmö Stad, 2022) (Malmö Stad, 2016) (Malmö Stad, 2020) (VA SYD, 2021)
Mariestad	• Beslutad strategi för Agenda 2030	(Mariestad, 2021)
Nacka	• Genomförandeplan för strategin för miljö- och klimatambitioner i stadsutvecklingen	(Nacka Kommun, 2019)
Skellefteå	• Klimat och energiplan N/A	Working document, not official yet
Stockholm	• Klimathandlingsplan 2020–2023 Beslutat av kommunfullmäktige 2020-05-25 För ett fossilfritt och klimatpositivt Stockholm 2040	(Stockholm Stad, 2020)
Umeå	• Åtgärdsprogram för Umeå kommuns miljömål 2022–2025	(Umeå kommun, 2022)
Uppsala	• Miljö- och klimatprogram • Handlingsplan för miljö och klimatpogram	(Uppsala kommun, 2022a) (Uppsala kommun, 2022b)
Växjö	• Hållbara Växjö 2030 Ansvar – Nytänkande – Resultat • Transportplan för Växjö kommun • Energiplan för Växjö kommun • Plan för förebyggande och hantering av avfall 2020–2025 – På väg mot ett Småland utan avfall • Träbyggnadsstrategi för Växjö kommun	(Växjö kommun, 2019) (Växjö kommun, 2019) (Växjö kommun, 2021) (Södra Smålands & Avfall och Miljö AB, 2020) (Växjö kommun, 2018)
Örebro	• Klimatstrategi för Örebro kommun. Mål och delmål för 2020 och 2030	(Örebro kommun, 2016)
Östersund	• Klimatprogram Färden mot ett fossilbränslefritt och energieffektivt Östersund 2030	(Östersunds kommun, 2023)

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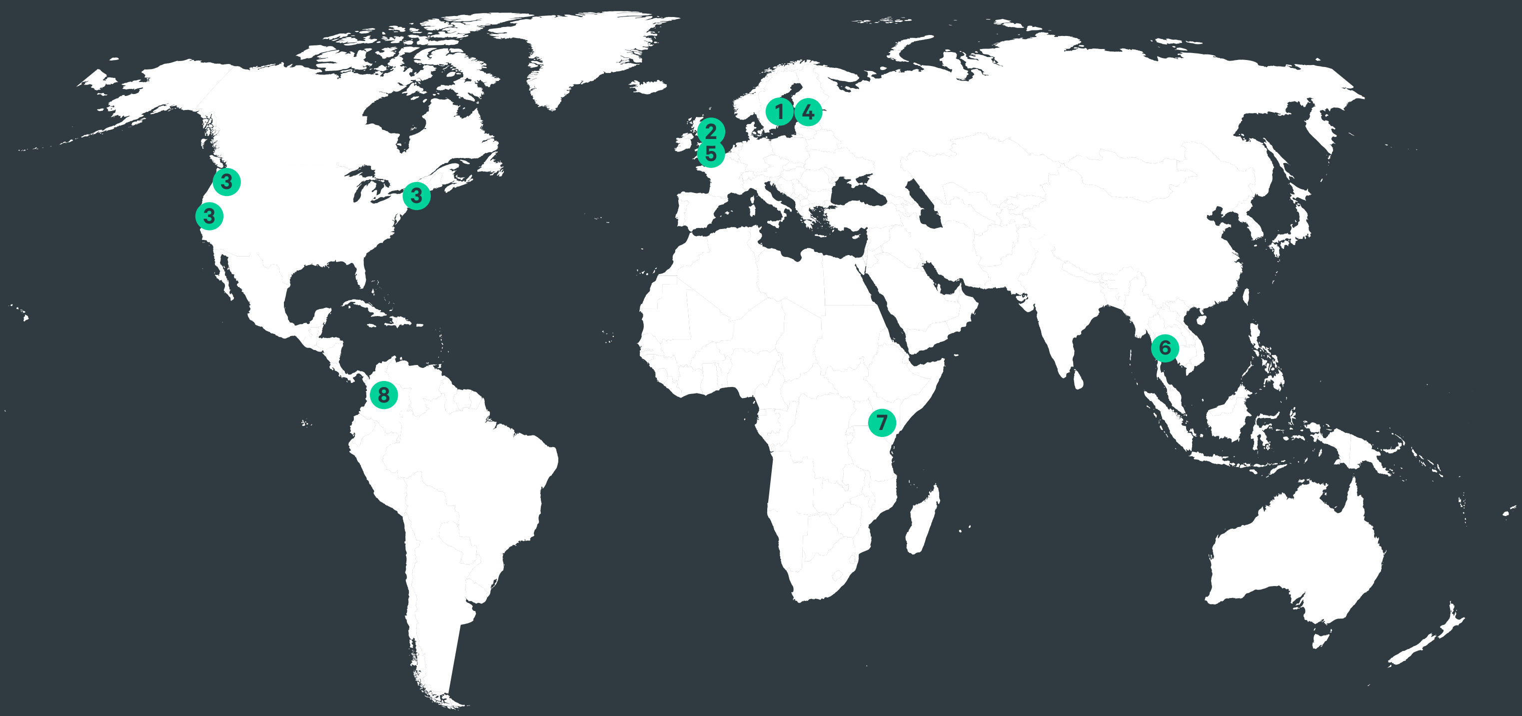

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