FLIP the Script

The Free, Local, Immediate, and Persuasive Co-Benefits of Climate Action

A New Framework to Catalyze Local Climate Solutions

2025

AUTHORS

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Chartered in May of 2021 at the George Washington University, the Climate and Health Institute is a university-wide collaboration that prioritizes cross-disciplinary research, training, and action to advance solutions and opportunities that mitigate the harmful effects of climate change on human health. The Institute envisions an evidence-based global response by governments and stakeholders to mitigate the climate crisis and equitably improve public health, and works to achieve this vision at the local, national, and global level through policy-relevant, multidisciplinary, and community-oriented research; tailored educational offerings; and research communication and translation.

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DESIGN

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KEY TERMS

Greenhouse Gas (GHG)
Gases that trap heat in the Earth's atmosphere, raising the temperature of Earth's surface. Excess GHG emissions cause climate change.

Decarbonization
The reduction or elimination of GHG from a system or process.

Climate action
Policies, programs, and projects that mitigate climate change by reducing GHG emissions.

Climate mitigation
Avoiding or reducing GHG emissions to prevent further climate change.

Co-benefits
The large and diverse range of societal benefits associated with climate action that are additional to the benefits conferred through avoided climate change-related risks.

FLIP Co-benefits
Co-benefits of climate action that are Free (benefits exceed costs), Local (benefits occur locally to action), Immediate (benefits are incurred immediate to action), and Persuasive (benefits are politically relevant) (FLIP).

Air pollutants and GHGs

- ***PM*** *= Particulate matter*
  - ***$PM_{2.5}$*** *= PM less than 2.5 micrometers in diameter*
  - ***PM_{10}*** *= PM less than 10 micrometers in diameter*
- ***CO*** *= Carbon monoxide*
- ***CO_2*** *= Carbon dioxide*
- ***CO_2e*** *= Carbon dioxide equivalent - standardized unit used to compare warming potential of different GHGs*
- ***CH_4*** *= Methane*
- ***NO_x*** *= Nitrogen oxides*
  - ***NO*** *= Nitric oxide*
  - ***NO_2*** *= Nitrogen dioxide*
- ***N_2O*** *= Nitrous oxide*
- ***SO_x*** *= Sulfur oxides*
  - ***SO_2*** *= Sulfur dioxide*
- ***O_3*** *= Ozone*
- ***VOCs*** *= Volatile organic compounds*

EXECUTIVE SUMMARY

Climate change mitigation, while a global challenge, requires local action to be successful. To reduce global greenhouse gas (GHG) emissions in the amount and scope required to halt the climate crisis, individual nations and subnational governments must develop and implement their own emissions reduction strategies. This responsibility creates a fundamental challenge for decarbonization: helping local communities and governments understand why **climate actions –** policies, programs, and projects that mitigate climate change by reducing GHG emissions – should be prioritized in the face of competing social and economic demands. The perceived disconnect between local investment costs and the distant, inchoate global benefits of GHG reduction creates barriers to implementing climate mitigation strategies at the local level. For these reasons, many have found that **the "primary challenge" of local climate action is persuading local policymakers to elevate GHG reduction amid competing local demands.**[1]

This report addresses the challenge of local climate action by reframing these actions in terms of the **free, local, immediate, and persuasive (FLIP) co-benefits** they can provide to the communities that implement them:

FREE – Climate action provides a net positive return on investment when all societal benefits are accounted for, as the value of improved public health, reduced energy costs, increased economic opportunities, and additional co-benefits far exceed upfront costs.

LOCAL – Climate action has many co-benefits, such as improved air quality, worker health and safety, and increased resilience, that are realized locally, providing benefits to residents in the community that implemented the action.

IMMEDIATE – Climate action has co-benefits, such as job creation, improved diet and nutrition, and reduced commuting times, that are realized relatively promptly upon implementation, as distinct from global, long-term climate impacts associated with reductions in GHGs.

PERSUASIVE – Climate action creates benefits that align with core local priorities unrelated to climate, such as promoting economic growth, protecting public health, and reducing inequality, making the action compelling to policymakers and the public.

By emphasizing that climate change mitigation is not just a global imperative, but a force-multiplying solution to localized economic, health, social, and environmental challenges, **FLIP provides a framework for recognizing and articulating the full value of climate actions, highlighting their broad, immediate, and strategic value beyond emissions reductions, with the ultimate goal of catalyzing action at the local level.**

This report builds on a growing body of work focusing on the **co-benefits of climate action –** the large and diverse range of societal benefits associated with climate actions that are additional to the benefits conferred through avoided climate change.[2] Our landscape analysis of currently available co-benefits resources identified several gaps including a need for tailored resources for diverse stakeholders, such as journalists and researchers, and for real-time, ex-post data on health, economic, and other action-specific outcomes. The FLIP framework was developed to address some of these needs, in particular by bringing focus to locally-realized co-benefits. To provide stakeholders with additional useful resources to catalyze action, a non-comprehensive list of reports, tools, and case studies in the co-benefits space are compiled in a **Co-Benefits Landscape Review.**

FLIP In Action

In this report, we apply the FLIP framework to 22 global case studies across 6 sectors – **POWER, BUILDINGS, TRANSPORT, FORESTS & LAND, FOOD & AGRICULTURE,** and **INDUSTRY** – to inform and inspire replication. These case studies show how climate actions, particularly those co-designed with affected communities, have delivered immediate, local benefits that align with community priorities. These case studies inform the **FLIP Co-benefits Taxonomy**, a comprehensive index of FLIP co-benefits linked to climate actions, which builds upon the C40 Cities' Climate Action Impacts Taxonomy.

POWER

Power generation is the largest source of global GHG emissions, primarily due to our continued reliance on coal and fossil fuels. As electricity demand grows, shifting to clean energy sources like wind and solar is essential. Projects like **Jack's Solar Garden** in Colorado, **Block Island** in Rhode Island, and DC's **Solar for All** program show how these shifts provide FLIP benefits like income for farmers, lower utility bills for low-income residents, and improved local air quality that make clean energy transitions broadly popular once their community value is realized.

BUILDINGS

The building sector contributes significant carbon emissions both through direct fuel use and indirect energy consumption. While emissions reduction strategies such as net-zero construction and efficiency retrofits are often seen as costly, such investments pay off through energy savings, health improvements, and job creation. Examples like **Ecuador's transition to induction stoves** and **Madison's building retrofits** show that building decarbonization reduces illness and improves comfort, making it a health, economic, and climate win.

TRANSPORT

Transportation is a major source of global emissions, with the majority share coming from road transport. Reducing car travel through investments in public transit, cycling, and pedestrian infrastructure lowers emissions and boosts health and quality of life. Cities like **Mexico City, London,** and **Paris** have demonstrated that sustainable transport policies and programs can reduce air pollution, shorten commutes, and revitalize local economies. These promptly realized, visible benefits are supported by data showing that long-term savings outweigh costs.

FORESTS & LAND

Land use changes such as deforestation account for a significant share of emissions but also offer solutions through carbon sequestration and climate resilience. Protecting and restoring ecosystems like mangroves and urban forests is cost-effective and provides immediate benefits to the community. Projects in **Java, Freetown,** and the **Biosphere Reserve** have reduced flooding, boosted livelihoods, and supported local policy goals, showing how nature-based solutions serve both local people and the planet.

FOOD & AGRICULTURE

Food systems both contribute to and are vulnerable to the effects of climate change. Shifting to low-carbon diets, reducing food waste, and improving agricultural practices can cut emissions while enhancing food security. Initiatives like **Oakland's plant-forward school meals, food waste recycling in South Korea,** and **shade-grown coffee in Mexico** show that these changes can save money, improve health, and increase local resilience – while also advancing local political priorities like waste reduction and economic development.

INDUSTRY

As global emissions from industry continue to rise due to an increasing demand for energy and materials, climate actions such as circular economy strategies, clean production, and zero-emission construction will be essential to decarbonize the sector. **Kalundborg's industrial park** and **Oslo's clean construction policies** reveal how such measures create green jobs, protect workers, and benefit local communities, helping to build public and political support.

TAKEAWAYS

These case studies offer accessible, actionable insights for how FLIP can be used by policymakers and advocates, journalists, and researchers, all of whom play a critical role in the climate action ecosystem. The FLIP framework helps these actors connect communities with climate efforts by showing how climate actions impact people and places locally.

POLICYMAKERS & ADVOCATES

Policymakers and advocates can apply the FLIP framework to affect climate actions that generate multiple benefits – health, economic growth, and more – that align with local priorities.

- **Make climate action tangible and popular by generating and communicating FLIP benefits.** When benefits are visible and local, communities support projects. Policymakers should emphasize how mitigation delivers direct, local advantages.
- **Align climate action with local priorities to build local support.** Using climate action as a tool to meet pressing local needs like job creation and resilience can boost local buy-in.
- **Engage with the community to ensure climate actions are effective and align with local priorities.** Stakeholder involvement ensures projects reflect community needs, builds trust, and generates local stewardship, improving long-term success.
- **Leverage multi-benefit strategies to build broad coalitions.** Climate actions with economic, health, environmental, and social benefits attract diverse support. Policymakers should design actions with multiple wins to engage varied constituencies.
- **Empower residents to take local, meaningful climate action.** FLIP actions offer accessible ways for individuals to contribute to climate action locally, combating feelings of helplessness in the face of global climate change.
- **Use evidence to address concerns and strengthen the case for climate action.** Providing data on local risks, benefits, and tradeoffs helps overcome opposition and build trust.
- **Track, share, and promote results to show success and inspire replication.** Documented outcomes encourage adoption elsewhere, bolstering the case for similar investments globally.
- **Compare mitigation options through the lens of local co-benefits.** Evaluating climate strategies by their immediate health, economic, and environmental returns helps prioritize the most equitably beneficial actions.
- **Use innovative financing and government purchasing power to fund climate action.** Creative financing and procurement approaches enable local climate investments without overburdening budgets.
- **Integrate FLIP actions into a long-term, cross-sector vision.** Sustained, comprehensive plans amplify the impact of individual climate actions.

JOURNALISTS

Journalists should consider the FLIP framework as a way to more effectively convey to their audiences what climate action will mean for them at the local and even personal level.

- **Focus on local benefits alongside local costs.** To give a complete picture of climate action, journalists should report co-benefits where and when they occur, who benefits, and include the costs of inaction.
- **Build a deep understanding of co-benefits.** Journalists should be familiar with the full range of co-benefits – economic, environmental, health, and social – to cover stories comprehensively. Tools like the FLIP Co-Benefits Taxonomy and resources in this report can help reporters go beyond climate science to capture meaningful local outcomes.
- **Use FLIP benefits to make climate stories more accessible.** Stories focused on near-term, visible gains make climate issues more relatable – especially when paired with visuals and plain language.
- **Focus on specific people and places to make climate coverage resonate.** Personal stories help readers connect with coverage and make complex topics easier to grasp.
- **Show readers how they can engage through local climate solutions.** Local stories help people see how they can participate, helping to combat climate fatigue and foster a sense of agency.
- **Explain the process as well as the outcomes.** Describing how solutions happen – stakeholder engagement, design decisions, and systems thinking – can help others replicate success.
- **Connect climate change to every beat.** Climate intersects with every field – health, infrastructure, politics, economics – so every reporter should understand how it relates to their work.

RESEARCHERS

Researchers can apply FLIP to ensure their research highlights local, immediate impacts and aligns with decision makers' priorities, helping to bridge the gap between climate science and affected communities.

- **Provide evidence in the form that policymakers need to make their case.** Policymakers need tools that estimate local co-benefits and equity impacts. Detailed cost-benefit models can guide decisions and persuade stakeholders.
- **Conduct more post-hoc analyses of climate actions.** More real-world evaluations of climate programs are needed. Researchers should prioritize observed data and longitudinal studies to build the evidence base and help scale effective interventions.
- **Promote interdisciplinary research on climate action co-benefits.** Climate solutions span multiple domains. Research teams should include diverse experts – public health, economics, engineering, earth sciences – to fully capture impacts.
- **Integrate community partners and end-users into research design.** Research is most useful when it reflects local priorities. Involving communities and decision makers in study design ensures that research is actionable, relevant, and responsive.
- **Translate research for policy and communications audiences.** Research communications should be provided in plain language and tailored for key audiences.
- **Capture a wide scope of co-benefits, both quantitative and qualitative.** Some co-benefits can be quantified, but others may require qualitative research. Both are essential to show the full picture of climate action impacts.

FLIP offers a practical, broadly applicable framework to ensure that the health, social, economic, and environmental co-benefits of climate action are foregrounded in policy decision-making, community engagement, and public discourse around climate change. By answering the question, "What's in it for us?" we can "FLIP" the perception of climate action from costly investments that will only benefit future generations to urgent actions that will improve present day quality of life in our own communities. The FLIP framework enables us to show how local climate action won't just protect future life on Earth, it will build a better world today.

INTRODUCTION

Climate change is a global crisis that requires a global response. At the same time, it is a deeply local concern that affects every town, city, province, and state in the world. Under the Paris Climate Agreement, the international community has set collective targets for **climate change mitigation** – the reduction of greenhouse gas (GHG) emissions in a global effort to address the climate crisis. Just as importantly, the Agreement guides nation states in developing emission reduction targets and adaptation plans to achieve these global GHG targets. While international collaboration is essential, climate mitigation itself will not be implemented at the international level. Instead, individual nations, as well as cities, towns, and other subnational governments, bear the ultimate responsibility for achieving these targets. This poses a central problem for effective climate change mitigation, as local governments often prioritize immediate social and economic concerns over GHG reductions. Climate actions – which we define here as policies, programs, and projects that mitigate climate change by reducing GHG emissions – have been perceived as counter to or lower priority than other pressing local issues: that residents have access to jobs, housing, clean food and water, and other basic needs. Furthermore, the perceived cost of climate action is high, while the consequences of inaction seem distant. **For these reasons, C40 Cities and other similar organizations have found that the "primary challenge" of local climate action is persuading local policymakers to elevate climate initiatives amid competing local demands.**[1]

When faced with local and immediate mitigation costs and a mountain of local and immediate public needs, some decision-makers have been reluctant to prioritize governmental action to reduce global, long-term climate change.[3] This is because of a perceived imbalance in the geographic scope and timeline of who pays for versus who benefits from climate action. First, the benefits of climate action feel remote and intangible (even while we are already feeling its effects). Curbing GHGs today influences the climate system over a period of decades to centuries, and these benefits are realized globally, regardless of where emissions are reduced. Meanwhile, the upfront costs of climate action, such as investment in new technologies and implementation of new regulations, often fall on local communities and taxpayers, who do not perceive a local benefit. As a result, local actors, such as city council members, mayors, county commissioners, and public health officials, may not understand why they should prioritize steps to reduce GHG emissions, which can be costly.

This thinking is short-sighted and misses the full picture. While GHG reductions are essential to sustain future life on Earth, the immediate, local benefits of climate action (as well as the immediate, local costs of inaction[4]) are just as significant. In fact, many climate mitigation strategies are mutually reinforcing of local priorities and broader sustainable development, and their enactment can help communities achieve economic, public health, and other related goals. The societal benefits of burning less fossil fuel, for example, are broad and varied, including clearer air, cleaner water, improved cardiovascular and respiratory health, expanded natural environments for both recreation and ecosystem protection, reduced congestion and noise, green jobs, and energy independence.[5,6,7,8] This report reframes local climate actions in terms of the **free, local, immediate, and persuasive (FLIP) co-benefits** – societal gains additional to an action's GHG reduction potential – they can provide to the communities that implement them. While climate actions frequently have upfront costs, they often deliver higher valued economic, health, environmental, and social benefits, making them effectively **free** or net-positive investments. In addition to global GHG reductions, many climate actions simultaneously deliver **local** co-benefits, such as cleaner air, reduced energy costs, and improved quality of life, that directly benefit residents in the community that implemented the action.[9,10,11] What's more, these co-benefits are often realized **immediately** upon implementation, as distinct from global, long-term climate impacts.[12,13,14] And because these benefits align with other top local priorities, such as economic growth, public health, and neighborhood resilience, they are **persuasive** to policymakers and the public, regardless of their views on climate change. **FLIP therefore provides a framework for recognizing and articulating the full value of climate actions, highlighting their broad, immediate, and strategic value beyond emissions reductions, with the ultimate goal of catalyzing action at the local level.**

This report details how climate actions, particularly those co-designed with affected communities, have concurrently solved pressing local problems, such as air pollution, high energy costs, and economic stagnation. By reframing local climate actions to capture their full and immediate value, FLIP offers a practical, broadly applicable framework to achieve necessary GHG reductions at the subnational scale, as communities can leverage these local and immediate benefits to achieve climate interventions and investment. Twenty two case studies from around the world demonstrate FLIP co-benefits of climate action to inform and inspire replication. Based on these case studies, we offer takeaways for policymakers and advocates, journalists, and researchers to ensure that the broader economic, social, environmental, and health co-benefits of climate actions are foregrounded in policy decision-making, community engagement, and public discourse around climate change. By taking this more holistic approach, we can "FLIP" the perception of climate action from costly investments that will only benefit future generations on a global scale to urgent action that will improve present day quality of life in our own communities.

FLIP shows how bold and local climate action won't just protect the future – it will build a better world here and now.

BACKGROUND

Understanding Co-Benefits

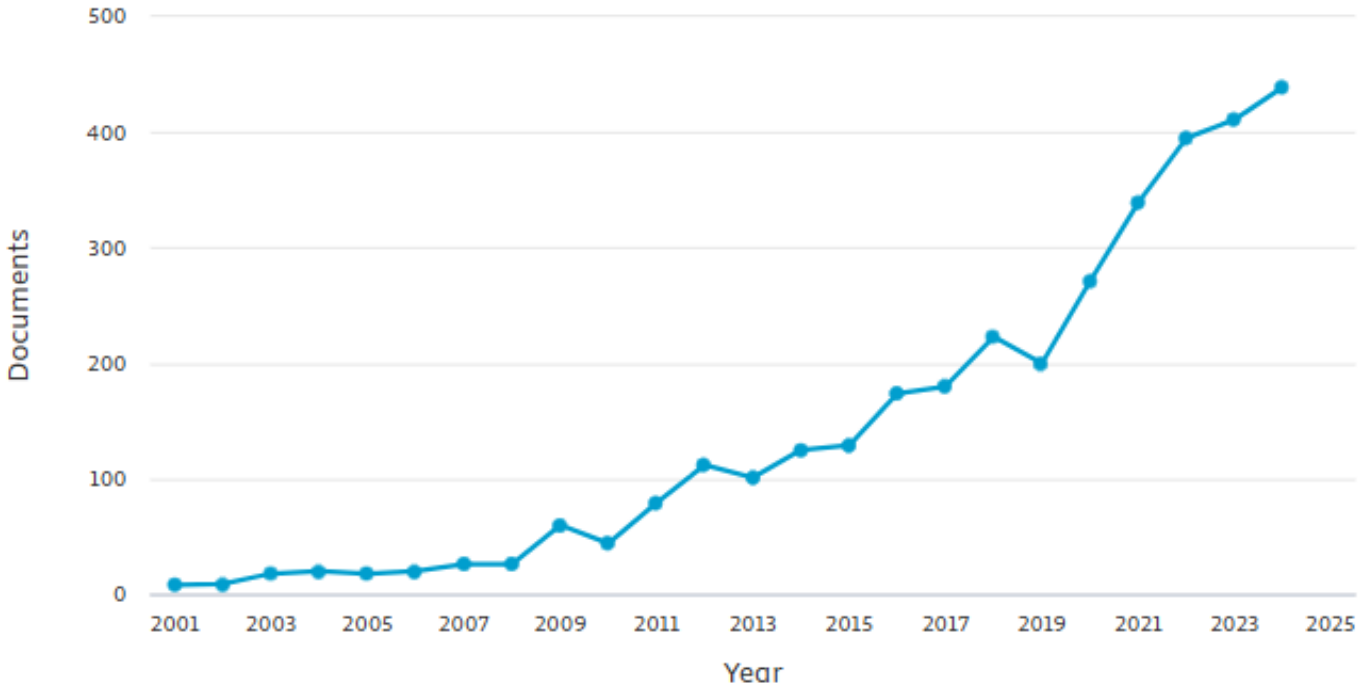
This report builds on a growing body of work focusing on the co-benefits of climate change mitigation, reframing local climate actions in terms of the free, local, immediate, and persuasive co-benefits they can provide to communities that implement them. The term "co-benefits" has had varying definitions over the past 30 years. In this report, we define co-benefits as **the large and diverse range of societal benefits associated with climate action that are additional to the benefits conferred through avoided climate change-related risks.**[2] These co-benefits include job creation, improved air quality, energy cost savings, and many others. In this report, we categorize co-benefits into economic, environmental, health, and social benefits.

Though still an emerging field, co-benefits are not a new concept. Research discussing the ancillary health benefits of reducing GHG emissions first emerged in the 1990s[15,16] and the concept of co-benefits was formally put forward in the Intergovernmental Panel on Climate Change Report in 2001.[17] Since then, articles about co-benefits in the academic literature have skyrocketed. An analysis of the Scopus database indicates that the volume of articles published with both co-benefit and climate action keywords increased from 8 in 2001 to 439 in 2024. Co-benefits have been considered in policy contexts using various terminology – co-benefits, ancillary benefits, multiple development benefits, multi-solving, and more.

Examples of Co-Benefits

Economic	Health
Job creation	Nutrition
Energy security	Physical activity
Housing & Energy affordability	Health benefits from improved air quality
Environmental	**Social**
Soil health	Civic participation
Air quality	Community resilience
Natural resource conservation	Social cohesion

Historical trend of academic articles on climate action co-benefits from 2000-present.



TITLE-ABS-KEY ("co-benefits" OR "co benefits" OR "ancillary benefits" OR "multi-solving" OR "multi solving" OR "non-climate benefits" OR "additional benefits") AND TITLE-ABS-KEY (climate* OR "climate action" OR "mitigation" OR "GHG reduction" OR "carbon reduction") AND PUBYEAR > 2000 AND PUBYEAR < 2026

How Co-Benefits are used (or not used) in Decision Making

These broader advantages to GHG mitigation may seem obvious but tend to be under-accounted for in climate policy decision making.[18] For example, as of 2021, a WHO survey found that only 16% of countries have conducted an assessment of the health benefits anticipated as a result of their national climate mitigation policies; of these, just two included a quantitative assessment.[19] Multi-sectoral collaborations on climate and health often fail to include consideration of urban planning, housing, transportation, and other social determinants of health, suggesting a missed opportunity to optimize the benefits of adaptation and mitigation efforts across sectors.[19] A 2014 World Bank report found that a broadened economic analysis that accounts for co-benefits led to far greater economic benefits (~40% to a factor of 10) than the primary development objective justifying several World Bank investment projects.[20] Because co-benefits have not been consistently integrated into climate mitigation planning, the economic, health, environmental, and social consequences of reducing fossil fuel burning are still often overlooked in decisions on whether and how to reduce GHGs.[21]

Media coverage also frequently focuses on the costs and political challenges of mitigation, rather than the many ways in which climate action would make local communities cleaner, healthier, and more sustainable. For example, in a content analysis of the most influential media sources in the US, researchers found that framing about the economic harm of climate action was prevalent and led to reduced public support of climate policy.[203] Omitting these additional economic, environmental, health, and social benefits frames fossil fuel-reducing actions as prohibitively costly and challenging to implement. In reality, the societal benefits, if properly accounted for, typically outweigh the upfront costs, making many climate actions appealing to decision makers and the general public alike. Research from the Tyndall Centre for Climate Change Research found that cities citing the co-benefits of their climate action reported 2.5 times more climate actions than cities that did not.[22] Our report helps address this gap by providing a framework to better integrate local co-benefits into policy analysis and communication and ensure that these benefits are properly accounted for in decisions about climate action.

Indeed, advocates and policymakers are already moving in this direction, as some have begun to more explicitly consider the co-benefits of climate action in their decision making. A few countries, including Nigeria, Colombia, Chile, and Mexico, have begun including air quality and health considerations into their national pledges related to GHG emission reductions under the Paris Agreement. At the urban scale, C40 Cities has helped cities worldwide begin to quantitatively assess the air quality and health benefits of ambitious GHG mitigation scenarios as part of their Climate Action Planning program.[23] Their Urban Climate Action Impacts Framework enables cities, experts, and other stakeholders to explore and share evidence on how urban climate action translates into wider impacts for society, health, the economy, and the environment. They have also created tailored tools for specific climate actions, such as walking and cycling infrastructure, healthy and efficient building retrofits, and heat resilient actions.

Jack's Solar Farm, Colorado

The Co-Benefits Landscape

Though there is an extensive and growing literature base promoting the wealth of benefits associated with climate mitigation policies, there is a need to better understand the body of resources used to communicate co-benefits knowledge. To ground this report, we assessed the current state of co-benefits resources by conducting a landscape analysis that identifies the types of resources provided and their intended audiences, as well as the types of indicators used to characterize co-benefits impacts. This landscape analysis (summarized in Appendix A) seeks to identify gaps in currently available resources in order to understand how to amplify and communicate co-benefits findings with the ultimate goal of incorporating them more effectively into local, national, and international policy-making.

Acknowledging that the table of resources compiled for this analysis is not exhaustive, we identified the following key themes: 1) the vast majority of resources identified were intended for policymakers, with only a small fraction intended for researchers and journalists; 2) resources most consistently referenced health co-benefits, followed by environmental co-benefits, economic co-benefits, and social co-benefits; and 3) while definitions of co-benefits vary across sources, there is a growing move toward a more cohesive description that includes both intended and unintended outcomes of climate action.

This report addresses several areas warranting additional exploration in the current co-benefits landscape, as identified by high-level reviews of the resources included in this analysis:

Resources address only a subset of stakeholders. Most resources are designed for policymakers, and less so for researchers and journalists, often excluding those communicating on co-benefits as well as the general public. Expanding and adapting tools and resources for wider audiences can boost understanding, engagement, and grassroots support for climate actions and their associated co-benefits. Private sector stakeholders such as climate impact investors are also an important audience; they are not addressed in this report but are identified in the future aims section as stakeholders to engage with.

Framing climate co-benefits locally increases their relevance and persuasive power. While some reports on co-benefits are primarily focused on a broader geographical scale, many resources, particularly case studies, highlight locally experienced co-benefits. Framing co-benefits locally is critical to demonstrate immediacy and persuasiveness of climate actions for local communities. This more targeted framing can help lead to increased public support and participation, and facilitate investment in projects that address both climate and development needs, all while advancing local priorities.

Bridging research and implementation remains a challenge as quantification methods vary, with data gaps remaining. Although many studies highlight potential co-benefits, the transition from research to real-world implementation is hindered by the lack of detailed, real-time data on health, economic, and other outcomes, and limited awareness of available datasets. Co-benefits are commonly estimated using quantitative tools, often complemented by qualitative methods like surveys. While tools like C40 Cities' Walking and Cycling Benefits Tool provide projections, actual observed data – especially ex-post – is still limited, highlighting significant gaps in city-level data availability.

Health is the most covered co-benefit, mainly focused around air quality improvements. Health-related co-benefits, such as disease risk reduction and life years gained, appear in most resources, signaling their priority in climate mitigation efforts. However, these are largely focused on the health benefits realized from improvements in air quality. Expanding measured health co-benefits to more frequently include other health improvement pathways like increased physical activity or improved mental health outcomes would provide a more robust evidence base. However, measuring health benefits is complex due to data limitations and broader lifestyle influences on health outcomes.

Economic benefits are under-leveraged in messaging and analysis. Despite their relevance to decision makers, economic benefits, such as reduced healthcare costs and long-term energy cost savings, are often overlooked or insufficiently quantified in cost benefit analyses of climate action. More targeted economic analyses and concrete examples of economic savings are needed to demonstrate that emissions reductions offer immediate, cost-effective returns, not just long-term environmental gains.

From Co-Benefits to FLIP

This report builds on existing resources to address some of these themes, in particular, by expanding the intended **audience** and by bringing a particular focus to **locally-realized co-benefits.**

This report offers unique value to the co-benefits literature by broadening disciplinary scope and audience. While most resources target decision makers, our report provides accessible, actionable insights for policymakers and advocates, journalists, and researchers alike, all of whom play a critical role in the climate action ecosystem. Policymakers rely on evidence-based research and public support to inform decisions, and public support can often be shaped by media narratives. By integrating recommendations for all three stakeholders, this report fosters a more unified and impactful climate action narrative.

Furthermore, it narrows the geographic scope to local co-benefits, which reflects a crucial fairness consideration: the communities asked to make changes, whether through infrastructure upgrades, land use decisions, or behavioral shifts, deserve to see and understand the tangible returns on those investments.

FLIP helps answer the question, "What's in it for us?"

Focusing co-benefits at the local and hyperlocal level also enables policymakers, journalists, and researchers to examine climate action through an equity lens, considering the link between costs of climate action and the benefits received, and how those benefits are realized variably across different groups within the community. For example, when hyperlocal impacts are properly considered, climate action is likely to benefit communities that are overburdened by pollution and historic disinvestment. The FLIP framing not only highlights how such communities can benefit from climate action, it also facilitates more deliberate decision making. When policies are thoughtfully designed in collaboration with affected communities, this helps to maximize their impact while also ensuring that they do not inadvertently reinforce the underlying systems of inequity the actions aim to address.

Rather than develop an entirely new framework, this project builds upon established tools, integrating emissions sectors and targets from the State of Climate Action 2023 and expanding upon the Urban Climate Action Impacts Framework developed by C40 Cities. Our report broadens the Urban Climate Action Impacts Framework focus by applying the framework to communities beyond those in the urban setting, including rural and Indigenous populations, and explicitly engages journalists and researchers as key audiences. Additionally, our report actively responds to C40's own stated intention to expand upon the Climate Action Impacts Taxonomy, a comprehensive catalog of the co-benefits of climate action, organized into three categories: social impacts, economic impacts, and environmental impacts. Our report adds to the Taxonomy by identifying additional co-benefit impact groups and proposing a fourth category, health impacts, separate from social impacts, to better reflect the importance of these benefits in motivating public engagement and thoughtfully-crafted policy. Through these contributions, our work both continues and advances existing efforts in the field, positioning the FLIP framing of co-benefits as a compelling tool for storytelling, advocacy, and decision-making that reframes climate action as a path for equitable and tangible solutions.

FLIP: FREE, LOCAL, IMMEDIATE, & PERSUASIVE

The FLIP Framework

The FLIP framework highlights the free, local, immediate, and persuasive (FLIP) co-benefits that local climate actions can provide to the communities that implement them. We define the four components of FLIP as follows:

FREE – Climate action provides a net positive return on investment when all societal benefits are accounted for, as the value of improved public health, reduced energy costs, increased economic opportunities, and additional co-benefits far exceed upfront costs.

LOCAL – Climate action has co-benefits, such as improved air quality, worker health and safety, and increased resilience, that are realized locally, providing benefits to residents in the community that implemented the action.

IMMEDIATE – Climate action has co-benefits, such as job creation, improved diet and nutrition, and reduced commuting times, that are realized relatively promptly upon implementation, as distinct from long-term climate impacts associated with global reductions in GHGs.

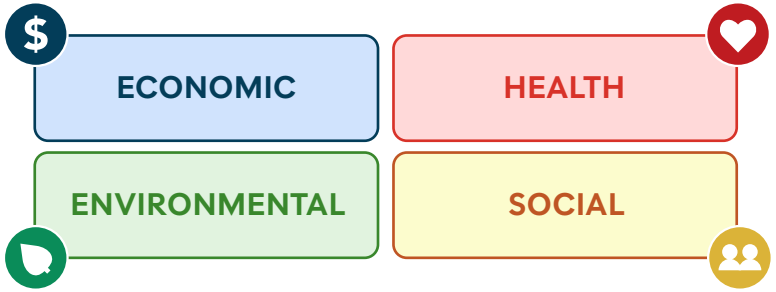
PERSUASIVE – Climate action creates benefits that align with core local priorities unrelated to climate, such as promoting economic growth, protecting public health, and reducing inequality, making the action persuasive to policymakers and the public.

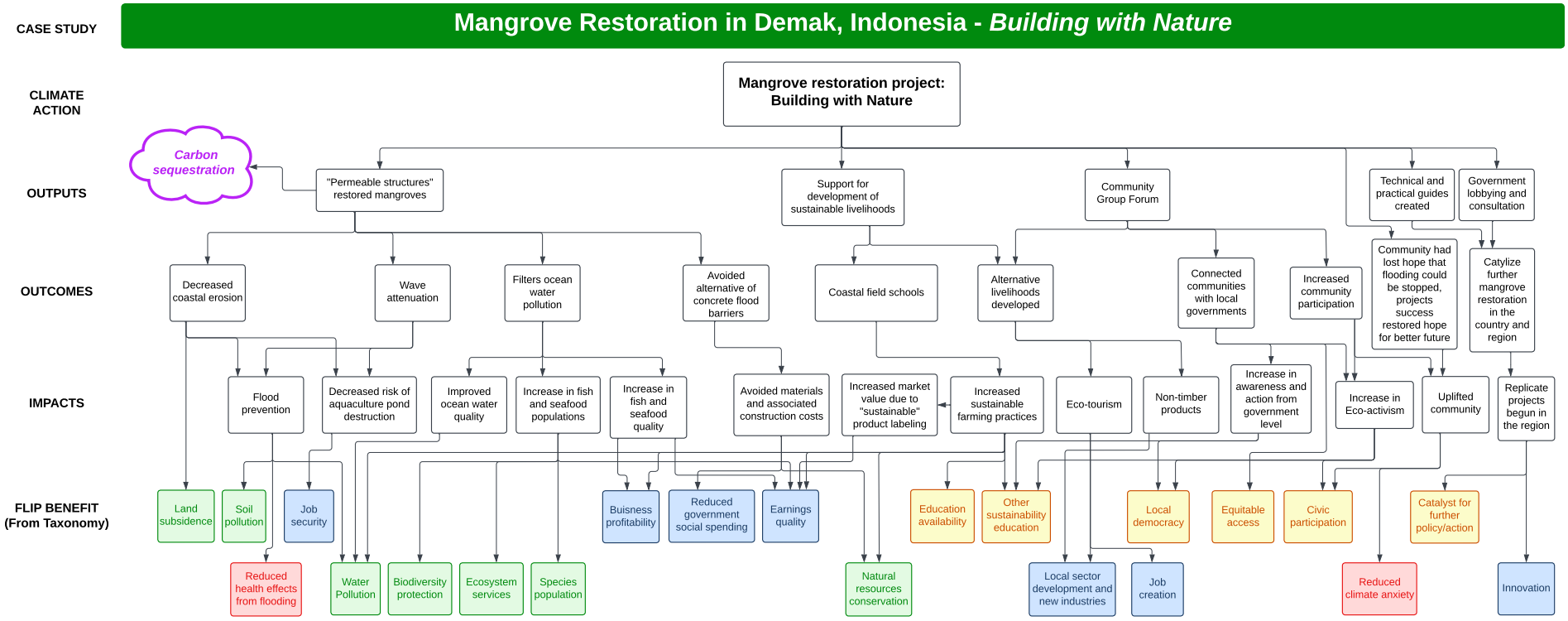
Applying the Framework

Because co-benefits have not been historically foregrounded in climate media coverage, research, and decision making, identifying the FLIP co-benefits of a climate action can be a challenging process for all stakeholders, particularly those for whom climate action is not their primary expertise. To aid in this process, this report provides the following three resources: a **logic model** demonstrating the causal pathways from climate action to FLIP co-benefit, as applied to one case study; a **FLIP Co-Benefit Taxonomy** indexing health, social, economic, and environmental FLIP co-benefits of climate actions; and, in the next section, **FLIP in Action**, 22 case studies from around the world that provide narrative examples of how different types of local climate actions realize FLIP co-benefits.

FLIP Co-Benefits Pathway

The logic model below uses one of the case studies, focused on **mangrove restoration** in Java, Indonesia, to conceptualize how FLIP co-benefits are realized from climate action. This model was created using C40 Cities' Climate Action Impacts Pathways framework. The logic model displays the causal pathways connecting the climate action of mangrove restoration to the FLIP co-benefits experienced by the local population. FLIP co-benefit categories are color coded using the convention pictured on the right, and are consistently used throughout the report.





FLIP Co-Benefits Taxonomy

The **FLIP Co-Benefits Taxonomy** is an index of FLIP co-benefits, co-benefits that accrue locally and are realized relatively promptly upon implementation of a climate action. The taxonomy only includes FLIP co-benefits and does not include the direct benefits and avoided costs associated with mitigating global temperature rise. Our Taxonomy adapts and builds upon C40 Cities' Climate Action Impacts Taxonomy framework, which is targeted towards urban populations and does not have geographic or temporal specifications for co-benefits of climate action. Our framing allows for the application of the FLIP framework across all populations – urban, suburban, and rural. We also identified additional FLIP co-benefits not included in the original Framework and suggested modifications to existing categories. The below table provides a small sample of the Taxonomy table, highlighting a selection of commonly referenced co-benefits. **The full taxonomy, along with additional background and explanation, can be found in Appendix B.**

	IMPACT GROUP	IMPACT	FLIP BENEFIT	DESCRIPTION	CASE STUDIES
HEALTH IMPACTS	***Physical & mental health***	***Resilience to disaster & weather-related hazards***	***Reduced health effects from extreme temperatures***	***Reduced adverse outcomes associated with extreme heat and other extreme temperatures, such as hospitalizations, mortality, negative mental health effects, and adverse birth outcomes.[24]***	
		Environmental health	***Reduced health effects from air pollution***	***Reduced adverse respiratory and cardiovascular outcomes, including chronic obstructive pulmonary disease (COPD), heart disease, stroke, and cancer, related to air pollution exposure, such as particulate matter (PM), ozone (O_3), nitrous oxides (NO_x), and sulphur oxides (SO_x).[25]***	
SOCIAL IMPACTS	***Quality of life and livability***	***Standard of living***	City/**neighborhood** attractiveness	Increases city's appeal through access to public spaces, aesthetics, and tourism.	
	Institutions	Good governance	***Catalyst for further policy/action***	***Success of the program inspired similar programs or action.***	
ECONOMIC IMPACTS	***System & business-level economics***	**Economic Output**	**Local economic production**	**Local income from increase in production/consumption of goods and services.**	
		Employment	**Job creation**	**Job creation in existing sectors.**	
ENVIRONMENTAL IMPACTS	Environmental quality	Biodiversity	Ecosystem services	Value of benefits provided by ecosystems.	
		Resource Management	***Natural resources conservation***	***Decreased rate of depletion of renewable and nonrenewable resources.***	

Adaptations from C40 Taxonomy

BOLD, ITALICS, & TEXT COLOR OF SECTOR = NEW CATEGORY CREATION
BOLD = CHANGED WORDING
BOLD & ITALICS = MOVED CATEGORY

FLIP in ACTION

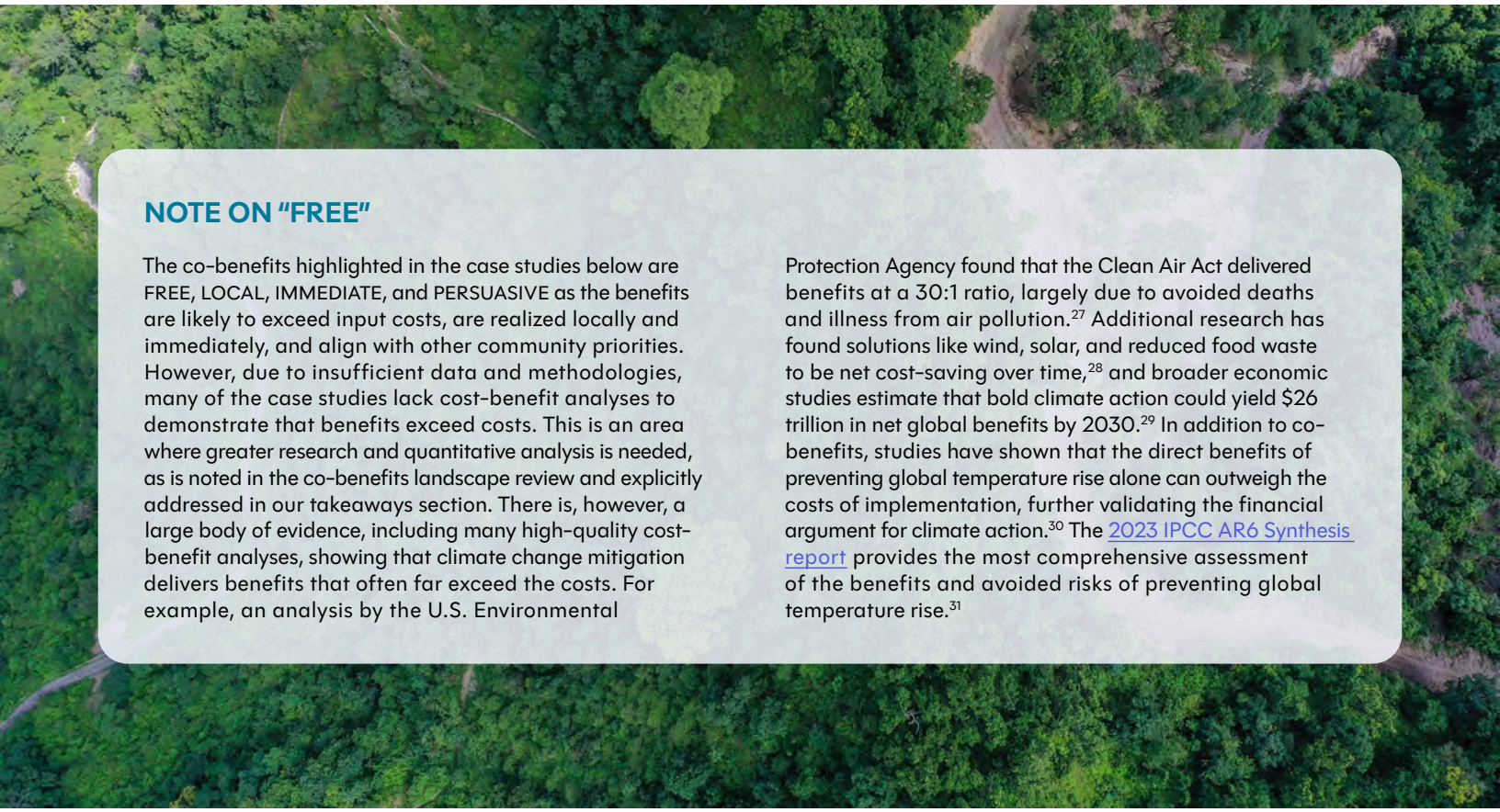
This section presents **22 case studies** of FLIP climate actions from around the world. These case studies demonstrate how actions that mitigate climate change achieve significant ancillary economic, environmental, health, and social co-benefits for local communities. The case studies are organized into six subsections – **POWER, BUILDINGS, TRANSPORT, FORESTS & LAND, FOOD & AGRICULTURE,** and **INDUSTRY** – to align with the sectors used in the State of Climate Action 2023.[26] *

Each case study is structured with a narrative section that provides a descriptive account of the case and implementing community, followed by a list outlining the case study's FLIP co-benefits categorized as follows:

ECONOMIC **HEALTH**
ENVIRONMENTAL **SOCIAL**

These case studies and identified co-benefits directly inform the FLIP Co-Benefits Taxonomy in Appendix B. From these case studies, we draw actionable takeaways for policymakers and advocates, journalists, and researchers, described in the TAKEAWAYS section.

By "climate action," we refer to **policies, programs, and projects that mitigate climate change by reducing GHG emissions**. For some of the case studies in this report, GHG reduction was not the primary political rationale; however, the motivation behind the climate action does not impact the magnitude of GHG mitigation. For example, the primary goal of the **mangrove restoration** project in Demak, Indonesia, was flood prevention; however; it is still a climate action as mangroves absorb more CO_2 than rainforests, achieving significant GHG reductions. FLIP gives stakeholders the power to frame and design climate actions to maximize the many other societal goals they achieve for local communities.

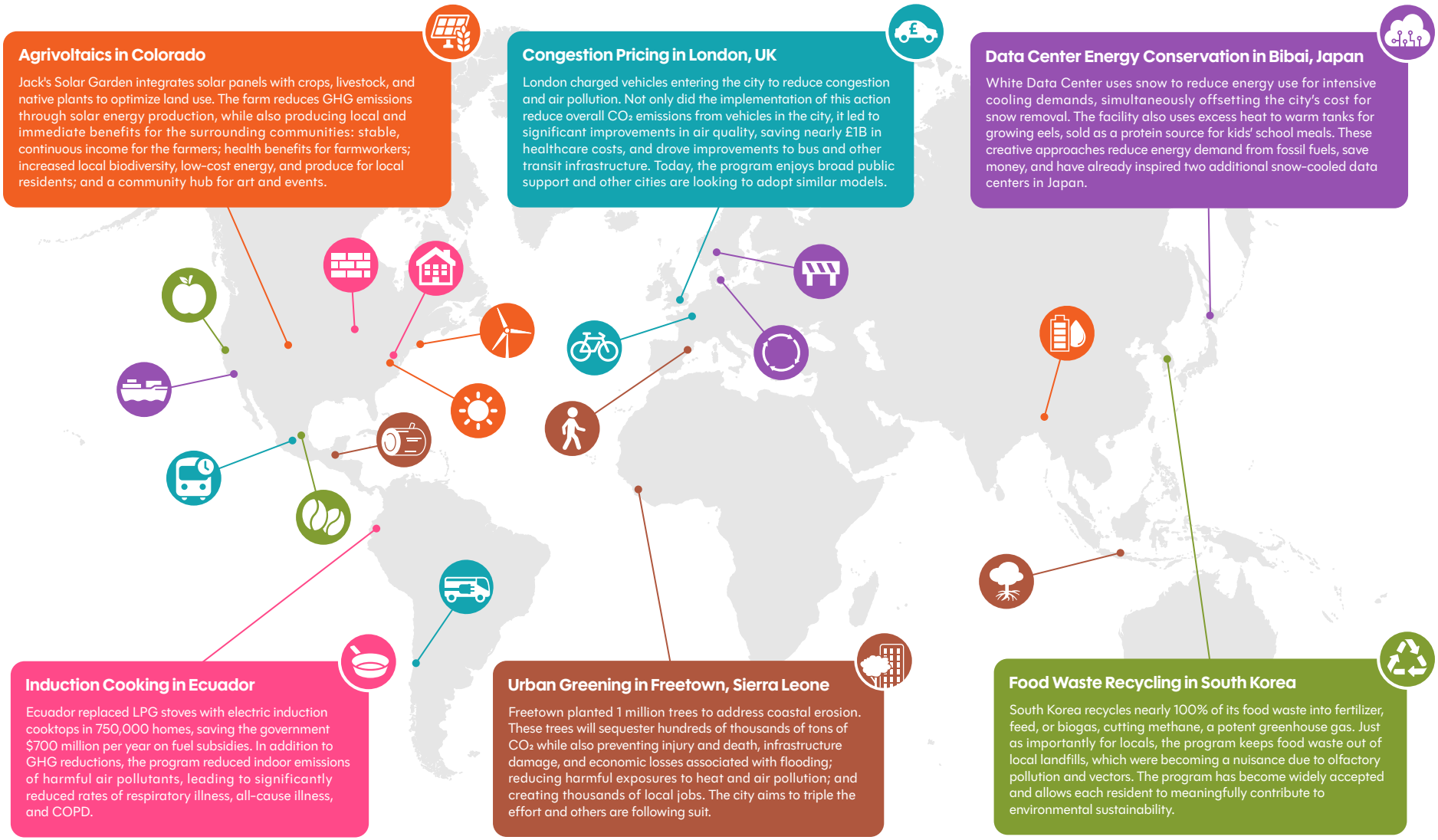


NOTE ON "FREE"

The co-benefits highlighted in the case studies below are FREE, LOCAL, IMMEDIATE, and PERSUASIVE as the benefits are likely to exceed input costs, are realized locally and immediately, and align with other community priorities. However, due to insufficient data and methodologies, many of the case studies lack cost-benefit analyses to demonstrate that benefits exceed costs. This is an area where greater research and quantitative analysis is needed, as is noted in the co-benefits landscape review and explicitly addressed in our takeaways section. There is, however, a large body of evidence, including many high-quality cost-benefit analyses, showing that climate change mitigation delivers benefits that often far exceed the costs. For example, an analysis by the U.S. Environmental Protection Agency found that the Clean Air Act delivered benefits at a 30:1 ratio, largely due to avoided deaths and illness from air pollution.[27] Additional research has found solutions like wind, solar, and reduced food waste to be net cost-saving over time,[28] and broader economic studies estimate that bold climate action could yield $26 trillion in net global benefits by 2030.[29] In addition to co-benefits, studies have shown that the direct benefits of preventing global temperature rise alone can outweigh the costs of implementation, further validating the financial argument for climate action.[30] The 2023 IPCC AR6 Synthesis report provides the most comprehensive assessment of the benefits and avoided risks of preventing global temperature rise.[31]

* This report does not include two additional sectors addressed in the State of Climate Action 2023 – Technological Carbon Removal and Finance.

FLIP World Tour: 22 Places Where Climate Action Brings Free, Local, Immediate, and Persuasive Benefits



Agrivoltaics in Colorado

Jack's Solar Garden integrates solar panels with crops, livestock, and native plants to optimize land use. The farm reduces GHG emissions through solar energy production, while also producing local and immediate benefits for the surrounding communities: stable, continuous income for the farmers; health benefits for farmworkers; increased local biodiversity, low-cost energy, and produce for local residents; and a community hub for art and events.

Congestion Pricing in London, UK

London charged vehicles entering the city to reduce congestion and air pollution. Not only did the implementation of this action reduce overall CO_2 emissions from vehicles in the city, it led to significant improvements in air quality, saving nearly £1B in healthcare costs, and drove improvements to bus and other transit infrastructure. Today, the program enjoys broad public support and other cities are looking to adopt similar models.

Data Center Energy Conservation in Bibai, Japan

White Data Center uses snow to reduce energy use for intensive cooling demands, simultaneously offsetting the city's cost for snow removal. The facility also uses excess heat to warm tanks for growing eels, sold as a protein source for kids' school meals. These creative approaches reduce energy demand from fossil fuels, save money, and have already inspired two additional snow-cooled data centers in Japan.

Induction Cooking in Ecuador

Ecuador replaced LPG stoves with electric induction cooktops in 750,000 homes, saving the government $700 million per year on fuel subsidies. In addition to GHG reductions, the program reduced indoor emissions of harmful air pollutants, leading to significantly reduced rates of respiratory illness, all-cause illness, and COPD.

Urban Greening in Freetown, Sierra Leone

Freetown planted 1 million trees to address coastal erosion. These trees will sequester hundreds of thousands of tons of CO_2 while also preventing injury and death, infrastructure damage, and economic losses associated with flooding; reducing harmful exposures to heat and air pollution; and creating thousands of local jobs. The city aims to triple the effort and others are following suit.

Food Waste Recycling in South Korea

South Korea recycles nearly 100% of its food waste into fertilizer, feed, or biogas, cutting methane, a potent greenhouse gas. Just as importantly for locals, the program keeps food waste out of local landfills, which were becoming a nuisance due to olfactory pollution and vectors. The program has become widely accepted and allows each resident to meaningfully contribute to environmental sustainability.

POWER

The energy sector powers the world and, as such, is one of the primary drivers of climate change. Since the global power sector still relies on burning coal and other fossil fuels for electricity, power generation is the largest source of anthropogenic GHG emissions, comprising an estimated 25% of emissions globally.[26] Global electricity demand is projected to continue to grow rapidly, driven by factors such as economic growth in developing nations, electrification of the transport and residential sectors, and recent rapid development in the data center industry.[32] Curbing global warming will require decarbonization of the power sector, shifting from coal and fossil fuel consumption to zero-carbon energy sources such as solar and wind. The case studies in this section demonstrate that shifts to zero-carbon sources are FLIP: The projects in this section yield benefits that likely exceed costs, making them **FREE** from a societal perspective. For example, at **Jack's Solar Garden** in Colorado, an upfront investment in solar panels has generated sustained income for farmers, making their farm financially viable. The co-benefits are often **LOCAL**: in the District of Columbia, **community solar projects** reduced energy bills for low-income residents by up to 50%. The local benefits are **IMMEDIATE**; after building their **pumped hydroelectric storage facility**, residents of Hengbung, India, gained access to reliable energy and light and experienced less frequent blackouts. And these benefits were **PERSUASIVE**, achieving other community priorities. The **Block Island offshore wind project** in Rhode Island addressed an issue that had long been plaguing residents: dependence on local diesel power generation that was unreliable, expensive, and dirty. While there may be initial resistance to upfront costs, because these projects have FLIP benefits, they become popular as residents immediately realize the benefits in their own communities.

Agrivoltaics in Colorado

Jack's Solar Garden harnesses the sun to power both its crops and community

Faced with financial challenges, Jack's Solar Garden owner Byron Kominek turned to solar power to save the 24-acre hay farm that has been in his family since 1972. Jack's Solar Garden has since leveraged the power of agrivoltaics – the co-location of solar panels with agriculture – to convert a portion of his land into a 1.2 MW agrivoltaic farm, the first large scale project of its kind in the United States.[33] Jack's Solar Garden primarily focuses on crop production; however, pollinator habitats and livestock can also be found under the panels, representing all three major types of agrivoltaic use-cases. Not only do Byron's 3,276 solar panels help keep the farm financially viable, they avoid thousands of tons of GHGs from entering the atmosphere over the lifespan of the panels by displacing fossil fuels from the Colorado grid, and provide several additional environmental, economic, health, and social co-benefits.[34,35]

Both global energy and food demand are increasing rapidly; this presents a challenge for these resource-intensive industries to produce enough supply to match a growing demand.[26] Traditional thinking may posit that more land will be required to meet this need, however, agrivoltaics offers a solution – allowing for production of both food and clean energy on the same land, while avoiding land degradation pitfalls commonly associated with traditional solar farms. The shade provided by the panels increases soil water retention, cutting water consumption needs for irrigation up to 75%.[36] Additionally, water used to clean the solar panels is recycled by the plants below. The cool microclimates created around the panels by shade and plant cellular respiration functions symbiotically, aiding the agriculture (crop productivity, livestock growth and health) and agriculture worker health.[37,38] In arid climates, this microclimate increases solar panel efficiency up to 3% in warmer months.[37] The solar panels shield crops from environmental hazards such as heavy winds, intense periods of sunshine, and hail, increasing crop resilience. Additionally, the panels create a temperature buffer, reducing the severity of both extreme heat and extreme cold underneath the panels (-4-6°C in summer, +2-4°C in winter), which can help avoid premature freezes and extend growing seasons by up to 3 weeks. Furthermore, increases in pollinator populations cultivated under the panels have been shown to increase neighboring crop yields.[39]

Jack's Solar Garden has become a staple in its community, providing numerous services and opportunities. Jack's donates 2% of its energy production to low income housing, enough to power 10 households year round for 20 years,[33] and the farm hosts a Community Supported Agriculture program, ensuring low-cost fresh produce for the community.[40] Educational tours of Jack's Solar Garden are available for government officials, businesses, and students, and pioneering research from Jack's nonprofit, the Colorado Agrivoltaic Learning Center, has helped inspire grants, legislative land use changes supporting agrivoltaics, and increased public awareness of and support for such projects.[33]

Agrivoltaic farms produce solar energy while decreasing the GHG emissions from agricultural production and avoiding deforestation, all necessary to meet Paris Agreement climate goals.[26]

FLIP Co-Benefits

Agrivoltaics provide farmers with a **stable, continuous source of income,** generating up to **$3,000 per acre per year** in revenue.[41] Agrivoltaics can also increase revenue by **raising crop value** from specialty "solar crop" marketing, **increasing crop yields** and **extending growing seasons**.[37,39] New panel installation and maintenance needs **create local jobs.**[42]

Working under the shade of the solar panels has been shown to **protect agricultural workers from occupational heat stress, decreasing skin temperatures by up to 15°C,** which is particularly vital as occupational heat-based mortality rates are 35 times higher among agricultural workers compared with other occupations.[38,44]

Agrivoltaic farms can support a diverse array of plant species, increasing **soil carbon sequestration** and **soil health.**[43] The increased soil stability **decreases erosion** and **agricultural runoff.** Pollinators supported by agrivoltaic systems **bolster biodiversity in the local area**. Shade from the panels increases soil water retention, **decreasing water consumption from irrigation by up to 75%.**[37]

Jack's Solar Garden serves as a community hub, **donating 2% of its energy production to low income housing,** hosting a Community Supported Agriculture program to provide **low-cost fresh produce for the community,** and **supporting local artists** by **hosting community events** under the panels.[33,40]

Offshore Wind Farm on Block Island, Rhode Island

America's first **offshore wind farm** replaces dirty diesel

Block Island, a small island just 14 miles east of Long Island's Montauk Point, is a vital biodiversity hub, home to over 40 rare or endangered animal and plant species, a key stop for 150 species of migratory birds along the Atlantic Flyway, and host to a critical marine ecosystem.[45,46] For over a century, the inhabitants of Block Island relied on a diesel power plant for their power generation, burning over a million gallons of diesel a year only half a mile from the island's downtown.[47] Residents near the generators reported frequently having to scrub soot from their houses, which is particularly concerning as exposure to diesel exhaust is associated with adverse health conditions such as asthma and other respiratory conditions as well as cancer and heart disease.[46,48] The plant emitted an estimated 40,000 tCO_2 per year, while additionally contributing to the production of ground-level ozone (associated with negative respiratory, cardiovascular, and other health outcomes); polluting marine ecosystems; and reducing visibility, obscuring residents' scenic ocean views.[46,48,49] Additionally, Block Island residents were at the mercy of highly variable diesel prices and unreliable service, paying four times the mainland rate for energy and experiencing frequent brownouts.[46]

Block Island residents' desire for new energy sources, aligning with Rhode Island's policy priority for renewable energy generation, set the stage for the first offshore wind farm in the United States.[50] On May 1, 2017, Block Island's diesel generator was shut off, substituted by 5 wind turbines located 5.3 km off the shore.[51] The island uses just 10% of the turbines' energy output, and exports the rest, enough to power 17,000 homes, to the mainland.[52] The project brought in an estimated $129 million in job creation and other business opportunities, while saving the average resident $140 a month in electricity costs.[46]

Though the project eventually gained public support, it initially faced harsh skepticism from the community, including fears of unforeseen construction costs, adverse environmental impact on marine wildlife, and spoiled ocean views, as the island community relies heavily on recreational fishing and tourism.[53] The project assuaged community concerns by funding multi-year studies demonstrating that through careful site planning, migratory bird, fish, and lobster populations, as well as marine floor ecosystems would be preserved, and by engaging a community liaison with deep ties to the Island to build trust between the project team and local residents.[54] Through this evidence collection, community outreach, and the natural realization of benefits in the community, the wind turbines have become a very popular addition to the island.

Block Island's transition to clean energy from diesel power generation will avoid an estimated 1,000,000 metric tons of CO_2 over the lifetime of the turbines.[46]

FLIP Co-Benefits

Electricity rates decreased 40%, saving the average resident **$140 per month** on electricity bills.[53,55] Recreational boating activity recovered quickly to pre-construction levels, with one study even showing a slight increase in tourism due to the wind farm.[54,56] The Rhode Island Economic Development Corporation estimated the project would bring **$129 million dollars** in economic benefits through **job creation and new business opportunities.**[57]

Four multi-year studies concluded that fish, squid, and lobster **populations were not significantly impacted by the turbines,** with Black Sea Bass showing increases in catch near the turbines, indicating that the turbines could possibly act as **artificial reefs.**[54] Transitioning from diesel to wind power **avoids emissions of harmful air pollutants** such as carbon monoxide (CO), nitric oxides, sulfur oxides, hydrocarbons and more.[58]

The turbines have eliminated Islanders' exposure to the generators' diesel exhaust, which is associated with **asthma** and **other respiratory conditions** as well as **cancer** and **heart disease.**[58]

As part of the Community Benefits Agreement, the project developer agreed to fund **tie-in to the grid, utility line upgrades,** as well as installation of **fiber optic cables for high speed internet.**[59] Additionally, the company donated **$2.5 million towards historical preservation** and the **local tourism industry.**[59]

Community Solar in the District of Columbia

Solar for All provides equitable energy savings

The District of Columbia has experienced rapid economic growth over the past several decades; however, the benefits of this growth have not been equitably shared. In particular, the District's communities of color continue to face persistent gaps in income, health outcomes, and employment. At the same time, households with lower income face rising housing costs and costs of living. For this reason, equity is a major priority of the city's leadership, with the goal of ensuring that all residents have the opportunity to thrive.[60]

With this priority in mind, DC has leveraged its clean energy programs to address rising costs while also achieving climate goals. Studies show that SNAP-eligible households in DC spend more than 20% of their income on energy bills, far in excess of what is considered affordable (generally, 6% or less).[61] Across the world, homeowners installing solar panels have realized energy cost savings; however, these benefits haven't always flowed equitably, as they are more accessible to well-resourced owners of single-family homes. In 2016, Washington, DC, established the Solar for All Program, which delivers the benefits of locally produced solar power to low- to moderate-income households, small businesses, nonprofits, and seniors by installing solar panels on the homes of income-qualified residents. In addition, its community solar program enables residents who cannot install solar panels on their own homes, such as those in multifamily housing, to access the benefits of solar energy by subscribing to or owning a portion of a larger solar array, typically located on commercial or apartment rooftops. The energy generated by that share is then credited towards the subscriber's electricity bill.

From the program's inception, the benefits of solar energy have been provided to over 11,000 households in the District, affording participating families an annual savings of up to $500 on their electricity bills, with a projected $80 million in lifetime project electricity bill savings.[62] Solar for All community solar installations are primarily located in Wards 7 and 8, neighborhoods which have higher asthma rates, a higher proportion of Black residents, lower rates of education and employment, and higher levels of poverty.[63,64] Solar for All prioritizes equal access to local, clean energy to decrease resident's utility burdens and protect underserved communities in the face of a changing climate.[65]

In one year, DC's Solar for All program supported the addition of 3.5 MW of solar capacity, and together with other renewable energy programs, reduced lifetime GHG emissions by over 1 million metric tons of CO_2e.[62]

FLIP Co-Benefits

The primary goal of the Solar for All program is to provide the benefits of solar to low-income households in the District, **reducing their energy bills by 50%** and saving participating families **around $500 per year.** The DC Sustainable Energy Utility, which administers Solar for All and other sustainable energy programs in DC, created **90 green jobs in 2024 alone.**[62]

Expanded local solar production makes the District more **resilient** to climate change and other environmental challenges.

Diversifying energy sources and decreasing reliability on centralized power providers can **improve grid reliability,** particularly in the face of a changing climate.[66] Grid reliability ensures access to essential services like medical care and safe food and water, which are vital for **public health and wellbeing.**

The program has lowered energy costs for thousands of low-income families, an indicator in the **District's Racial Equity Action Plan.**[60] The program provides a business model for historically excluded communities to access the benefits of solar energy. Recent projects include the city's first solar and battery storage system in an **affordable housing building.**

Distributed Pumped Hydroelectric Storage (PHS) in Manipur, India

Hengbung Village Distributed PHS provides clean and reliable local energy storage

India, home to 21 of the world's 30 most polluted cities, experiences the worst air pollution of any country globally, causing an estimated 2 million premature deaths every year.[67] To combat this, India has committed to achieve 50% renewable energy powering their grid, 500 total GW of power, by 2030.[68] India has already made great progress, setting national records in 2024 for renewable energy capacity installed, with wind and solar leading the way.[69] However, the intermittent nature of wind and solar generation requires energy storage solutions to maintain grid reliability. Solutions such as utility-scale lithium-ion batteries can be prohibitively capital intensive and may require environmentally damaging mining and disposal of hazardous metals. Pumped hydroelectric storage (PHS) stores energy by pumping water from a lower reservoir to a higher one. Unlike the aforementioned battery solutions, this storage method has far fewer environmental impacts, eliminating the need for critical metals, and has an expanded battery life (lasting up to 60 years).[70] However, PHS at a utility-scale can be prohibitively expensive, as it requires large amounts of land, infrastructure, and capital to build.

Hengbung, a small village in Manipur, India, has developed a promising local-scale solution by integrating solar power generation with a small-scale or "distributed" PHS system. The distributed PHS system consists of two reservoirs, built in 6 months by local labor, one 4.5 m higher than the other, able to hold a combined 1.9 million L of water collected from a local stream.[71] Energy generated from the solar panels during the day pumps water to the higher reservoir and during the night, or during power outages, the water is released back into the lower reservoir, spinning a turbine to generate electricity. This system produces ~53 kWh/day, providing 350 residents with light in their homes, and powers 84 street lights at night while producing ~40 kWh/day of excess electricity which Hengbung will sell back to grid.[71]

More pertinent to the residents of Hengbung, the project provides them with access to clean, safe energy. The village's mountainous terrain, frequent landslides, and many streams have historically led to prolonged power outages, as repairs were difficult and expensive.[70] Kerosene and diesel lamps were previously relied upon in homes to provide light, exposing residents to harmful indoor air pollution. The distributed PHS system, and the solar panels that power it, are now fully operated by trained locals, with villagers paid to conduct repairs as needed.[70] Rai, a 32-year-old poultry farmer in Hengbung, testified how the system has improved their lives, by providing light to complete everyday chores at night and allowing their 6-year-old son to do his homework without fear of the lights turning off.[70]

Hengbung's solar power and PHS systems work toward meeting the Paris Agreement climate goals as the share of zero-carbon sources in electricity generation must increase to ~90%.[26]

FLIP Co-Benefits

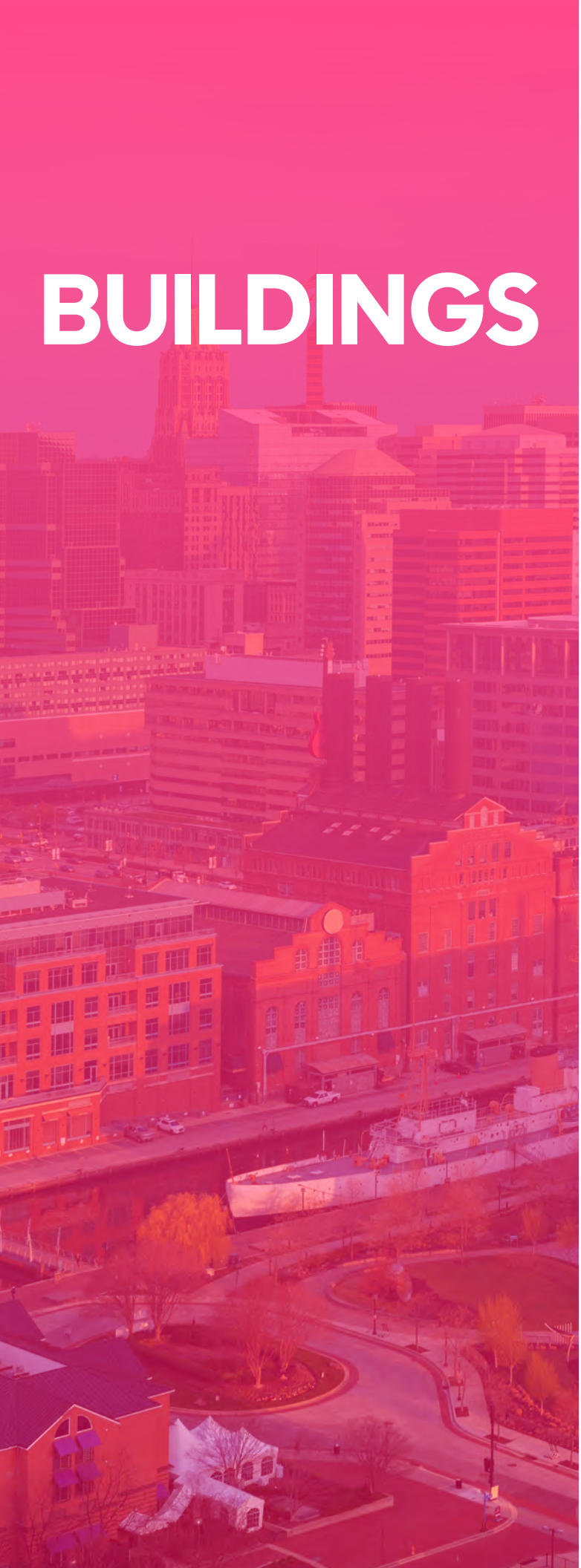
Construction, management, and maintenance of the reservoirs have created **local jobs.**[70] 80% of the energy generated by the system **(~40 kWh/day)** can be **sold back to the grid** for local profit. The average cost of energy from the distributed pumped hydro storage systems in India is estimated to be **$0.036/kWh, less than half that of other storage technologies,** namely lithium-ion batteries.[70]

As 80% of India's electricity generation comes from coal, offsetting this carbon-intensive source with renewable energy is crucial to local air and water quality.[72] Distributed PHS avoids **environmentally damaging mining and disposal** practices that are required by other energy storage solutions, such as lithium-ion batteries.

Lighting supplied from the system replaces reliance on diesel or kerosene powered options, which emit harmful pollutants such as particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NOx), and sulfur dioxide (SO_2), which **impair lung function and increase risk of asthma and cancer.**[73]

The distributed PHS system, and the solar panels that power it, are fully operated and maintained by locals, granting the village **reliable, independent energy.** Anecdotal accounts suggest that blackouts have become significantly less frequent and residents are empowered by access to light at night.[70]

BUILDINGS



Buildings, where people live, work, and play, are a significant source of carbon emissions. The direct GHG emissions from burning fuel for cooking and heating on site accounts for about six percent of global GHGs; when indirect GHG emissions from the production of energy for heating, cooling, lighting, and other activities are included, these emissions roughly triple.[26] Decarbonizing the building sector will require improved energy efficiency in buildings, reduced embodied carbon of building materials, and a shift to zero-carbon energy sources to power them. Reducing the energy intensity of buildings helps minimize overall energy demand from the sector, making it easier to decarbonize their energy supply. New buildings will need to be designed and constructed to be "net-zero," to generate more energy than they consume, while existing buildings will need to be retrofitted to be more efficient (i.e., adding insulation to reduce heating and cooling needs and upgrading electrical appliances and lighting). Building decarbonization contributes to global decarbonization targets while also achieving FLIP co-benefits. While building decarbonization is perceived as an expensive action initially, in the long-term it is **FREE** because it generates benefits that far outweigh the upfront costs. Net-zero buildings such as the **Unisphere** in Maryland are cheaper to operate in the long run, while **energy efficiency retrofits** such as those in Wisconsin ultimately pay for themselves through energy savings. Local residents see benefits of these actions that are **LOCAL** and **IMMEDIATE**; transitions from gas to **induction cookstoves** in Ecuador resulted in significantly reduced rates of respiratory related illness, all-cause illness, and chronic obstructive pulmonary disease (COPD), while **building retrofits** in Wisconsin reduced residential exposure to excess heat, mold, and noise. And these projects achieve local priorities unrelated to climate, creating local jobs, reducing healthcare costs, and more, making them **PERSUASIVE** to decision makers that might not otherwise prioritize climate action.

Building Retrofits in Madison, Wisconsin

Efficiency Navigator delivers cost savings and health benefits

Building energy retrofits, such as improvements to the building envelope, glazing, HVAC, lighting, and energy controls, allow for improved energy efficiency for structures that already exist. However, small independent landlords often face challenges when investing in building improvements. Legal requirements to individually meter each rental unit make it difficult for them to benefit directly from these upgrades, limiting their ability to recover costs. As a result, tenants may continue to face high energy bills, while landlords are forced to choose between keeping rents affordable or raising them to cover improvement expenses.[74] Affordable housing units often consume 39% more energy than market rate housing, attributed to an older and less efficient building stock. As such, utility costs contribute to higher monthly expenditures among working class families.[75]

Recognizing the importance of locally-driven action, Madison's Common Council adopted a resolution in March 2017 to achieve community-wide 100% renewable energy use and net-zero carbon emissions by 2050.[76] To work towards this goal, Madison's Efficiency Navigator, a resilience, equity, and climate change program that focuses on energy retrofits for small-and medium-sized multifamily housing units, was launched in 2022. This program, open to unsubsidized multifamily housing with rents that are affordable to households at or below 80% area median income, provides free technical assistance and building upgrades (*e.g.*, efficient lighting; improved heating, ventilation and air conditioning systems; better insulation and air sealing; and recommendations to improve home health, such as by reducing asthma triggers). Since the efficiency upgrades are provided for free, owners of the buildings participating in the program agree to maintain rents at affordable levels for a minimum of five years, addressing the challenge faced by landlords when balancing building upgrades and rent prices.[77]

As of early 2024, the program has completed retrofits on 22 multifamily buildings, comprising 126 units altogether, and is anticipated to include 32 multifamily buildings, or 166 units, by the end of 2024.[76] This program reduces GHGs while also addressing key community priorities related to health, and equity simultaneously: 1) maintaining housing affordability by investing in and preserving an unregulated affordable housing stock that provides renters with healthier homes without increasing rent burden; 2) reducing energy cost burden by providing an average annual savings of $625 per building; and 3) prioritizing public health by reducing residents' exposure to indoor air pollutants associated with natural gas and mold.[76]

The first cohort of buildings upgraded through the Efficiency Navigator program cut GHG emissions by 50,000 kg/year – comparable to eliminating nearly 130,000 miles of vehicle travel each year.[76]

FLIP Co-Benefits

A cost-benefit analysis of energy efficiency improvements for new project building vs retrofitting found that the **values generated by retrofit projects are up to 142% greater** than new projects. In 2023, participating households in Madison's retrofit program saw **annual energy savings** of $90 on average, with some saving over $120. The program supports a **diversifying workforce of contractors** to bring these renovations to fruition through a partnership with the Latino Academy of Workforce Development.[76]

As people often spend around 90% of their time indoors, the quality of indoor living conditions directly impacts physical and mental well-being.[78] Energy efficiency measures such as improved ventilation and heating systems can lead to **reduced symptoms of respiratory disease, reduced stress and infectious disease, and reduced risk of cancer.**[79] Additional health benefits associated with building retrofits include **reduced exposure to excess heat or cold, mold, and nighttime noise.**[80]

In the first cohort of building upgrades in the Wisconsin Efficiency Navigator program, ventilation was improved in six buildings, leading to **improved indoor air quality** and **reduced exposures to environmental pollutants.**

This program specifically targets a portion of the housing sector that is **frequently left out of energy efficiency programs:** unregulated affordable multifamily buildings. Program outreach has led to a sense of **empowerment amongst renters,** catalyzing broader community conversations about the benefits of energy efficiency.

Induction Cooking in Ecuador

Cleaner cookstoves promote public health and save money

Beginning in the 1970s, like many developing nations, Ecuador's government subsidized the transition to cook stoves that used liquified petroleum gas (LPG). Because 80% of LPG is imported, these subsidies cost the government ~$700 million/year.[81] Though cleaner than many alternatives, LPG is not harm free; gas stoves using LPG emit pollutants harmful to humans such as nitrogen dioxide (NO_2), volatile organic compounds (VOCs), and benzene into the air, in many cases even when stoves are turned off.[82]

In 2014, the Ecuadorian government launched the LPG Substitution Programme, replacing 750,000 gas burners with induction stoves over six years, representing 1/10 of all households in Ecuador.[82] A post implementation study found that this transition translated to immediate, local health benefits for Ecuadorians, including significantly reduced rates of respiratory-related hospitalizations, chronic obstructive pulmonary disease (COPD), and all-cause hospitalizations even after adjusting for confounding factors such as income, healthcare access, and ambient air quality.[82] For each 1% increase in household enrollment in the program, hospitalizations decreased by 0.74% for both all-cause and respiratory illnesses, and by 2.11% for COPD.[82,83] At the same time, quantified from 2015-2021, the program reduced Ecuador's GHG emissions from the residential energy sector by 7%.[82] Residential electrification has proven to be a particularly effective GHG reduction strategy in Ecuador because the grid consists of 90% renewable energy sources and induction stoves are 10-40% more efficient than gas burners.[82]

The program's overall aim is to replace 3 million stoves (83% of households in Ecuador) by 2030, at an estimated total public cost of $150-180 million dollars, the equivalent price of just ~3 months of subsidized LPG.[82] The ambitious goals have gained momentum through widespread support: private industry, motivated by financial interests, has organized local workshops to showcase induction stove benefits; pilot study participants have praised the stoves as quicker and easier to use; and the government has benefited from both cost savings and improved energy security due to reduced LPG consumption.[81] A win-win-win-win for public health, business, government and the environment.

Ecuador's program reduces carbon emissions by an estimated 2.58 metric tons of CO_2e per year (49 million from 2014-2030) – equivalent to 9% of Ecuador's total energy sector emissions.[81]

FLIP Co-Benefits

Full implementation would save the government **$700 million/year in avoided LPG subsidies** while costing only **$150-180 million dollars in public investment** (a payback period of ~3 months).[82] **Decreased hospitalization rates** associated with the program saves government dollars. Manufacturing and installing induction stoves creates **new jobs and local industry. Individual households save on energy bills** as induction cook stoves are more efficient.[81]

Transitioning from LPG to electric stoves **reduces indoor emissions** of harmful air pollutants such as VOCs, NO_2, and benzene.[81]

A post implementation study found that the transition to induction stoves **significantly reduced rates of respiratory related illness, all-cause illness, and COPD** even after adjusting for factors such as income and healthcare access.[82] For each 1% increase in household enrollment in the program, hospitalizations decreased by 0.74% for both all-cause and respiratory illnesses, and by 2.11% for COPD.[82,83]

Pilot program participants **preferred the new electric stoves,** highlighting induction burners' "ease of use, speed of cooking, increased [energy] security, and reduced energy consumption."[81] The program's implementation introduced stakeholders new to climate related issues and various socio-economic impacts in a tangible way.[81]

Net-Zero Building in Silver Spring, Maryland

The Unisphere builds resilience while lowering emissions

To achieve global GHG reduction goals, new buildings will need to be designed and constructed to be "net-zero," meaning they produce as much, if not more, energy from clean sources as they consume.[84] Net-zero buildings provide benefits beyond just carbon reductions, delivering additional environmental, economic, and social benefits for their inhabitants, users, and surrounding communities.

The Unisphere, located just outside Washington, DC, in Silver Spring, Maryland, is a 210,000 square foot building that features office and laboratory space, structured parking, retail space, and a sizeable atrium, making it one of the largest net-zero commercial buildings in the United States.[85] Opened in 2018, the building has a tray of solar panels that generates 1,175 MWh of energy per year, the equivalent amount of energy needed to power 109 homes in the US.[85]

The building leverages design features such as natural ventilation, a geo-exchange system that provides efficient heating and cooling cycles, vegetated roofs to reduce heat and manage stormwater runoff, and a centralized automation system that optimizes system performance, thus reducing energy consumption.[85] The building also features a large storm water basin, designed to collect 780 gallons of water per minute and prevent overwhelming the city sewer system.[85] Heating and cooling systems within the building use refrigerants that have a lower atmospheric impact, and during the construction phase of the building, over 96% of waste was diverted from landfills.[85]

In addition to its minimal environmental footprint, the Unisphere builds climate resiliency: ne- zero buildings with scaled renewables are more resilient to grid disruptions and extreme weather events, which are expected to become more frequent due to climate change.[86]

Zero-carbon buildings like the Unisphere support progress toward meeting the Paris Agreement as all new buildings must be zero-carbon to meet emissions reductions targets.[26]

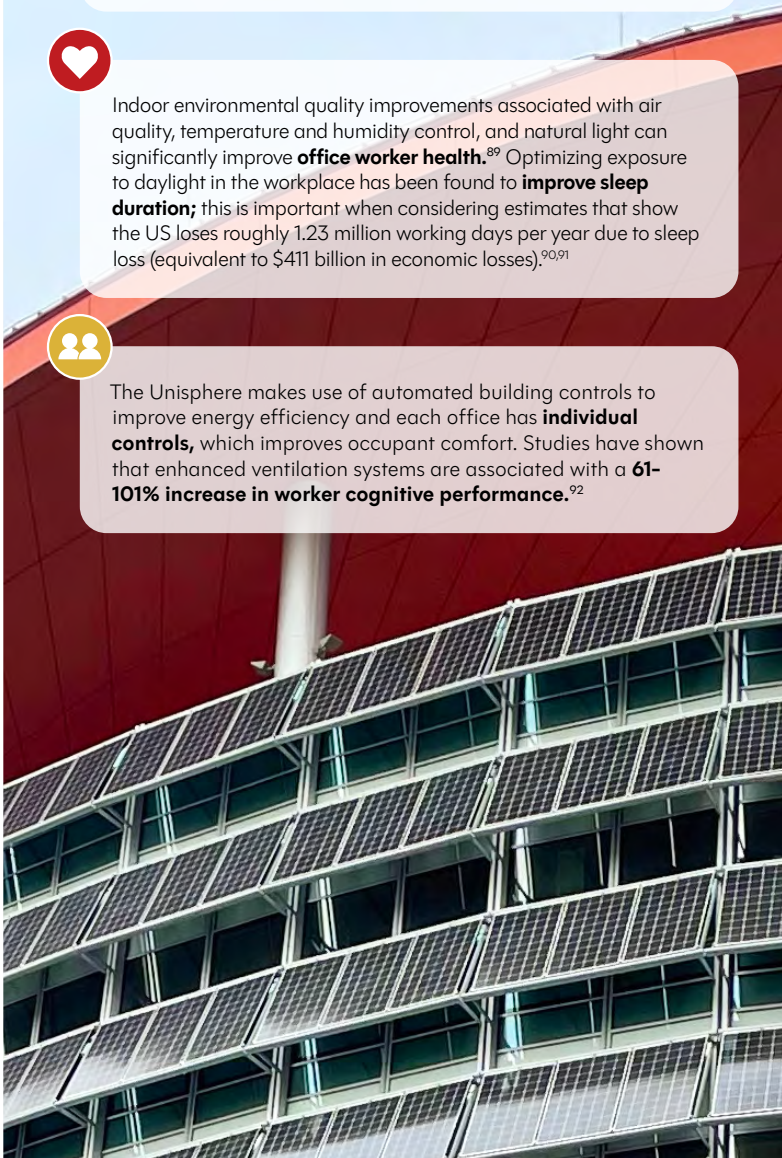
FLIP Co-Benefits

The Unisphere generates all needed energy onsite, eliminating the need for traditional energy sources and **associated costs.** So far, the project has exceeded energy-swap expectations, producing energy exceeding its needs and delivering additional power back to the grid – in just nine months, enough energy was generated to power nearly 23 homes for a year.[87]

Green roof infrastructure serves as a **natural purification system,** removing harmful pollutants and reducing **hyperlocal ambient air and surface temperatures**. Green roofs retain rainwater, reducing stormwater runoff and the costs associated with combined sewer system treatment and energy usage.[88] Clean construction practices kept over 96% of construction waste out of landfills.[85]

Indoor environmental quality improvements associated with air quality, temperature and humidity control, and natural light can significantly improve **office worker health.**[89] Optimizing exposure to daylight in the workplace has been found to **improve sleep duration;** this is important when considering estimates that show the US loses roughly 1.23 million working days per year due to sleep loss (equivalent to $411 billion in economic losses).[90,91]

The Unisphere makes use of automated building controls to improve energy efficiency and each office has **individual controls,** which improves occupant comfort. Studies have shown that enhanced ventilation systems are associated with a **61-101% increase in worker cognitive performance.**[92]



TRANSPORT

Transportation is humanity's connective tissue, linking people to jobs, education, essential services, and each other. It also remains a carbon-intensive sector in most of the world, contributing nearly 14% of the global emissions share.[26] The majority of these emissions come from road transport, chiefly personal vehicles, which emit more CO_2 per passenger-kilometer traveled than all other urban land transport modes.[93] To achieve the necessary reductions in the transportation sector, we must reduce and avoid motorized travel wherever possible. This will require investment in public transit, including metro, light rail, and bus rapid transit, and the reallocation of urban space away from cars and towards other transportation infrastructure like walking and cycling. For the motorized travel that remains, we must improve fuel and material efficiency (i.e., electrification). Decarbonization of the transportation sector will help achieve global climate change mitigation targets while also providing significant FLIP co-benefits. Public transportation projects are cost effective, producing benefits that far exceed costs, making them **FREE** in the long term. For example, a cost-benefit analysis of Mexico City's **bus rapid transit system** found that the benefits far exceed the capital and maintenance costs, and the system has reduced the operating cost of public transport vehicles overall. Transportation-related co-benefits are **LOCAL** and **IMMEDIATE**; **congestion pricing** in London and investment in **cycling infrastructure** in Paris have both generated immediate reductions in traffic-related air pollution, with significant benefits for health and quality of life. These projects have simultaneously achieved other local priorities, making them **PERSUASIVE**: improving transportation reliability, reducing travel times and traffic congestion, and supporting local businesses through increased foot traffic.

Congestion Pricing in London, UK

The **Low Emissions Zone** delivers major improvements to local air quality

Ambient, or outdoor, air pollution causes the premature deaths of approximately 4,000 Londoners annually.[94] In London, road vehicle transportation is the largest source of air pollution emissions, including NO_x, VOCs, carbon monoxide, and PM.[95,96] Traffic congestion also accrues significant economic costs; in 2003, lost time due to congestion cost the economy an estimated 4 million pounds per week.[97]

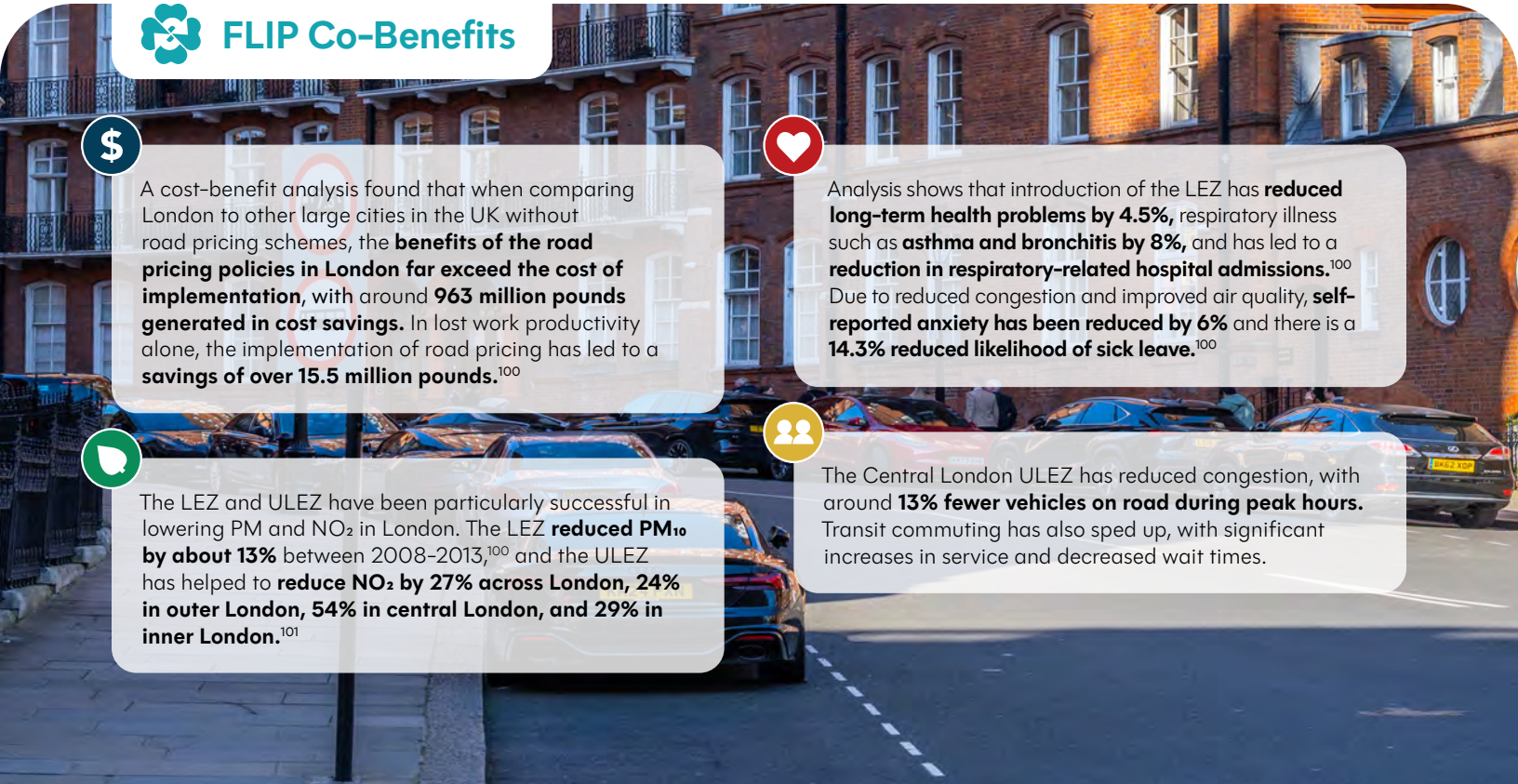
To address chronic traffic congestion and improve air quality in the city, London has implemented a series of targeted road pricing schemes, all designed to meet strategic outcomes. The first and oldest, known as the Congestion Charge, was introduced in 2003 with the intention of combating chronic traffic congestion. The city then established the Low Emissions Zone (LEZ) in 2008, designed to bring London into PM_{10} compliance limits, and within the LEZ, the Ultra Low Emissions Zone (ULEZ) was established in 2019 to address $PM_{2.5}$ and NO_2 pollution.[97] London used the revenue generated from these schemes to invest in public transport infrastructure improvements, including buses, road safety, pedestrian and cycling facilities, neighborhood planning, and green infrastructure.

While the Congestion Charge serves as a blanket charge for all vehicles entering central London, the LEZ and ULEZ additionally impose strict emissions standards by further charging older, more polluting, and heavier vehicles, encouraging a shift to cleaner vehicle usage. Analysis shows that almost 80,000 older, more polluting cars were taken off the road within the first month of the ULEZ expansion in 2023.[98] Since the ULEZ was introduced, NO_2 pollution in London has declined at a rate five times greater than the average across the rest of the United Kingdom, and the NO_2 exposure gap between the most and least deprived areas in London has been cut in half.[97]

While the introduction of a congestion pricing scheme in London was regarded as a political risk at the time of its implementation in 2003, charging zones have quickly become a staple feature of city life. Polling conducted in 2024 by Clean Air Wins, found that once congestion pricing schemes have been introduced and there is a period of time for the community to get adjusted to the changes, support is largely positive for road pricing: Support for the ULEZ in outer London rose from 46% before the expansion to 53% within six months of it being extended to those areas.[99]

The success of London's strategy has helped drive national efforts to cut air pollution, leading to the introduction of Clean Air Zones – modeled on the LEZ and ULEZ – in cities such as Birmingham, Bristol, and Bath, with more planned across the country.[97]

Between 2018 and 2022, the ULEZ led to an estimated reduction of 800,000 tons of CO_2 from vehicles across London.[102]



FLIP Co-Benefits

A cost-benefit analysis found that when comparing London to other large cities in the UK without road pricing schemes, the **benefits of the road pricing policies in London far exceed the cost of implementation**, with around **963 million pounds generated in cost savings.** In lost work productivity alone, the implementation of road pricing has led to a **savings of over 15.5 million pounds.**[100]

Analysis shows that introduction of the LEZ has **reduced long-term health problems by 4.5%,** respiratory illness such as **asthma and bronchitis by 8%,** and has led to a **reduction in respiratory-related hospital admissions.**[100] Due to reduced congestion and improved air quality, **self-reported anxiety has been reduced by 6%** and there is a **14.3% reduced likelihood of sick leave.**[100]

The LEZ and ULEZ have been particularly successful in lowering PM and NO_2 in London. The LEZ **reduced PM_{10} by about 13%** between 2008-2013,[100] and the ULEZ has helped to **reduce NO_2 by 27% across London, 24% in outer London, 54% in central London, and 29% in inner London.**[101]

The Central London ULEZ has reduced congestion, with around **13% fewer vehicles on road during peak hours.** Transit commuting has also sped up, with significant increases in service and decreased wait times.

Cycling Infrastructure in Paris, France

The **100% Cyclable City** achieves benefits for climate and health

When Paris Mayor Anne Hidalgo assumed office in 2014, she set ambitious goals to mitigate climate change while enabling all Parisians to thrive. Recognizing the "urgency of both the health crisis and the climate crisis we are facing," she committed to reduce pollution and restore urban nature, particularly in the face of climate change and rising temperatures.[103]

A central part of Mayor Hidalgo's vision for Paris was to reallocate space away from personal vehicles, and put pedestrians, cyclists, and transit users at the forefront. With these actions, she aimed to mitigate climate change, while also improving air quality and reducing death and disease from traffic-related air pollution.[25] The shift from car-centric infrastructure would also produce safer, more vibrant public spaces while supporting Hidalgo's efforts to create a "15-minute city," wherein residents can access everything they need – food, work, play, healthcare, and more – all within a 15-minute walk of their home.

The Mayor's efforts have delivered unparalleled success. Over the past 10 years, Paris has closed more than 100 streets to motor vehicles, including, famously, both banks of the Seine, making what had been a noisy and polluted four-lane highway along the river into a vibrant public space. The city has removed over 50,000 parking spots, and constructed over 550 km of new cycle paths, with the goal of making Paris a "100 percent cyclable city." [104] These investments offer safer environments for pedestrians and cyclists, fostering a sense of community.

In addition to its investment in the cycling network, Paris has expanded its bikeshare "Velib" fleet, now one of the largest such systems in the world; installed bike racks and bike parking facilities, particularly at transit locations; implemented a subsidy program for new electric bikes and bike repairs; redesigned traffic light cycles to prioritize buses, streetcars, and bicycles over personal vehicles; and plans to extend a 'how to ride a bike program" to all elementary school students to ensure that all young Parisians know how to ride a bike by the time they reach secondary school.[104]

Between 2019 and 2022, cycling in the city increased by 70%,[105] and cycling now surpasses cars as a means of transportation both within the city and between the city and its surrounding suburbs.[106] This has resulted in major air quality improvements; according to a report from the City of Paris, the majority of air pollutants, including PM, NO_2, and benzene, saw their concentrations decrease by 35% to 45% between 2013 and 2023, thanks in particular to the reduction in emissions from road traffic.[107] Meanwhile, the 15-minute city is supporting quality of life for all Parisians; as of 2024, 95% of residents live within 5 minutes of a *boulangerie*.[105]

Paris's high-quality bike network reduces CO_2 emissions by making it possible to avoid vehicle transportation.[26]

FLIP Co-Benefits

Biking infrastructure is low cost, making it a highly cost-effective strategy to reduce car use. Pedestrianized zones have **boosted local businesses** by attracting more foot traffic. Walking and cycling support the 15-minute city, which further bolsters local business; 95% of Parisians **have a bakery within 5 minutes of their home.**[105]

Reduced traffic-related air pollution is associated with **improved outcomes for respiratory and cardiovascular health,** including decreased prevalence of asthma, improved lung function, and lower blood pressure, as well as mental health benefits. Designated cycling infrastructure reduces conflicts between cyclists, motor vehicles, and pedestrians, **reducing injuries.** Active transport such as walking and cycling encourages **daily physical activity,** reducing the risk of heart disease, stroke, and diabetes.[108]

Shifts from car use to cycling and active transport modes reduce traffic-related air pollution. Paris has seen a **40% reduction in air pollution** between 2013 and 2023.[107]

Reclaiming public land for active and shared mobility schemes supports **public safety, builds community cohesion, and improves quality of life** for residents.

Bus Rapid Transit in Mexico City, Mexico

Metrobús brings faster commutes and cleaner air

Mexico City is one of the largest metropolitan areas in the world, with a population of over 20 million people and a population density of over 6,000/km^2. The region has long struggled with air pollution due to rapid industrialization and population growth (growing from just 3 million residents in 1950) and the City's poor air quality is further exacerbated by its topography; in 1992 the UN declared Mexico City the most polluted city in the world.[109] Air pollution has a significant impact on the city's economy and the health of its residents. In 2007, the city's residents were losing 2.5 million working days a year due to health problems caused by particulate matter.[110] The government, as the provider of healthcare, bore the costs of these health impacts. For the last three decades, improving air quality has been a major priority for policymakers in the region.

At the same time, Mexico City has struggled to meet the transportation needs of its rapidly growing population. The main public transit system, Metro rail, had long exceeded capacity, leading to increased prevalence of private bus and minibus lines, as well as private car ownership.[111] In the early 2000s, Mexico City identified bus rapid transit (BRT) as a way to simultaneously address congestion, transportation needs, and air pollution. BRT is a public, high-quality bus service, characterized by dedicated lanes and intelligent technologies, that offers similar service to a rail transit system but can be implemented at a fraction of the time and cost. It has low initial investment costs, continued low maintenance costs, as well as operating flexibility.[112] BRT offers a way to reduce GHG emissions by reducing vehicle miles traveled (VMT) from single-occupancy vehicles.

Mexico City opened its first BRT lines in 2005, replacing standard buses with articulated BRT vehicles that stop at enclosed, rail-like stations.[111] Vehicles have a maximum capacity of 160 passengers and run at extremely high frequencies, as high as 56 per peak hour.[113] These routes significantly reduce travel times; one corridor reduced travel time by public transit from 1.5 hours to 1 hour. [113] Metrobus has also reduced traffic-related fatalities and injuries, with one particular line found to have reduced both by 38%.[111]

Since implementation, the city has observed significant reductions in CO, NO_x, and PM_{10}.[114] These reductions were augmented by the efficiency of BRT – because passengers are transported more quickly and efficiently, their exposure to air pollution is reduced. One study found that the implementation of the BRT system reduced commuters' exposure to pollutants such as CO, benzene and $PM_{2.5}$ by 20% to 70%.[115] These reductions, which have been observed with diesel buses, are expected to further improve with current efforts to electrify the bus fleet.[116]

These reductions in air pollutant exposure have translated to health and economic benefits. One study estimated that just one line of the BRT system, Metrobús Line 3, has prevented more than 2,000 days of lost work due to illness, four new cases of chronic bronchitis, and two deaths per year, saving an estimated USD $4.5 million.[116] At the same time, the residents of Mexico City are enjoying significantly improved and more predictable travel times, with benefits for their quality of life, productivity, health, and safety.

As of 2015, Metrobús was estimated to avoid 122,000 tons of CO_2 emissions each year, with this number rising as the city works to electrify the entire fleet.[117]

FLIP Co-Benefits

A cost-benefit analysis of Metrobús found that the benefits far exceed the capital and maintenance costs, and that the system has **reduced the operating cost of public transport vehicles overall.** BRT **reduces healthcare costs** associated with injury and fatality crashes and air pollution, and offers **economic benefits** from reductions in lost work days and increased productivity from reduced travel times.[116]

BRT has **reduced overall exposure to traffic related air pollution,** which is associated with heart disease, asthma, and respiratory infections, among other diseases.[116] Metrobús has also been found to **reduce traffic-related fatalities and injuries**, with one particular line found to have reduced both by 38%,[111] and has also led to **increased physical activity** – BRT passengers walk more per trip than those who rely on private cars or taxis, providing additional benefits for cardiovascular health.[116]

Introduction of Bus Rapid Transit helped to **significantly reduce traffic-related air pollution** in Mexico City, a major policy priority for the city. Analysis based on real field data from air quality monitoring before and after BRT implementation found **significant reductions in CO, NO_x, and PM_{10}.**[114] Other studies have found that BRT resulted in **20-70% reductions in commuters' exposure to benzene and $PM_{2.5}$.**[115]

Reduced travel times and more reliable service has **improved quality of life** for Mexico City residents. Commuting passengers can get to work faster, allowing them to work more hours, enjoy more leisure time, or both. Improved reliability **reduces stress** associated with commuting. Because the largest proportion of Metrobús users are in lower- and middle-income groups, these benefits are most concentrated among lowest income populations, promoting **equity.**

Bus Electrification in Santiago, Chile

Electric Red Movilidad buses lower emissions and save lives

Over 84% of the Latin American and Caribbean population lives in cities, making this region the second most urbanized in the world. This primarily urban population makes use of mass-public transport. Existing regional public transportation systems service 68% of all passenger travel, with roughly 43% of urban residents having convenient access.[118]

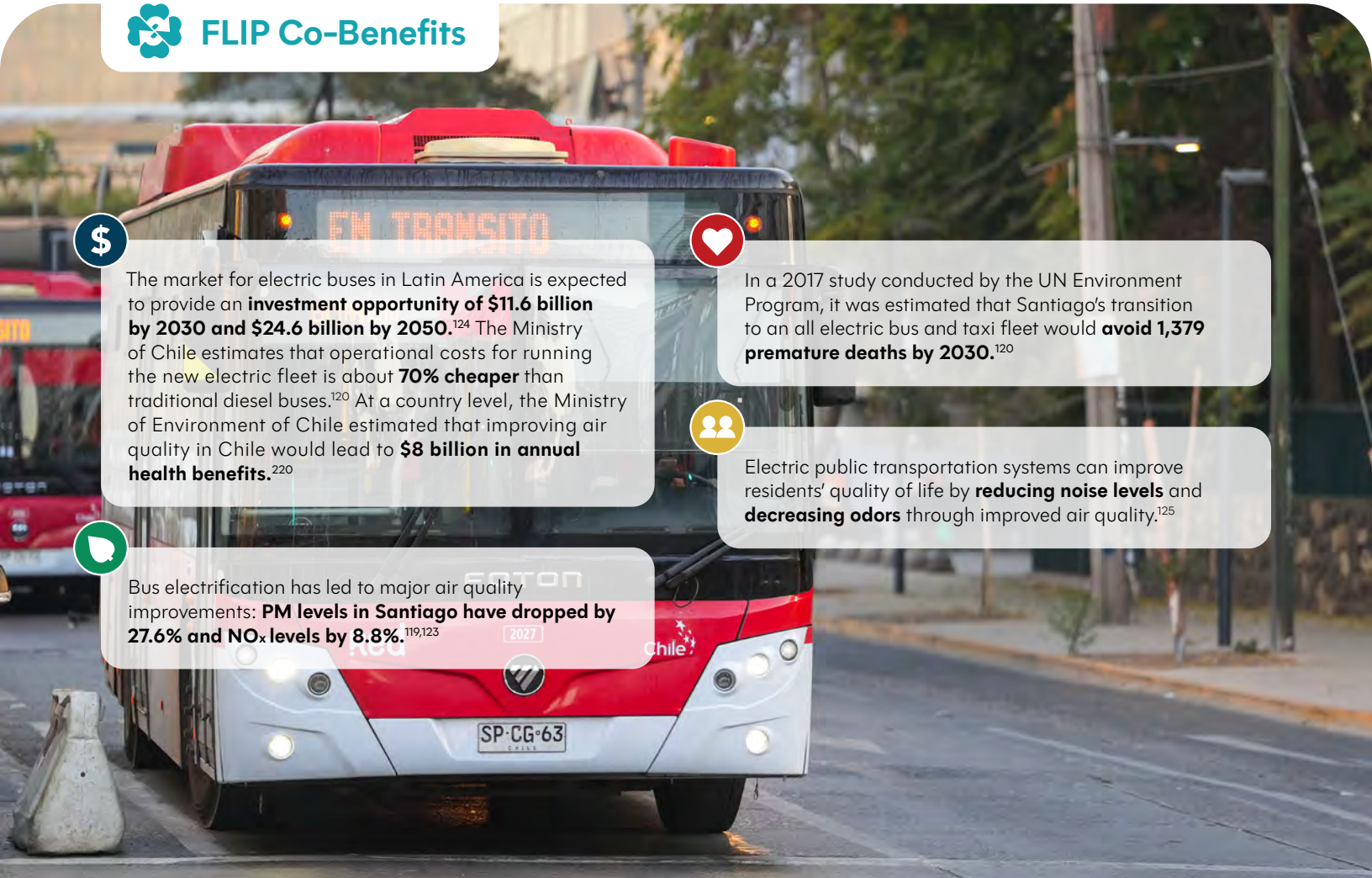
In Chile, poor air quality caused by diesel powered vehicles and wood burning for heating and cooking accounts for 4,000 premature deaths annually.[119] The city of Santiago has had particularly historic struggles with poor air quality. In 2015 over 1,300 businesses were forced to close and 40% of personal passenger vehicles were taken off the road due to disastrous environmental conditions. With close to 25% of GHG emissions coming from the transport sector, Chile had an opportunity to prioritize mobility solutions at the intersection of air quality, health, and climate change.[120]

In 2018, Santiago became the first city in Latin America to adopt Euro VI emissions standards – stringent emissions standards for heavy duty vehicles such as buses – for its public transportation system, an action that laid the groundwork for electrifying its bus fleet.[119] Today, the city is operating approximately 2,500 electric buses with the target to have a fully electric fleet by 2035, the second largest outside of China.[121,122]

Since implementation, Santiago's PM emissions dropped by 27.6% in the two year period between 2018-2020.[119] Additionally, there has been an 8.8% reduction in nitrogen oxides (NO_x).[123] The Clean Air Coalition estimates that due to Santiago's pollution control programs and activities, including the implementation of electric buses, there has been a 17% decrease in emergency room visits (equivalent to 500,000 visits).[119]

Each electric bus in Santiago prevents as much as 60 tons of annual CO_2 emissions.[120]

FLIP Co-Benefits



The market for electric buses in Latin America is expected to provide an **investment opportunity of $11.6 billion by 2030 and $24.6 billion by 2050.**[124] The Ministry of Chile estimates that operational costs for running the new electric fleet is about **70% cheaper** than traditional diesel buses.[120] At a country level, the Ministry of Environment of Chile estimated that improving air quality in Chile would lead to **$8 billion in annual health benefits.**[220]

In a 2017 study conducted by the UN Environment Program, it was estimated that Santiago's transition to an all electric bus and taxi fleet would **avoid 1,379 premature deaths by 2030.**[120]

Electric public transportation systems can improve residents' quality of life by **reducing noise levels** and **decreasing odors** through improved air quality.[125]

Bus electrification has led to major air quality improvements: **PM levels in Santiago have dropped by 27.6% and NO_x levels by 8.8%.**[119,123]

FORESTS & LAND

The natural world – forests, peatlands, wetlands – provides crucial ecosystem services, such as air and water purification, carbon sequestration, and erosion control. Human activities that degrade ecosystems, such as deforestation, currently contribute to climate change through the release of GHGs into the atmosphere. Agriculture, forestry, and other land uses (AFOLU) accounted for nearly one-fifth of net anthropogenic GHG emissions globally in 2021; within AFOLU, land use and forestry contribute about 40–45% of such emissions.[26] But, these same ecosystems represent a climate solution if sustainably managed; forests and other ecosystems can lower GHG emissions, sequester carbon by acting as "carbon sinks," and build resilience to climate impacts by acting as natural barriers against storms and erosion. To make global progress in this sector, we must prevent deforestation, peatland degradation, and mangrove loss, while simultaneously pursuing significant reforestation and peatland and mangrove restoration efforts. These strategies are relatively inexpensive, compared to other types of climate interventions, and generate multiple additional benefits for local communities. The economic benefits of **mangrove restoration** in Java, Indonesia, surpassed the initial investment after only 5 years, even while excluding the valuation of significant additional environmental, social, and health benefits – making it **FREE** from a societal perspective. Benefits are **LOCAL** and **IMMEDIATE**: Barcelona's **Superblocks** increased greenspace and tree canopy, reducing noise and heat exposure, while increasing access to nature and physical activity, and community cohesion. And these benefits are **PERSUASIVE**, achieving major local priorities; Freetown's **urban greening** project addressed coastal erosion and the city's exposure to flooding, protecting against future loss of life and infrastructure damage, while sustainable development in Guatemala's **Maya Biosphere Reserve** has reduced outmigration rates in the region – a major policy priority of the Guatemalan government.

Urban Greening in Freetown, Sierra Leone

Freetown the Treetown sequesters carbon and increases community resilience

Freetown, both a port city and the capital of Sierra Leone, is already experiencing adverse impacts from climate change. Freetown's position in a steep, forested peninsula in the Atlantic Ocean, coupled with its high annual rainfall, puts the city's 1.5 million residents at increased risk from floods, landslides, and extreme heat – risks all exacerbated by sea level rise, coastal erosion, and rising temperatures. The city has experienced rapid deforestation alongside massive population growth; in 2020, the city was losing about 500,000 trees per year, and its population is projected to reach 2 million residents by 2030.[126] The erosion from deforestation has contributed to catastrophic flooding and landslides; an August 2017 landslide killed more than 1,000 people, displaced 5,000 more from their homes, and caused millions in damage to buildings and infrastructure.[127]

Freetown's leaders recognized that immediate actions needed to be taken to build the city's resilience to future weather-related hazards. The city has embraced nature-based solutions to address tree canopy loss and reduce erosion. In 2020, the city launched a campaign to plant 1 million new trees by 2024, a campaign they dubbed "Freetown the Treetown." This innovative effort directly engaged community members by paying residents to plant, grow, and digitally track trees in a mobile app. This sustained, community-based approach ensured that trees would receive the care needed to survive to maturity.[128] The campaign generated 3,000 local jobs and sourced seeds from local businesses; in all, an estimated 80% of project resources remained in the local community.

Freetown's planners recognized that the tree planting would achieve multiple objectives, and strategically determined tree planting locations with these objectives in mind. Trees were planted in residential areas and near community hubs such as schools in order to address health impacts from heat stress and air quality. Trees were planted in the water catchment to improve water security. And additional plantings targeted roadsides and high slopes around the city to reduce flood and landslide risks.[126]

Freetown the Treetown has been considered a massive success, already reducing flood risk, coastal erosion, and the risk of landslides, while enhancing water security, reducing heat stress, and improving air quality.[128] It has served as a model for other cities looking to reforest urban areas.[126] In particular, its success has been attributed to the robust community engagement, effective use of technology, and effective messaging strategies.

Despite the success of the original project, Freetown has already determined that the 1 million newly planted trees will be insufficient to address looming climate risks. It has developed plans to dramatically scale up the project, aiming to plant an additional 3 million trees by 2050.

The Treetown project area has the potential to sequester up to 500,000 tons of CO_2.[128]

FLIP Co-Benefits

The campaign has strengthened the capital's resistance to erosion and flooding, protecting **against infrastructure damage and attendant economic losses,** as well as **increasing property values.** It has also benefited the local economy by **creating 3,000 green jobs,** and the 2050 campaign is expected to create many thousands more. The project has intentionally kept **80% of investment in the local economy.**

Increased resilience will save lives that would otherwise be threatened by floods and landslides. Increased tree canopy **reduces heat exposure** and its adverse health impacts, including heat exhaustion, heatstroke, heart attack, and stroke. Freetown residents will also see **health benefits from improved air quality.** Evidence suggests that neighborhood tree cover in urbanized areas is associated with **better overall health.**[129] In addition, the program was designed to protect water security, which helps **prevent water shortages** that would further threaten community health.

Ecosystem restoration in Freetown helps **prevent biodiversity loss** caused by deforestation and **improves air quality.**

The project invested in the local community, **particularly women and young people.** Tree cover in urban communities is also associated with **better neighborhood social cohesion.**[129]

Mangrove Restoration in Demak, Indonesia

Building with Nature builds resilience and community cohesion

Over 30 million people on the Indonesian island of Java have had their communities and means of living destroyed by coastal flooding.[130] Man-made barriers and traditional mangrove replanting projects have been expensive and ineffective in protecting these communities from environmental impacts. In Demak, a district of towns on the northern coast of Java, Wetland International's community-based "Building with Nature" restoration project achieved a sustainable, affordable solution with immediate local benefits for the community.[131]

From 2015-2021, the $8 million project employed local community members to build and maintain permeable structures to trap mud, allowing mangroves to naturally grow back. Additionally, local aquaculture farmers were trained in sustainable practices at schools created as part of the project and given conditional loans to convert to sustainable farming methods. If by the end of the loan at least 80% of agreed terms were successfully implemented, the loan would be forgiven, converted to a grant. Communities were further empowered through the creation of the "Bintoro Forum," a coalition of 10 community groups tasked with government advocacy and maintenance of the project.[132] This novel approach has yielded up to a ~6x higher success rate than traditional replanting schemes, restoring 119 hectares of mangroves and 300 hectares of sustainable aquaponds, a total area larger than NYC's Central Park.[133] The mangroves protect against flooding by reducing the impact of storm surges, dampening waves, and trapping sediments, and act as a large carbon sink, pulling 3-5x more carbon out of the atmosphere than tropical forests of the same size.[134] The program's success has inspired action both domestically and abroad; Building with Nature has kicked off an identical program in Suriname and other replication sites throughout Indonesia.[135]

Originally working under Wetlands International, Building with Nature is now fully operated by the local communities the projects serve. Though the project has been successful in the short term, the Bintoro Forum and other local partners' continued engagement will be paramount to the project's long term success. As the over-extraction of groundwater from government and corporate projects in the nearby city of Semarang is projected to cause 2 meters of subsidence in Demak over the next decade, Building with Nature will be essential to Demak's future resilience.[131]

Building with Nature's restoration of 119 hectares of mangroves and counting works towards the Paris Agreement climate goals as 240,000 hectares of mangroves must be restored globally, a 16x increase from current rates.[26]

FLIP Co-Benefits

Before the project, **>500 ha of aquaculture and rice fields had been lost to flooding and coastal erosion,** decreasing local income in Demak by 60-80%. Since implementation, **farmer profit margins have tripled** from reduced erosion, higher fish yields, and organic labeling.[131] Farmers' new sustainable practices avoid the need for costly chemicals. Replanting **avoided government spending** on man-made flood barriers, while **new local jobs** were created in the "Eco-tourism" sector. Economic gains **surpassed the initial investment within 5 years,** without considering the environmental, social, and health benefits.[131]

The mangroves **prevent flooding** by reducing the impact of storm surges, dampening waves, and trapping sediments. Additionally, they **provide new habitats** and **filter toxins,** greatly increasing fish and bird populations, and thus, **increase biodiversity.** Sustainable farming practices **decrease use of toxic chemical inputs** such as fertilizers and pesticides.[131]

The restored mangrove forests make the Demak coastline more resilient to coastal flooding, reducing health risks for local residents, such as **acute injuries and drownings, gastrointestinal infection** from contaminated flood water, and **vector-borne disease** from the increase in vector habitat formation from standing water.[136] Sustainable farming practices **reduce occupational exposure** to harmful chemicals.

The project created a **sustainable coastal farming school,** leading to >80% adoption of sustainable techniques by participants. The **"Bintoro Forum,"** the community group now running the program, has become a powerful liaison to the government. Most importantly, the project brought **hope, cohesion,** and **empowerment** back to a community struggling from the effects of climate change.[131]

Community-Centered Sustainable Forestry in Guatemala

Maya Biosphere Reserve's (MBR) Community Forest Concessions (CFCs) support deforestation and the local economy

A massive carbon sink and key biodiversity hub, home to nearly 2,000 plant and animal species, the 2.1 million hectare UNESCO-designated Maya Biosphere Reserve (MBR) holds great importance both within Guatemala and globally.[137,138] Experts estimate that globally, rainforests constitute up to 50% of all plant based carbon sequestration.[139] As every hectare of rainforest prevents an estimated 330 tonnes of carbon from entering the atmosphere, curbing deforestation is vital to Guatemala's United Nation (UN) Nationally Determined Contribution (NDC) commitment to reduce country emissions by 11.2%, as well as for broader global emissions reduction targets.[139,140]

In the 1990s, two options emerged for the Guatemalan government to curb the MBR's deforestation crisis: adopt strict conservation, including expelling existing Indigenous populations from their homes in the reserve, or establish "Community Forest Concessions (CFCs)", entrusting local populations to sustainably manage and benefit from the land.[141] Though initially opposed by many environmentalists, CFCs have proved incredibly successful, in stark contrast to the neighboring conservationist projects. Local communities benefit from the land in many ways, creating successful business ventures through sustainably harvesting timber, processing ramon nuts into flour, creating traditional church service floral bouquets known as Xate, and many other creative enterprises.[138] While benefiting from the land over the 20 years of forest management in the MBR, CFCs have accomplished a nearly 0% deforestation rate. By contrast, strictly conserved forest lands that do not legally allow locals to utilize the forest's resources have suffered up to 87% deforestation rates, mainly due to illegal cattle ranching and drug trafficking activity in the area.[139]

In addition to preserving the MBR's forests, CFCs have built sustainable local economies, creating 12,000 jobs and generating $69.6 million in sales from 2013-2021.[138] Many of the 100 newly formed businesses are led and staffed by women. This growth has led to significantly lower poverty rates in CFCs when compared to the rest of the country, evidenced by decreased migration out of these communities (2% from CFCs vs 7% nationally).[138] These achievements contribute towards Guatemala's core policy aims of combating poverty and underdevelopment, issues that have fueled migration to the US, complicating diplomatic relations between the nations.[142] An additional 424,000 Ha of land were granted to the stewardship of CFCs in 2021, illustrating that economic development and climate action can go hand in hand.[137]

MBR's CFCs' near 0% deforestation rate over 20 years works toward meeting the Paris Agreement climate goals as deforestation rates must decline by a factor of 4.[26]

FLIP Co-Benefits

Community concession areas have **significantly lowered poverty rates** when compared to the rest of Guatemala, highlighted by **drastically decreased outmigration rates** (2% vs 7% nationally).[138] This effect is due to the development of a sustainable local economy, creating over **100 forest businesses** (many **led and staffed by women**), generating over **12,000 jobs,** and **$69.9M** in total sales between 2013 and 2021.[138]

Associated with the growth of the local economy, **child malnutrition significantly decreased** in the communities.[143] Additional health benefits may include **reducing the risk of vector-borne and waterborne diseases** as these illnesses are associated with deforestation in rainforests.[143] Decreased air pollution from forest fire prevention in CFCs likely improves **respiratory** and **cardiovascular health** in local communities.[144]

Forests managed by community forest concessions in the MBR have accomplished a near **0% deforestation rate over the 20 years** of management, even posting a **net gain** of over **900 acres of forest** for the first time since data tracking began.[138] In addition to serving as a critical **carbon sink,** the MBR serves as a massive **biodiversity hub,** home to over **1,800 animal and plant species.**[137] Due to proper management, **only 2% of forest fires** in the MBR have been started on land managed by community forest concessions.[138]

Civilian involvement in local government and military has increased in community forest concession communities, resulting in an **increase in prosecution of environmental crime** in the region due to an **increase in environmental social awareness.**[141] In addition, **illegal drug trafficking is far less prevalent** compared to neighboring regions, where it remains a critical concern.[139]

Sustainable Urban Design in Barcelona, Spain

Superblocks promote community health and wellbeing

In 1980, an urban planner named Salvador Rueda was tasked by Barcelona's city council to find a solution to Barcelona's noise pollution. The main culprit he found: Cars. All modelled urban design scenarios that included cars passing at 20 mph or higher resulted in unsafe levels of noise exposure for the citizens of Barcelona.[145] As Barcelona has the highest traffic density of any city in Europe, this was a major local concern.[146] Over the following 40 years of research, he found cars to be the villain in the stories of air pollution, carbon emissions, greenspace, active transportation access, and many other urban challenges. With this realization, he set out to design a "post-car city"; not to completely remove cars, but to reclaim public space for the people.

To achieve this, Rueda designed "Superillas" or "Superblocks" in English. Under this model, through traffic is blocked for a 9 square block neighborhood, only open to local traffic and with a strict 6 mph speed limit. Streets are raised to the same height as the curb, and infrastructure like picnic tables, trees, and playgrounds are added. Though cars (including ambulances, fire trucks, delivery trucks, and other essential vehicles) can still pass, ownership of public space is shared equally between car and pedestrian.

When implemented correctly (i.e., providing necessary public transit infrastructure and taking steps to prevent gentrification and displacement), Superblocks provide a clean, quiet, safe environment that's otherwise unattainable in a car-dominated setting. In the Vitoria-Gasteiz Superblock, noise has reduced by 8%, PM air pollution has decreased 38% and NO_2 42%, pedestrian space has increased 29%, and over 60% of residents walk or bike as their primary mode of transportation.

As of 2023, Rueda has completed 6 superblocks, with an ambitious 503 planned in total.[146,147] If all planned superblocks were completed, the projected increases in greenspace and physical activity, and decreases in noise pollution, heat, and air pollution, are estimated to prevent 667 premature deaths annually.[146] Not all benefits are tangible either; perhaps the greatest benefit of all is the fostering of community. Silvia Casorrán, a Poblenou Superblock native recounts, "When we came here, this was like a ghost town; there was no life... Suddenly [after the superblock], you meet your neighbors, you can have dinner outside, kids playing in the street. We love it!" [145]

Superblocks saw motor vehicle travel decrease by 19%, crucial as the percentage of trips made in passenger cars must decrease worldwide to reach the Paris Agreement climate goals.[26,146]

FLIP Co-Benefits

The superblocks model has been estimated to translate to public budget savings by avoiding **$1.8 billion annually in healthcare costs.**[146] Superblocks also may **increase local trade**, as the superblock in Sant Antoni saw a 16% increase in foot traffic.[147]

Implementing all planned superblocks would avoid an estimated **667 premature deaths annually** through reductions in NO_2, noise, and heat, as well as through expanded access to greenspace and increased physical activity.[146] **Increased community cohesion and leisure time physical activity, especially among elders,** have large unquantified health benefits as well.

Superblocks are estimated to **decrease motor vehicle travel** by **19.2%,** saving an estimated 1,190,000 car or motorcycle trips/weekday.[146] In the Gracia superblock, car traffic decreased by 26%, with pedestrian and cyclist travel increasing by 10 and 30% respectively, which is estimated to **reduce city-wide NO_2 pollution levels by 24%.**[146,148] Superblocks **increase urban greening**, expanding greenspace from 6.5 to 19.6% in the Example superblock, including 438 new trees planted.[147] Implementation of all 503 superblocks was estimated to cut the city's **urban heat island effect in half,** decreasing local temperatures by 1-2°C.[146]

Superblocks are seen as **more desirable living conditions** by residents, and **increase community cohesion** by facilitating social interaction, especially among elders.[145,146,147] They also provide spaces for **safe and independent child play,** increasing sociability and physical activity, while decreasing safety concerns among parents.[145,146,147]

FOOD & AGRICULTURE

The food system, or the way we produce, distribute, and consume food, is inextricably linked to climate change, being both causal of and threatened by the climate crisis. Emissions from agricultural production contribute significantly to the global GHG emissions profile; in 2021, they represented 55% of GHG emissions from agriculture, forestry, and other land uses.[26] By some estimates, food system activities, such as raising livestock for consumption, transporting food around the globe, and disposing wasted food in landfills, produce up to a third of global anthropogenic GHG emissions.[149] At the same time, our food system is extremely vulnerable to climate change, as drought, flooding, and severe weather can damage farms and crops and disrupt supply chains.[150,151] As global food demand continues to rise, we will only be able to achieve global food security while also limiting global warming to necessary targets if we significantly change our food production and consumption systems.[152] This will include shifting consumption away from high-carbon foods such as ruminant meats, reducing the carbon intensity of agricultural practices, and preventing food loss and waste.[153,154] In addition to achieving global carbon reductions, these actions generate significant co-benefits at the local level. These actions generate benefits that exceed upfront costs, making them **FREE** in the long term. Oakland's shift to more **climate-friendly school food** actually saved the school district money, while achieving health benefits for students through higher quality, healthier meals. Many of these benefits are **LOCAL** and **IMMEDIATE**; for example, the Tosepan Titataniske Cooperative's **shade-grown coffee** provides improved economic stability and community resilience for farmers in the region. Such climate actions are **PERSUASIVE** as well, addressing local priorities; South Korea's model **food recycling** scheme reduced reliance on landfills in dense population centers, which were becoming a focal political priority due to pests and odors.

Climate-Friendly School Food in Oakland, California

Oakland Unified School District serves up sustainable, healthy school meals

The agricultural industry is responsible for one-fourth of global GHG emissions, with animal agriculture specifically responsible for ½ of the GHG emissions in the sector.[155] The Intergovernmental Panel on Climate Change (IPCC) found that reducing meat consumption is the most effective climate mitigation and water conservation measure for the agricultural industry.[153] Recognizing the climate impact of the food system, the Oakland Unified School District (OUSD) engineered a solution to both feed their students healthier meals and reduce their carbon emissions, while also saving money. In 2014, encouraged by successful pilot programs such as Meatless Mondays and national policy efforts to improve the dietary quality of school meals, the OUSD decreased the amount of animal products in school meals by about a third, and shifted to a climate-friendly approach to menu planning that emphasized locally produced fruits and vegetables and higher quality animal products.

This simple switch reduced school-wide food service GHG emissions by 14%, avoiding 600 tCO2/year, and reduced embedded water use by 6% (42 million gallons a year).[155] The shift also meant 10% more vegetables and fruits on plates, which students have enjoyed; surveys of initial pilot programs showed increased student satisfaction with school meals.[155] These climate, health, environmental, and student satisfaction benefits were realized while saving money, about 1% on every meal.[155] These savings accrued even while increasing the quality (not quantity) of the animal products OUSD purchased by sourcing organically and humanely raised animals from local farms.

This program is not an outlier: "Balanced Menus: Less Meat Better Meat," a plant-forward program at four hospitals, found food service savings of $400,000 per year, and other climate-friendly school meals projects such as Meatless Mondays and California Thursdays have implemented these principles across hundreds of schools.[155] The purchasing power of schools has the ability to reshape the entire food service industry, with 800 million meals purchased by schools annually in California, and over 7 billion nationwide.[155] Healthier, more sustainable meals that students enjoy, all while saving schools money.

Oakland's climate-friendly lunch program reduced GHG emissions from food services by 14%, avoiding 600 tons per year.[155]

FLIP Co-Benefits

Cutting back on animal products **saved OUSD $42,000/year,** 1% per meal.[155] Similar projects at hospitals have seen **savings of $400,000/year.**[155] Moving towards healthier diets for children will help California reduce healthcare costs, generating **substantial long-term savings.**[156] OUSD's commitment to sourcing local food provides a substantial and steady demand, over 26,000 meals daily,[157] that **supports regional farmers and strengthens rural economies.**[155]

The program reduces embedded water consumption by 6%, saving **42 million gallons of water per year.**[155] Sourcing food locally also **decreases transportation distance and time,** reducing air and water pollution along travel routes.

Eating fewer animal products and switching to a more plant-based diet reduces **risk of heart disease, cancer, and diabetes.**[155] Healthy eating promotes a myriad of additional benefits for children, including **promoting brain development, strengthening bones, and supporting healthy growth.**[158] Healthy lunch programs build **healthier, more sustainable eating habits** for the rest of students' lives.[155] The purchase of organic, humanely raised animals reduces exposure to potentially harmful chemicals, which can be particularly harmful to children.[155]

An assessment of the pilot found that the shift to more plant-based menus boosted **student satisfaction** with the meals.[318]

Food Waste Recycling in South Korea

Food waste diversion reduces both methane and odors

Banchan, a variety of side dishes including kimchi and unfermented vegetables, are a staple of South Korean cuisine. Traditionally, they are served with every restaurant meal at no added cost, and are often left unfinished. In part due to this practice, South Korea has one of the highest rates of food wastage in the world, where residents generate an average of 130 kg of food waste per person per year.[159]

In the 1990s, food waste became a major policy priority in South Korea, following an intense period of urbanization and rising standards of living. Together, these changes contributed to significant population density (today, South Korea is one of the most densely populated countries in the world) and increasing levels of food waste began to create a nuisance, as landfills located near population centers reached or exceeded capacity. Residents complained about pests and odors, making the issue a top political priority. Due to South Korea's population density, traditional waste solutions such as landfills and incinerators were not a viable solution, so the country turned to recycling.[160]

In response to resident demand, South Korea developed a comprehensive food waste recycling program. Under the program, residents dispose of their food waste in designated bins and pay for it by weight. Food waste is picked up on a weekly basis, and transported to a facility that processes it, separating it into liquid, which is then turned into biogas and solid scraps, which are used as compost and livestock feed.

South Korea's food waste policies were initially met with some pushback from the public due to having to pay fees for food waste. However, the government's intensive education and outreach efforts (accompanied by the rising frustration with smelly landfills) helped get the public on board with the new scheme, which was further reinforced once residents experienced how well the system worked.[159] To address resident concerns, the government implemented the program thoughtfully, taking time to study barriers to implementation, engaging stakeholders such as restaurant owners and citizens, and ensuring that it created a reliable system that is streamlined and easy to use. Policymakers also made sure that the waste would be applied to practical ends, further increasing support. Now, South Koreans consider food recycling a part of daily life.

Today, South Korea recycles nearly 100% of its food waste into fertilizer, animal feed, or biogas for energy (up from just 2.6% in 1996).[161] The program has reduced pressure on landfills, as well as their associated emissions. The generated fertilizer and animal feed saves farmers money and reduces the need to cultivate farmland for animal feed, particularly crucial in a country with already limited arable land. And the biogas reduces South Korea's reliance on fossil fuels, helping the country achieve its ambitious goals for renewable energy. The program also has social benefits; in the words of one resident, "I get a small sense of fulfillment knowing I'm contributing to lowering carbon emissions." [160]

Food waste is a major source of methane, a powerful GHG that traps roughly 80 times more heat than a ton of carbon over a 20-year period.[162]

FLIP Co-Benefits

South Korea's food recycling scheme provides **economic benefits to the agricultural sector** by producing animal feed and fertilizer, reducing costs of supplies for farmers and the need to cultivate already-limited arable land.[161]

Reducing ozone formation by reducing methane emissions has been found to yield substantial **premature mortality benefits**.[204] Reduced reliance on landfills has health benefits for nearby population centers, as exposure to landfill gases may pose health risks.[206]

Food waste recycling **reduces methane emissions,** that also contributes to formation of ground-level ozone, a harmful air pollutant.[205] Fertilizer from the program **reduces the country's reliance on synthetic fertilizers,** which can pollute water sources and harm the environment.

The food recycling scheme has **improved quality of life** among residents in densely populated South Korea by **reducing exposure to the olfactory pollution and vermin associated with landfills** near population centers. Recycling also provides individual benefits through the feelings of purpose and contribution to environmental sustainability.

Shade Grown Coffee in Oaxaca, Mexico

Tosepan Titataniske Cooperative (TTC) applies Indigenous knowledge to produce sustainably grown coffee

In the misty rainforests of the Sierra Norte of Puebla in Mexico, the Tosepan Titataniske Cooperative (TTC) has grown into a highly regarded model of sustainable agriculture, even winning the Nobel prize for Ecological Merit in 2001. The Cooperative, founded in 1978 by Nahua Indigenous communities, spans 66 villages and includes over 18,000 members. Their solution to the widespread challenges of poverty and environmental degradation in the coffee industry is rooted, literally, in the forest: coffee grown in traditional Indigenous agroforestry systems known as Kuojtakiloyan, "productive forests."

The TTC's shade-grown coffee is cultivated beneath a multilayered canopy of native trees, fruit-bearing plants, herbs, and vines. This agroforestry method reduces emissions by avoiding deforestation and emissions typically seen in conventional coffee agriculture, such as those from chemical fertilizers and pesticides. But for TTC, the value of these forests is rooted in more than just carbon. These coffee gardens foster local food systems, economic stability, and community health. Interplanted with over 250 useful plant species, from bananas and citrus to cinnamon and honey, TTC farm products provide nutrition, medicine, building materials, and income. Though these systems produce less coffee than conventional farms, they afford families more financial stability than typically experienced by small-scale coffee producers, even those that have an increased income from the "organic" and "fair trade" labels. Rather than relying solely on the price of coffee, farmers generate revenue through a diversity of crops and forest products, and avoid costly, polluting inputs such as chemical fertilizers and pesticides.

Environmental restoration, often viewed as a tradeoff to economic development, in this case, forms the very basis for it. Trees protect soil from erosion, restore groundwater, nitrogenate the soil, and serve as natural mulch. Over 180 species of birds, as well as bees and other pollinators, thrive in these biodiverse systems, increasing crop yields. The healthy, diverse ecosystem has been shown to protect the coffee from pests and diseases often controlled for by using harmful chemicals in conventional farming setups. The TTC's landscapes have even reversed regional deforestation trends, with satellite data showing a net forest gain in the region. Most importantly, the Kuojtakiloyan is not just a model of sustainable farming, it is a living preservation of centuries-old Nahua knowledge and culture for generations to come.**

** Information for this case study was obtained from Toledo and Moguel (2012), Coffee and Sustainability: The Multiple Values of Traditional Shaded Coffee, *Journal of Sustainable Agriculture*, 36(3), 353-377. http://dx.doi.org/10.1080/10440046.2011.583719 [207]

TTC's agroforestry methods work towards meeting the Paris Agreement climate goals as the GHG emissions intensity of agricultural production must be reduced by 3x relative to 2017 rates.[26]

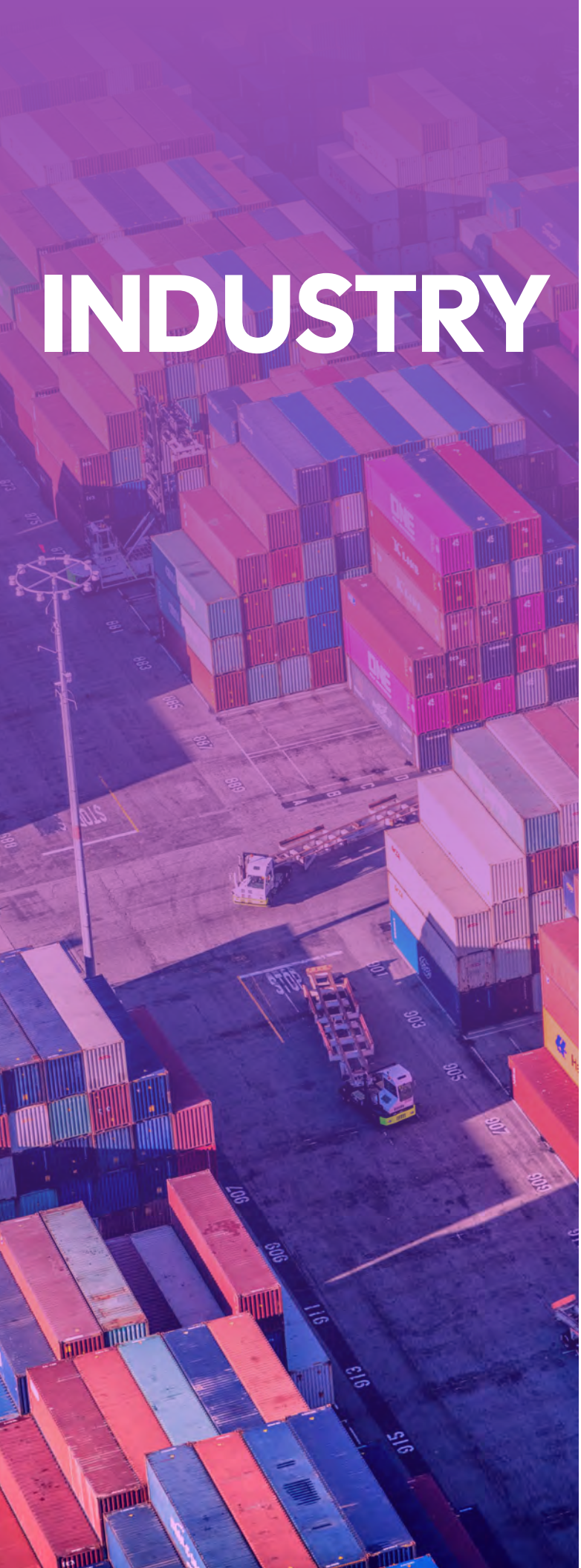
FLIP Co-Benefits

The TTC's intercropping agroforestry model creates multiple, **diverse revenue streams** while also filling their subsistence needs. The forest model **decreases demand for conventional farming inputs** such as chemical pesticides and fertilizers.

Though health benefits were not quantified in the TTC, **decreases in pollution from reduced chemical farming inputs**, as well as **improvements in air quality** from decreased slash and burn techniques frequently seen in conventional agriculture, likely lend health benefits to the local population.

The TTC supports over **250 plant species and 180 species of birds** (20% of all bird species found in Mexico). According to Landsat observations from 1988–2003, the TTC showed a ***reforestation trend,*** in stark contrast to the coffee industry as a whole. The increased biodiversity enhances soil fertility through natural composting and **reduces the need for chemical fertilizers or pesticides.**

The TTC's Kuojtakiloyan farming method is a **living preservation of centuries-old Nahua culture and knowledge**. The cooperative indirectly promotes self-governance through **self-sufficiency and community solidarity.** The TTC has created an educational center for sustainability and cultural preservation and **empowers women** through leadership roles, income-generating opportunities, and training programs.



INDUSTRY

The industry sector, which encompasses the production of goods and materials like cement, steel, and chemicals, as well as the construction of buildings, roads, and other infrastructure, is a major driver of greenhouse gas emissions. Direct emissions from these activities, such as fuel combustion and industrial processes, are responsible for about 20% of global emissions; this figure rises significantly if indirect GHG emissions are included.[26] Industrial emissions are steadily rising due to increased demand for materials and infrastructure due to population growth and rising incomes. Industrial expansion is responsible for about 45 percent of the worldwide growth in GHG emissions over the last two decades alone.[163] To curb industrial emissions in the face of such growth, we must reduce demand for industrial products, substitute more sustainable and efficient materials, and increase circularity in industrial processes. These strategies have significant economic, health, environmental, and social FLIP co-benefits at the local level. These benefits often exceed upfront costs, making them **FREE** in the long term. For example, the **circular economy** employed at Kalundborg's Eco-Industrial Park saves participating companies $26 million per year. These benefits are **LOCAL** and **IMMEDIATE**: the Port of Los Angeles's implementation of **alternative maritime power®** reduced local air and noise pollution, achieving health benefits for the millions of Angelenos living near the port. Finally, these projects are **PERSUASIVE** because they achieve local policy priorities: Oslo's pioneering investments in **zero-emissions construction** have supported the city's efforts to create more green jobs in the construction sector and improve worker health and safety.

Alternative Maritime Power® in Los Angeles, California

The **Port of Los Angeles** delivers cleaner air to workers and surrounding communities

Maritime shipping is a highly polluting industry, accounting for around 3% of global greenhouse gas (GHG) emissions.[164] At ports, the auxiliary engines that are kept running to power the ship's systems during docking emit pollutants such as sulphur dioxide (SO_2), NO_2, and PM, while also contributing to water and noise pollution.[164] Studies conducted globally show roughly 265,000 premature deaths were attributed to global shipping emissions in 2020.[165]

As the busiest container port in the Western Hemisphere, handling roughly 17% of international trade cargo, the Port of Los Angeles experiences heavy traffic and associated emissions, with harmful effects for local health.[166] In Los Angeles (LA) County specifically, health survey data shows that, when compared to other LA communities, those in close proximity to the Port of Los Angeles have higher rates of asthma, coronary heart disease, and depression.[167] Compounding the exposures from the port, many surrounding communities have populations that have been historically overburdened by pollution and face additional socioeconomic vulnerabilities.[168]

In 2004, the Port of Los Angeles opened the first container terminal in the world with Alternative Maritime Power® (AMP), which reduces emissions from vessels while docked at port. In place of the continuous running of a ship's diesel powered auxiliary engines while at berth, AMP®, referred to as shore power at all ports besides Port of Los Angeles, allows for equipped ships to "plug in" to shore side electrical power.[169] Connecting ship power to an electrical grid not only reduces greenhouse gases and harmful air pollutant emissions, but reduces the costs of running a ship's systems, enables fuel conservation, improves maintenance and repair efficiency, and reduces noise pollution.[170] As of 2024, the Port of LA has installed 80 AMP® vaults, the most of any port worldwide.[169]

The California Air Resources Board (CARB) passed a regulation in 2007 requiring that all diesel auxiliary engines be shut off for a percentage of time while at berth, with the option to use a combination of technologies (including shore power) to achieve equivalent emissions reductions.[169] As of 2023, CARB has strengthened the at-berth regulation by expanding vessel categories and requiring that all container, cruise, and reefer vessels use grid-based power (i.e., shore power) or other approved emissions control technologies while docked.[169] A cost-benefit analysis conducted by CARB calculated that the anticipated benefits of avoided adverse health outcomes, valued at $2.32 billion, would exceed the costs of implementing the regulation.[168] Communities surrounding the port have seen significant decreases in emissions, with benefits for public health and environmental quality.

The Port of Los Angeles's CO_2e emissions for 2023 were 24% lower than for 2005, equivalent to a 243,760 ton reduction.[171]

FLIP Co-Benefits

Connecting ship power to an electrical grid **reduces the costs of running ship systems,** allows for **fuel conservation** (thus lower fuel costs), and improves **maintenance and repair efficiency**.

Shore power reduces air pollution exposure for surrounding communities as well as for dock and shipworkers. It is estimated that the proposed 2023 regulation would **reduce the risk of cancer for approximately 2.4 million people.**[168,170] Reduced noise pollution also has public health benefits, as noise pollution is associated with high blood pressure, hearing loss, sleep disruption, and stress-related illnesses.[172]

Since CARB's existing regulation has been put in place, the Port of Los Angeles and other California ports have seen an **80% reduction in emissions** from container, reefer, and cruise vessels at berth; this is expected to increase to 90% emissions reduction with the new 2023 guidelines.[168] Since 2005, the Port of Los Angeles has **reduced $PM_{2.5}$, NO_x, SO_x, and CO emissions by 90%, 74%, 98%, and 61%, respectively.**[171] Cutting off auxiliary engines **eliminates noise pollution,** which affects wildlife and public health.

Local air quality and health benefits are primarily realized by **dock and shipworkers** and in **surrounding communities** – many of which are overburdened by pollution and socioeconomic vulnerabilities.[168]

Clean Construction in Oslo, Norway

Zero-emission construction sites are cleaner and quieter for workers and neighbors

In Oslo, construction accounts for 7% of the city's total emissions profile, without accounting for transportation of both materials and people to and from sites.[173] To help reduce overall emissions from municipal construction projects, as well as to reduce local air and noise pollution, the City of Oslo set out to be a leader in the transition to cleaner construction.

In 2019, the city began operation of likely the first zero-emission urban construction site, using battery and cable electric excavators and battery electric wheel loaders. Zero-emissions construction sites employ extensive material reuse and require that all processes on site use zero-emissions machinery, eliminating the production of CO_2, PM, and NO_x emissions.[173] As of 2024, 85% of city-managed projects use zero-emissions machinery.[174] From 2025 on, all public projects will require the use of emissions-free construction equipment, a step which Governing Mayor Eirik Lae Solberg says "marks a shift in Oslo's clean construction work." [175] Because municipal construction projects in the City of Oslo make up around 20% of the construction market, the city plays a driving force in creating demand for clean technologies.[173]

This move not only signals Oslo's continued prioritization of reducing construction-related emissions, but its commitment to creating safer, greener jobs in the construction sector. Oslo involved workers in decision making, and chalks up its success to worker engagement, job training, and a commitment to equity and inclusivity.[176] The zero-emissions construction equipment creates a healthier environment for construction workers and for the surrounding community. The reduced noise and air pollution is appreciated by neighboring residents and businesses, particularly in busy urban areas, near schools and other institutions, and for nighttime worksites, and has resulted in fewer noise-related complaints.[173] Workers who had initial concerns about the program became supportive once they experienced the quieter, vibration-free tools firsthand.[176]

The City engaged the local construction industry through a Business for Climate network and frequent dialogue to ensure that its policies are feasible for small and medium-sized businesses, including phasing in the environmental requirements gradually to accommodate business size.[176] The local building industry has largely supported the city's policy.[173,176] Oslo's investments will also pay off in the long term. C40 Cities estimated that transitioning to a clean construction industry would require an 18.3% increase in investment but would generate cost savings over time from reduced carbon and air pollution emissions, project efficiencies, worker safety improvements, climate resilience, and overall health and well-being.[177]

Just four years after piloting its first zero-emission construction site in 2019, Oslo reduced its total direct emissions from construction machinery by approximately 15%.[178]

FLIP Co-Benefits

By 2050, the clean construction industry in Oslo is estimated to generate **16.6% more jobs** than traditional high-carbon construction practices would. Over **70% of these new jobs would be created locally,** bolstering Oslo's economy.[177]

Improved air quality and reduced noise creates a **healthier environment for construction workers,** as well as for surrounding communities.[175]

In 2024, 85% of all municipal construction sites in Oslo were **emissions free**.[174] Both machine operators and local residents report that zero-emissions construction sites in Oslo have **drastically reduced noise pollution.**[179,180]

Oslo took care to ensure that the benefits of the clean construction transition accrued equitably, particularly that it be **inclusive to minoritized groups and women.**[176]

Data Center Energy Conservation in Bibai, Japan

White Data Center recycles snow to keep cool and uses excess heat to grow food

In the snowy northern city of Bibai, Japan, the White Data Center (WDC) offers a clever solution to two persistent local challenges: the high cost of snow disposal for the city and the intensive cooling demands of the data center. Data centers like WDC require enormous energy inputs to stay cool, especially as global digital demand surges.[181] At the same time, Bibai faces the expensive task of clearing and disposing deep snow, up to 11 meters each winter, at a cost of $2.9 million in taxpayer dollars annually.[182] The WDC turns these two distinct issues into a single coordinated solution by collecting and storing the snow under an insulative layer and using it to passively cool the data center year round.[183]

Snow passive cooling is not WDC's only creative solution to decrease energy consumption. Rather than discard the remaining heat, it is used to warm tanks for eel farming, a practice chosen for its short cultivation time and high demand in Japan. Excess heat from the data center supports the cultivation of around 300,000 eels every 7 months, many of which are purchased for children's healthy school lunches. The center is also experimenting with using waste heat to cultivate vegetables, such as mushrooms, in an attached greenhouse.[183] WDC's strategy has borne fruit in energy savings as well; these circular practices have reduced cooling costs by 50%, resulting in a 20% reduction of the data center's total energy bill.[182] Currently operating 20 racks of servers, WDC hopes to soon scale up to 200. Serving as a model for success, the WDC has inspired the construction of two additional snow-cooled data centers in Japan.[183]

WDC's creative energy demand reductions are a crucial model for climate mitigation as data centers are a rapidly growing source of carbon emissions, estimated to account for 11.7% of US electricity consumption in 2030, a startling jump from the current 4% share.[184]

FLIP Co-Benefits

WDC's project saves **20% on their energy bill** and diversifies revenue by generating around **83 tons of eels/year for sale.** Recycling snow helps offset the **$2.9 million taxpayer burden** of municipal snow removal. Curbing data center energy consumption is crucial to the local community as local energy prices near large data centers are otherwise expected to increase drastically.[185]

Reduced energy demand from the WDC project indirectly contributes to cleaner air by lowering the need for fossil fuel-based power generation. Pollutants emitted from power generation such as PM, nitrogen oxides, and sulfur dioxide are linked to **respiratory illness, cardiovascular disease,** and **premature death.**[186] Air pollution is a key mortality risk factor in Japan; PM exposure alone accounted for 44,200 deaths in 2017.[188]

Located on Hokkaido near eight coal-fired plants and just 15 minutes from Sunagawa Station, decreased energy consumption at WDC could significantly **decrease coal-based power generation**.[186,187] These plants emit nitrogen oxides, sulfur dioxide, and heavy metals, contributing to smog, acid rain, and water pollution.

The WDC has elevated Bibai's status in Japan as a **center of innovation.** Additionally, eels cultivated at the data center are sold for local school meals as a **healthy source of locally grown protein.**[183]

Circular Economy in Kalunborg, Denmark

Kalundborg Symbiosis eco-industrial park delivers economic and environmental benefits

As the saying goes, one man's trash is another man's treasure. In Kalundborg, a small coastal town in Denmark of 16,000 people, industry has taken these words and put them into practice. Seventeen public and private companies, ranging from utility energy companies to pharmaceutical manufacturers and shipping companies, make up the "Kalundborg Symbiosis," a marketing term for a small scale model of the more widely known phrase: 'circular economy'.[189] Across all participating companies, Kalundborg's "Eco-Industrial Park" shares over 34 resource recycling streams: For example, a pharmaceutical company's organic byproducts are converted to biogas by the neighboring Biogas Plant, whose biproducts are then used in fertilizer production. Surplus steam from a power plant is utilized not only for heating the corporations offices, but for many other processes such as equipment sterilization. Importantly, the Kalunborg Symbiosis is highly dynamic, allowing for new companies and flows to enter and exit the circular model, adapting as quickly as the companies and methodologies necessitate.[190,191]

This circular approach to resource use offers significant benefits for a wide range of stakeholders. Recycling within this system offers significant advantages to businesses, as it involves known and controlled materials, in contrast to municipal recycling, which demands additional processing due to the heterogeneous nature of the waste stream. Economically, decreased dependence on raw materials and the realization of new revenue streams saves the companies a combined $26 million annually on their bottom line.[191] Additionally, the interconnection between companies has increased trust between them, fostering the growth of new business.[191] Water reuse conserves 4 billion liters of groundwater annually, while energy reuse, primarily through excess steam used for heating, saves many GWh of energy each year.[190] Additionally, material reuse prevents 62,000 tons of solid waste from being discarded.[189]

Pollution from industrial sites is strongly associated with negative health outcomes such as adverse pregnancy outcomes, childhood cancer, cardiovascular and respiratory illnesses, end-stage renal disease, and diabetes, disproportionately damaging the health of the communities around them.[192] While the specific health impacts of Kalundborg's eco-industrial park have not been quantified, the reductions in air and water pollution through material capture and reuse would not only clean the environment, but could mitigate a number of health risks for the local community.

The Kalundborg Symbiosis avoids 586,000 metric tons of CO_2 per year.[189]

FLIP Co-Benefits

Decreased dependence on raw materials and the establishment of new revenue sources through byproduct recycling saves companies in the Kalundborg Symbiosis **$26 million/year.**[191] Additionally, the interconnection of businesses through input and output flows has increased trust, **fostering the growth of new business** between industries.

Materials recycling has saved **4 billion L of groundwater/yr, many GWh of energy,** and **62,000 tons of solid polluting materials** from entering the environment.[189,191] Recycled materials, such as sulfur dioxide from power plants, are prevented from polluting the local environment.

Industrial site proximity has been associated with negative health effects, including adverse pregnancy outcomes and heightened risks of cancer, respiratory, and cardiovascular diseases.[192] Although no health data from Kalundborg are currently available, reductions in air and water pollution through resource reuse likely contribute to **improved public health outcomes.**

Reduced impact on community from industrial sites could **mitigate some effects of long-standing environmental injustices** associated with the siting and proximity to industrial sites.

TAKEAWAYS

The case studies in this report detail the FLIP co-benefits of climate mitigation actions from around the world. These case studies provide many actionable takeaways for actors focused on climate change solutions, including policymakers and advocates, journalists, and researchers. Notably, FLIP offers a framework to more effectively connect people with climate action in their own communities – to highlight and communicate how such actions directly help them and the people and places they care about.

POLICYMAKERS & ADVOCATES

A major challenge that hinders effective climate action at the local level is convincing decision makers and the public that climate change mitigation should be a priority when balanced with competing community needs. As the many examples above make clear, local communities stand to realize significant benefits – for health, economic growth, and more – from projects that also achieve GHG reductions. The FLIP framework offers policymakers a way to align climate action with other local priorities and to realize multiple goals from the same investment. Many of these takeaways apply to advocates and communities working toward local climate action.

Make climate action tangible and popular by generating and communicating FLIP benefits.

Local policymakers may avoid investing in climate mitigation efforts if the benefits will not be directly realized by the community that pays. When climate action has FLIP benefits, local community members personally experience these benefits and are able to link them to the action. As a result, projects that may face initial opposition begin to receive support once they are implemented. For example, while **Block Island** residents had misgivings about proposed wind farms, the project became popular once residents began to see savings on their electricity bills and reduced exposures to diesel exhaust. Similarly, Londoners began to support **congestion charges** once they saw reduced traffic congestion and improved bus service. Policymakers and advocates should emphasize how climate change mitigation efforts will deliver visible, local benefits that communities will personally experience and support.

Align climate action with local priorities to build local support.

Climate action can be hard to sell at the local level because it is perceived to be in conflict, or lower priority than, other local needs. Highlighting climate benefits of an action may make it difficult to garner buy-in from stakeholders that do not consider climate to be a top priority. However, this report shows that climate action can concurrently advance common local priorities such as job creation, community resilience, and economic development. The **mangrove** and **tree planting** programs in Demak and Freetown were developed principally to build local resilience to climate-related threats to community safety and livelihoods, while simultaneously achieving progress toward carbon sequestration goals. Climate action can also be consistent with more idiosyncratic local needs: South Korea's **food waste program** addressed residential concerns about proximity to smelly landfills, a top political issue, and secured major methane reductions at the same time. Policymakers should look for ways to design climate action to simultaneously address pressing local priorities like jobs, safety, or sanitation.

Engage with the community to ensure climate actions are effective and align with local priorities.

Climate action is most effective when it engages the local community both before and during implementation to incorporate stakeholder and community input in program or policy design, and develop community ownership over a project in the long term:

» **Engage communities early to ensure relevance and equity.** Collaborating with local stakeholders and community members through education and outreach helps build trust and ensures that climate actions reflect the needs and priorities of local companies, organizations, and communities. Because FLIP benefits are local, and even hyperlocal, they can impact certain communities differently, even within a single city, census tract, or neighborhood. For this reason, it is critical that policymakers work with community members to consider equity in decision making and take steps to ensure that benefits of local climate action extend to underserved communities, who are often the ones that will be most adversely impacted by climate change and environmental hazards. For example, strict conservation strategies supported by many non-local environmentalists in the Maya Biosphere

KEY TAKEAWAYS

- **Make climate action tangible and popular by generating and communicating FLIP benefits.**
- **Align climate action with local priorities to build local support.**
- **Engage with the community to ensure climate actions are effective and align with local priorities.**
- **Leverage multi-benefit strategies to build broad coalition.**
- **Empower residents to take local, meaningful climate action.**
- **Use evidence to address concerns and strengthen the case for climate action.**
- **Track, share, and promote results to facilitate and inspire replication.**
- **Compare mitigation options through the lens of local co-benefits.**
- **Use innovative financing and government purchasing power to fund climate action.**
- **Integrate FLIP actions into a long-term, cross-sector vision.**

Reserve were significantly less effective than the **sustainable forest management** efforts of local Indigenous populations, which were put into practice without implementing regulations that forced migration and/or negatively affected local livelihoods. Consideration of local Indigenous knowledge and practices can often identify effective solutions that already exist, such as the century-old practice of **shade-grown coffee** employed by the Tosepan Titataniske Cooperative in Mexico. Projects should engage directly with frontline communities, and even develop Community Benefit Agreements, as was done at **Block Island,** to ensure that they contribute positively to the surrounding community, mitigate potential negative impacts, and equitably distribute benefits. More targeted stakeholder engagement also helps ensure that programs and regulations are designed to be successful; for example, Oslo's **clean construction codes** were developed in partnership with the local construction industry to ensure that policies are consistent with what is technically and financially viable for local businesses.

» **Foster long-term community ownership for sustainable impact.** Many climate actions, in addition to requiring initial upfront financial investment, need long-term stewardship to be successful. For this reason, projects that continue to engage frontline communities during implementation such as Freetown's **urban greening campaign** are able to generate a sense of local ownership and responsibility for a project, helping to ensure long-term success and impact beyond initial investment. Similarly, following initial external investments, Java's **Building with Nature** is now fully operated by the local communities the projects serve. This community-based model, which gives the local community a voice and meaningful stake in its success, has been more successful than other replanting schemes.

Leverage multi-benefit strategies to build broad coalitions. As seen throughout this report, many local climate actions can achieve multiple benefits – economic, environmental, health, and social – simultaneously. For this reason, if properly messaged, such actions can garner support from a diverse coalition of different constituencies, including the healthcare sector, environmental advocates, and business groups. **Bus rapid transit** in Mexico City not only addressed one of the city's top priorities – air pollution – it also brought down healthcare costs associated with vehicle crashes and air pollution and increased economic productivity due to reductions in lost work days and shorter commutes. FLIP actions can be a way to engage new stakeholders in climate change mitigation, including the private sector. For example, the **Efficient Induction Cooking** program in Ecuador engaged the electric stove industry in climate action as it gave them a vested interest in promoting the climate benefits of their product. Policymakers and advocates should design and message climate actions that achieve multiple goals and attract support from diverse constituencies.

Empower residents to take local, meaningful climate action. In addition to bringing on broad constituencies that might not otherwise support climate action, FLIP action provides an accessible way for people who are concerned about climate change to both make a difference in their own communities and contribute to global climate mitigation. Many people who already care deeply about climate change feel overwhelmed by the scope of the problem and struggle to find ways to take action. Local climate actions not only offer local benefits, but more accessible opportunities to create impact. Rather than thinking about global emissions, residents can make change by engaging in more familiar spaces, such as their local planning board, city council, or school leadership, to support local transportation initiatives or efforts to offer more climate-friendly foods at local schools. Indeed, many of these activities, such as waste management and local transportation planning, are decisions that can only be made at the local level, and thus require place-based advocacy to be successfully achieved. For this reason, the FLIP framework creates accessible, actionable pathways to engage in climate mitigation through everyday local decisions.

Use evidence to address concerns and strengthen the case for climate action. While FLIP actions often become popular once the benefits are realized, they typically face upfront opposition from local constituencies who have concerns about costs and other potential risks. Successful campaigns provide data on local risks, anticipated outcomes, and tradeoffs to overcome opposition and build trust. For the **Block Island** project, modeling and environmental reviews helped assuage community concerns related to the potential impact of offshore wind on local marine habitats and tourism. In addition, evidence can be used to help identify potential drawbacks and think through how to address them. Recognizing that **Superblocks** would make it more difficult to drive, decision makers in Barcelona made sure to invest in alternate transport modes. When implementing the **food waste program** in South Korea, the government took time to study barriers to implementation and ensured that the system was designed to address stakeholder concerns. In cases where evidence is lacking or difficult to obtain, smaller scale exploratory projects, such as pilot programs, can be utilized to develop the evidence base needed for larger projects.

Track, share, and promote results to facilitate and inspire replication. For all the reasons described above, many FLIP climate actions are seen as major successes, achieving multiple priorities locally and immediately, and yielding a significant return on investment. Unsurprisingly, many of them serve as models for other jurisdictions. **Building with Nature** has inspired action both domestically and abroad, inspiring replications throughout Indonesia and in Suriname, and the **White Data Center** has already led to the construction of two additional snow-cooled data centers in Japan. For this reason, it is particularly important that local climate actions establish clear metrics and timelines, and build in regular, transparent reporting on outcomes to demonstrate and promote progress, benefits, and return on investment for the local community, and to build the case for similar initiatives to be replicated in other places. For example, as part of its investment in a **100% cycling city,** Paris has documented improvements in air quality, safety, and local business revenues, which helps reinforce the benefits of cycling infrastructure and build the case for other cities looking to

follow. In addition, while FLIP climate actions are cost-effective, sometimes they can be logistically challenging. For example, the **Kalundborg Eco-Industrial Park** required significant coordination and strategic collaboration between 17 public and private companies and 34 resource recycling streams. To facilitate replication, communities could provide technical guides for projects that follow, and actively advertise their solutions to locales that face similar struggles.

Compare mitigation options through the lens of local co-benefits.

Local governments may not have the budget or bandwidth to invest in multiple climate change mitigation strategies at once. Because mitigation actions range in terms of their benefits for the local environment and public health, quantifying the co-benefits of different mitigation actions enables decision makers to assess which actions will yield the most beneficial outcomes and prioritize strategies that generate local co-benefits. For example, while both electric vehicle adoption and investment in alternate transport modes are expected to reduce air pollution, alternate transport modes provide additional health benefits, as displacing personal vehicle ridership with active mobility (e.g., walking and cycling) also improves physical fitness and mental health. Decision makers should evaluate climate strategies by their local and immediate health, economic, and environmental returns to inform the types of climate action communities want to prioritize.

Use innovative financing and government purchasing power to fund climate action.

Because climate action comes with local costs, it can sometimes be a tough sell for local constituencies. Many locales have engaged creative financing structures to relieve public funding pressures and reduce financial risks, such as in **Freetown** and **Java.** Jurisdictions have leveraged co-ops and other grouping techniques to keep projects local and supportive of small businesses. At the same time, local governments can use their purchasing power thoughtfully, employing funding they were going to already spend to achieve climate goals. For example, Oslo leveraged its existing infrastructure spending, which comprises 20% of the local construction market, to create demand for **clean construction** technologies, while Oakland used its school food dollars to increase purchases of more **climate-friendly and locally produced foods.** In these ways, creative financing and government procurement can support local climate solutions without overburdening local budgets.

Integrate FLIP actions into a long-term, cross-sector vision.

FLIP actions are particularly effective when they tie in to comprehensive plans for a location, whether that be climate, economic, or otherwise. For example, Paris's investments in **car-free infrastructure** are driven by the Mayor's commitment to address the interconnected public health and climate crises facing the city. In furtherance of these goals, the Mayor established a vision that would address public health and climate resilience by reclaiming city streets for cyclists, pedestrians, and urban nature. Over a decade later, the city has implemented a myriad of programs, policies, and funding mechanisms to advance these goals, including closing 100 streets to cars, removing 50,000 parking spaces, constructing hundreds of miles of new cycling paths, expanding its bike share program, and more. Together, these decisions have taken the city closer to realizing its overall vision, increasing cycling by 70% and reducing air pollution by 40% over 10 years. Achievements at this scale cannot happen overnight, but require sustained action toward a consistent vision to be successful. Policymakers and advocates should embed climate action within a sustained, citywide strategy for public health, equity, and environmental resilience.

JOURNALISTS

Communication is an essential component of any successful climate adaptation and mitigation effort. The extent and pace of change required to meet our climate targets will require public engagement; however, the enormity and global nature of climate change can make it difficult to communicate the topic in a way that the general public understands and finds relevant to their own lives and experiences. In addition, because media coverage of climate action often focuses on the economic costs and does not cover local benefits, the general public is often not aware of what they stand to gain. Journalists should consider the FLIP framework as a way to more effectively convey to their audiences what climate action will mean for them at the local and even personal level.

Focus on local benefits alongside local costs.
Climate reporting is inherently complex, with global impacts that are hard for many readers to conceptualize. Stories often focus on carbon reduction potential and implementation costs. While important, this means that audiences only learn the local costs and frequently do not gain an understanding of local benefits. To provide a more complete understanding of climate mitigation actions, journalists should include co-benefits in addition to carbon reduction potential and implementation costs in their reporting. They should also make clear where and when those benefits will be realized, how they align with local priorities, and whether co-benefits will be equitably dispersed across various demographics. In addition, they should make clear what the local costs of inaction would be – such as the health effects of pollution and the energy costs of inefficient buildings. This will ensure that stories balance coverage of carbon reductions and implementation costs with clear explanations of local co-benefits and how they align with community priorities.

Build a deep understanding of co-benefits to ensure that readers are getting the full picture.
For audiences to understand the full implications of a given climate action, they will need a framework of mitigation policies and the connections that link such actions to specific co-benefits. For this reason, journalists should develop an understanding of the co-benefits landscape to ensure comprehensive reporting and that all short- and long-term implications are fully explored. In this report, we have developed a **FLIP Co-Benefits Taxonomy** that identifies the types of co-benefits within the four broad categories of economic, environmental, health, and social impacts that journalists should be considering in their coverage of local climate actions. In addition, the **Co-Benefits Landscape Review** provides an overview of existing resources in the co-benefits space. Learning the full range of co-benefits will allow for more complete, nuanced climate stories.

Use FLIP benefits to make climate stories more accessible.
Media audiences can struggle with climate stories due to the overwhelming nature of the topic and the complexity of scientific information involved. FLIP provides journalists with a way to report on climate that is more accessible to readers. Co-benefits are often seen in local communities, almost immediately following the implementation of a decarbonizing action. For example, in the first year of DC's **Solar for All** program, participating families began to see lowered energy bills. By focusing stories on the immediate, local co-benefits angle of a climate action story, journalists can provide a more relatable and engaging entry point for readers to understand a project's timeline and how it will affect them beyond taxpayer costs. These stories can be particularly effective when told using images and video, which help make effects tangible and concrete for all types of audiences, and through the use of accessible language.

Focus on specific people and places to make climate coverage resonate.
While climate stories should include the full context of how the planet and humankind are impacted, stories highlighting individual people help readers relate to and understand the link between decarbonization and specific benefits to humans. For example, the story of **Agrivoltaics in Colorado** illustrates the connection between renewable energy, sustainable agriculture, and rural communities - themes that can be hard for a reader to conceptualize at the general level. Readers are most able to connect with stories that describe personal details alongside quantitative metrics. For example, effective stories about the **Maya Biosphere Reserve** would provide data in terms of carbon sequestration and acres of deforestation prevented, but also describe individual small local businesses that have

KEY TAKEAWAYS

- **Focus on local benefits alongside local costs.**
- **Build a deep understanding of co-benefits to ensure that readers are getting the full picture.**
- **Use FLIP benefits to make climate stories more accessible.**
- **Focus on specific people and places to make climate coverage resonate.**
- **Show readers how they can engage through local climate solutions.**
- **Explain the process as well as the outcomes.**
- **Connect climate change to every beat.**

been created and are thriving as a result of the project. While particularly relevant for more local coverage, this type of focus can also be impactful for journalists that reach a national or global audience, who can use examples of specific communities and places to help tell a larger story.

Show readers how they can engage through local climate solutions.

Because the subject of climate change is so overwhelming, many people struggle to find a way to engage with the topic, both as news consumers and as participants in civic life. FLIP actions provide a way for people to personally take part in climate mitigation and may make them more interested in climate coverage. FLIP-focused stories can foster a sense of agency and efficacy among readers. Indeed, many of the types of climate action described in this report can only be achieved locally. When people see that local action makes a tangible difference, this can combat feelings of helplessness about climate change and ease the psychological onslaught of climate stories. Highlighting locally-driven solutions that demonstrate community ownership gives readers a personal stake in the story and a way to take action.

Explain the process as well as the outcomes.

In addition to grounding climate action in a local community, journalistic coverage of the co-benefits of decarbonization can provide a model for other communities looking to achieve similar social, economic, environmental, and health benefits. Thus, it is important to provide coverage not only of solutions, but how solutions happen – the process and decisions along the way that led to the ultimate action, and how others might learn from those experiences. For example, South Korea is a global leader in **food waste management,** recycling 98% of its food waste (up from just 2.6% in 1992). Its success is the culmination of many factors: the initial political will and objectives for the program; the various stakeholders and interests in play; the community engagement and implementation studies employed to inform program design; and numerous tactical and design choices that make the program effective, easy to use, and popular. In addition to these brass tacks, it is important to include context about how solutions are a part of systems change, rather than just individual actions. South Korea's program does not work just because individuals choose to recycle, but because it is designed at a systems level to advance such behaviors.

Connect climate change to every beat.

Climate change is a complex and interdisciplinary issue. Reporting on climate and climate mitigation strategies requires journalists to make connections between science, health, policy, and many other technical, institutional, and social factors. As the effects of climate change are already being felt around the world, climate change affects every aspect of human life: infrastructure, transportation, financial systems, economic development, health, politics, and more. For this reason, journalists of all focus areas should familiarize themselves with climate issues so that they understand how the issue intersects with and impacts their beat.

RESEARCHERS

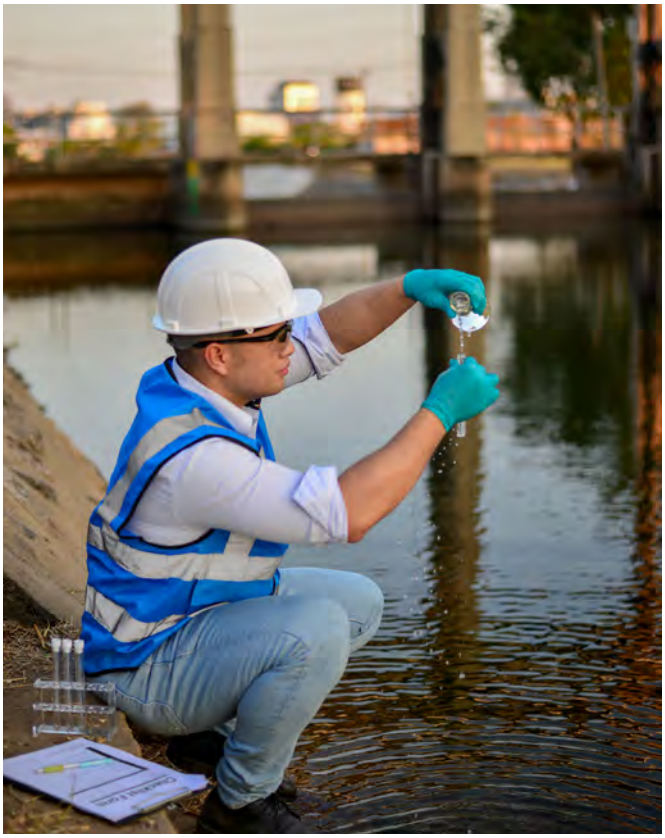
Policymakers, advocates, and journalists rely on evidence when covering the potential costs and benefits of climate action. An evidence-based understanding of climate change, as well as of climate mitigation and adaptation solutions, can guide decision makers as they decide which policies and strategies to prioritize and implement. However, evidence is only actionable when it is accessible and when it concerns the issues decision makers care about. For these reasons, the local and immediate impacts of climate actions and how they align with other priorities are fertile ground for researchers across a range of disciplines, including environmental science, public health, public policy, education, and economics. Engaging policymakers and community members in research can help bridge the gap between evidence and action.

Provide evidence in the form that policymakers need to make their case.
Even where climate action is generally accepted as a priority, policymakers and advocates often lack the locally specific tools and evidence to calculate and communicate co-benefits to make the wider case and affect action. Modeling tools should strive to include co-benefits as well as GHG emissions estimates. Tools that enable policymakers to estimate benefits at the local level and examine how to maximize them for equity and other priorities would be particularly helpful. Such tools would both enable policymakers to design action plans that maximize benefits and use these calculations to persuade stakeholders of the benefits. Detailed cost-benefit analyses and life-cycle assessments, such as those conducted for **Metrobús** in Mexico City, can be critical to bolster evidence-based policy decisions. Researchers should develop tools and analyses that include co-benefits, localized impacts, and equity considerations to support decision-making and stakeholder communication.

Conduct more post-hoc analyses of climate actions.
Although many studies highlight potential co-benefits, the transition from research to real-world implementation is hindered by the lack of detailed, real-time data and limited awareness of existing inventories. While many studies provide projections or modeled effects, actual observed data – especially ex-post – is still limited. In addition to modeling that incorporates co-benefits, researchers should conduct post-hoc analyses of climate action to quantify the actual co-benefits realized, particularly locally and on shorter timelines. Longitudinal studies examining the co-benefits of regulations or programs, such as the post-implementation study of the Ecuador **clean cookstove** program, are particularly impactful. In that case, the evidence from the study effectively laid the groundwork for an expansion of the program from 750,000 households to 3 million. In many of the FLIP case studies, benefits associated with health effects have not been measured, and as such, can only be extrapolated or modeled (e.g., benefits resulting from pollution reduction in Kalundborg's **eco-industrial park** and decreased forest fires in the **Maya Biosphere Reserve**). More

KEY TAKEAWAYS

- **Provide evidence in the form that policymakers need to make their case.**
- **Conduct more post-hoc analyses of climate actions.**
- **Promote interdisciplinary research on climate action co-benefits.**
- **Integrate community partners and end-users into research design.**
- **Translate research for policy and communications audiences.**
- **Capture a wide scope of co-benefits, both quantitative and qualitative.**



post-hoc analyses of real-world data would be helpful to develop a stronger evidence base for how solutions can provide benefits beyond greenhouse gas emission reductions and to inform future scaling.

Promote interdisciplinary research on climate action co-benefits.
Climate change is a global, complex crisis that impacts economies, public health, social structures, the environment, and life on Earth. Mitigation and adaptation actions also feature a complex interplay between climate, social and environmental conditions, and human health. Researchers working from the perspective of a single discipline frequently lack the big picture vision to understand how changes in the Earth's systems, and the steps we take to adapt to and mitigate them, will affect where people live, their health, and their quality of life. Successful examinations of climate solutions must employ researchers from a diverse range of disciplines, including public health, engineering, economics, communications, geography, environmental science, and more. By bringing together experts from diverse fields, multidisciplinary teams will more comprehensively capture the economic, environmental, health, and social co-benefits of climate action.

Integrate community partners and end-users into research design.
Climate action has implications – both costs and benefits – for implementing communities. For this reason, researchers should engage with end-users, whether that be frontline communities, decision makers, or advocates, to ensure that research is responsive to their questions and concerns and relevant to decision making on climate solutions. This engagement should persist throughout the research life span: from co-creation of research questions to study implementation and research transition. This type of engagement not only ensures that research is actionable, it helps ground research in its context, making clear what lessons and extrapolations can be drawn from a given set of findings.

Translate research for policy and communications audiences.
Even research that is directly relevant to potential policies is not actionable if it does not reach the necessary policy, advocacy, and communications audiences, and if it is presented ininaccessible academic jargon. Researchers should work directly with end-users, such as subnational governments and community partners, to ensure that findings are presented in a way that can inform decision making and advocacy. For example, researchers might create journalism and policy guides to accompany their research that includes research takeaways tailored for each audience. For journalists, this might include the most poignant talking points and quotes; for policymakers and advocates, this would highlight the policy implications of the research findings. All guides should employ lay language to ensure they are understood by audiences of diverse backgrounds.

Capture a wide scope of co-benefits, both quantitative and qualitative.
Research on climate action co-benefits often addresses only a subset of impacts. Some pathways through which climate actions benefit health are robustly characterized by existing scientific literature and tools, making it possible to quantify them. For example, analysis of the **Bus Rapid Transit** program in Mexico City quantified and monetized the reductions in lost work days, illness, and deaths from improved air pollution associated with the program. Other climate impact pathways may be important and of interest to policymakers and the local community, but may be difficult to quantify given lack of data, methodologies, or other factors. For climate impact pathways that are currently not possible to quantify, researchers should explore them qualitatively. For example, the benefits of Barcelona **Superblocks** include increased community socialization, while **mangrove restoration** in Java has built up community hope in the face of mounting environmental pressures. As shown by these and other case studies, many FLIP benefits could be better communicated and informed through qualitative findings, especially ones that gain perspective from the people most impacted by climate change.

CONCLUSION AND NEXT STEPS

Climate change is both a global emergency and a deeply local challenge, requiring action not just from nations but from cities, towns, and communities worldwide. While international targets guide the scope and scale of emissions reductions, real progress depends on local implementation. Yet many local governments struggle to prioritize climate action amid pressing economic and social concerns, especially when the costs appear immediate and the benefits seem distant or diffuse.

This report has aimed to "flip" that perspective by introducing the FLIP framework – a strategic tool to reframe climate action in terms of the free, local, immediate, and persuasive co-benefits it delivers to implementing communities. From cleaner air and lower energy bills to improved public health and job creation, these co-benefits directly support core local priorities. As the case studies presented here show, communities that embrace this approach not only advance climate goals but also enhance economic resilience, social equity, and quality of life.

To support broader application of the FLIP framework, the next phase of this work will focus on practical implementation tools, expanded audiences, and deeper engagement. The project will advance the following core objectives, to be further developed and refined in collaboration with key partners and audiences.

Develop practical guidance for implementation. Future FLIP work will provide actionable tools and strategies for applying FLIP in diverse community settings, including policy guides for how to integrate FLIP into decision making, communications resources to help stakeholders convey co-benefits clearly and persuasively, and best practices for how to engage and center frontline communities.

Expand on FLIP as a storytelling device. We will build on the case studies in this report to develop companion pieces that tell in-depth personal stories to spotlight individuals and communities who have experienced the FLIP co-benefits of climate action firsthand.

Strengthen data and quantification methods. We will develop more detailed guidance on how to expand the use of evaluation tools to better measure co-benefits at the city or neighborhood level, and identify gaps in data collection – especially for health and economic outcomes.

Engage the private sector and additional audiences. Future work will explore the role of startups, venture capital firms, and other private-sector actors who are advancing local climate solutions and co-benefit-driven innovations, including models like climate impact investing.

This report shows how climate actions have significant and far-reaching value for implementing communities beyond GHG emissions reductions. By providing a way to fully recognize and incorporate this value into decision making, the FLIP framework can help catalyze essential climate action at the local level. The path to global climate stability runs through local leadership, and FLIP provides a strategy for getting there.

APPENDICES

Appendix A: Co-Benefits Landscape Review
Appendix B: FLIP Co-Benefits Taxonomy

Appendix A: Co-Benefits Landscape Review

To evaluate the landscape of current co-benefits resources, we began with an initial list of key actors in the co-benefits space (C40 Cities, ISGlobal, WHO, MultiSolving Institute), created by report authors based on existing knowledge. We then used a snowball sampling method to incorporate additional resources. Our snowball sampling method consisted of scanning reports, documents, and tools for additional resources, or for the mention of organizational partnerships that resulted in additional data points. Because most co-benefits resources consist of gray literature and organizational reports, traditional literature review methods were insufficient for capturing the full scope and current state of these materials. Additionally, due to volume and to maintain clear objectives within the analysis, scholarly and academic literature was excluded.

Following several searches (most recent was conducted in May 2025), co-benefit resources were grouped by entity, and evaluated by the following categories: intended audience (researchers, policymakers, journalists); type of resource (case study, report, tool, index); and co-benefits categories that were used in the product (economic, health, social, environmental).

Intended audiences	Type of resource	Co-benefits categories included
Researchers Policymakers Journalists	Case study – Analysis of specific example Report – Document presenting co-benefits analysis, framework Tool – Quantitative analysis tools Index – When selected along with another resource type, this indicates an index of the selected resource(s)	Economic Environmental Health Social **Flipped def.** – Co-benefits are defined as the climate mitigation/adaptation benefits of sustainable development. *If no categories selected, resources within an index varied and could not be categorized.

Titles	Intended audiences	Type of resource	Co-benefits categories included
C40 Cities			
Climate Opportunity: More jobs, better health, liveable cities	Policymakers	Case study Report	Health Economic Environmental Social
Toward a Healthier World: Connecting the dots between climate, air quality and health	Policymakers	Case study Report	Health Economic Environmental
Benefits of Urban Climate Action	Policymakers	Case study Report	Health Economic Environmental Social
Quezon City: Electrification of Municipal Vehicle Fleet	Policymakers	Case study	Health Economic Environmental
Bengaluru: Electric buses	Policymakers	Case study	Health Economic Environmental
Jakarta: Electric buses	Policymakers	Case study	Health Economic Environmental
Creating job opportunities with la Rolita electric buses in Bogotá: Benefits Assessment – Preliminary results	Policymakers	Case study	Health Economic Environmental Social
Addis Ababa - Setting vehicle standards	Policymakers	Case study	Health Economic Environmental
Lima: Assessment of Low Emission Zone in Damero de Pizarro	Policymakers	Case study	Health Economic Environmental
Lima: Efficiency incentives for restaurants & rotiseries	Policymakers	Case study	Health Economic Environmental
Cool-free cities: the health and economic case for a clean energy revolution	Policymakers	Case study	Health Economic Environmental
Medellín Green Corridors	Policymakers	Case study	Health Economic
Sao Paulo: Ipiranga Stream Revitalisation	Policymakers	Case study	Health Economic
Mexico City: Massive Bike Parking Facilities	Policymakers	Case study	Health Economic Environmental Social
Rotterdam: Superblock Oude Westen	Policymakers	Case study	Health Economic Environmental Social
Bengaluru: Tender Sure Project	Policymakers	Case study	Health Economic Environmental Social
Houston: Benefits of the White Oak Bayou Greenway	Policymakers	Case study	Health Economic Environmental
Mexico 2018 - Benefits of Ecobici and the pedestrianization of the city centre	Policymakers	Case study	Health Economic Environmental
Technical report: The case for a green and just recovery	Policymakers	Report	Health Economic Environmental
Canada - The case for an urban green and just recovery	Policymakers	Case study	Health Economic Environmental
The Future is Public Transport	Policymakers	Report	Health Economic Environmental
Urban Climate Impacts Framework	Policymakers Researchers	Report	Health Economic Environmental Social
Case studies index	Policymakers	Index Case study	
NYC: Milan, Copenhagen building retrofits	Policymakers	Case study	Health Economic Environmental
Lima Historical Center Pedestrian Zone	Policymakers	Case study	Health Economic Environmental Social
Organic Waste to Biogas in Rio de Janeiro's Biomethanisation Unit	Policymakers	Case study	Economic Environmental
Clean air, healthy planet: A framework for integrating air quality management and climate action planning	Policymakers	Report	Health Environmental
Healthy and Efficient Retrofitted Buildings Tool (HERB)	Policymakers	Tool	Health Economic Environmental Social
C40 walking and cycling benefits tool	Policymakers	Tool	Health Economic
Heat Resilient Cities - Measuring benefits of urban heat adaptation	Policymakers	Tool	Health Economic Environmental
MultiSolving Institute			
Multi Solving at the intersection of health and climate	Policymakers	Report Case study	Health Economic Environmental Social
Multi Solving for climate resilience	Policymakers	Case study	Health Economic Environmental Social
Pathfinder Initiative			
Pathways to a healthy net zero future	Policymakers	Report Case study	Health Environmental
Climate & Health Evidence Bank	Policymakers	Index Case study	
More Bikes, Less Emissions	Policymakers	Case study	Health Environmental Social
Improved cookstoves in Senegal, The Gambia and Guinea-Bissau	Policymakers	Case study	Health Environmental Social
Poverty alleviation and environmental restoration in Humbo	Policymakers	Case study	Health Economic Environmental
Nnakata Mountains Forest Protection Programme	Policymakers	Case study	Health Economic Environmental Social
Urban road pricing schemes in London, Stockholm and Milan	Policymakers	Case study	Health Economic Environmental Social
Developing sustainable urban transport in New Taipei	Policymakers	Case study	Health Environmental
Victorian Healthy Homes Program	Policymakers	Case study	Health Economic Social
Sustainable school meals in Sweden	Policymakers	Case study	Health
World Health Organization			
Climate change and health toolkit	Policymakers	Index Tool	
Health in the green economy: health co-benefits of climate mitigation – housing center	Policymakers	Report	Health
Health in the green economy: health co-benefits of climate mitigation – transport sector	Policymakers	Report	Health
Health in the green economy: Healthcare facilities	Policymakers	Report	Health
Health in the green economy: Occupational health	Policymakers	Report	Health
The health benefits of tackling climate change	Policymakers	Report	Health
ClimaHealth	Policymakers	Report	Health
Protecting health in Europe from climate change: 2017 update	Policymakers	Report	Health
COP24 special report: health and climate change	Policymakers	Report	Health
AirQ+: software tool for health risk assessment of air pollution	Policymakers	Tool	Health
Health Economic Assessment Tool (HEAT) for walking and cycling	Policymakers	Tool	Health
iSTHAT: the Integrated Sustainable Transport and Health Assessment Tool	Policymakers	Tool	Health
GreenUr: the Green Urban spaces and health tool	Policymakers	Tool	Health
Benefits of action to reduce household air pollution (BAR-HAP) tool	Policymakers	Tool	Health
Co-benefits of climate actions for air and health in India	Policymakers	Case study	Health Environment
Health and air quality co-benefits of climate change mitigation	Policymakers	Case study	Health Environment
PAHO Health co-benefits of climate action	Policymakers	Report	Health
World Bank			
Climate-smart development: adding up the benefits of actions that help build prosperity, end poverty and combat climate change	Policymakers	Report	Health Economic Environmental Social
What You Need to Know about Climate Co-Benefits	Policymakers	Report	Flipped def.
Quantifying and Measuring Climate, Health and Gender Co-Benefits from Clean Cooking Interventions	Policymakers	Report	Flipped def. Health Environmental Social
Typology of Activities with Climate Co-Benefits by WB Sector	Policymakers	Report	Flipped def.
Tyndall Center			
The co-benefits of climate action: Accelerating city-level ambition	Policymakers	Report	Health Economic Environmental Social
New Climate Institute			
TRACE - Co-benefits in decarbonising transport	Policymakers	Tool	Health Economic
Institute for Advanced Sustainability Studies (IASS)			
Mobilizing the co-benefits of climate change mitigation	Policymakers Researchers	Report	Health Economic Environmental Social
Centre for Climate Change and Social Transformations			
Catalysts of Change People at the Heart of Climate Transformations	Policymakers Researchers	Report	Health Economic Environmental Social
Intergovernmental Panel on Climate Change			
Human health: impacts, adaptation, and co-benefits. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects	Policymakers	Report	Health Economic Environmental
Climate Change 2023 Synthesis Report: Summary for Policymakers	Policymakers	Report	Health Economic Environmental
The climate bonus			
Co-benefits of climate policy Summary of Co-Benefits Table	Policymakers	Report	Health Economic Environmental Social
Climate policy info hub			
Mitigation: Co-Benefits and Interlinkages to Adaptation	Policymakers	Report	Health Economic Environmental
Asian Co-Benefits Partnership			
What are Co-Benefits?	Policymakers	Report	Health Economic Environmental
2024 flagship report: Integrating Co-benefits into Nationally Determined Contributions, Climate Policies and Air Pollution Policies in Asia	Policymakers	Report	Health Economic Environmental
Quantifying Co-Benefits in Asia: Methods and Applications	Policymakers	Report	Health Economic Environmental Social
Putting Co-benefits into Practice: Case Studies from Asia	Policymakers	Report	Health Economic Environmental
Good Practice Map	Policymakers	Index Case study	
United Nations			
Synergy Solutions for a World in Crisis: Tackling Climate and SDG Action Together	Policymakers	Report	Health Economic Environmental Social
UNECE The co-benefits of climate change mitigation	Policymakers	Report	Health Economic Environmental
UNFCC CDM Sustainable Development co-Benefits description reports	Policymakers	Index Case study	Health Economic Environmental Social
Health Care without Harm			
Climate co-benefits of healthy food access interventions	Policymakers	Report	Flipped Def.
European Environment Agency			
Cross-cutting story 5: Co-benefits of addressing climate change and pollution	Policymakers	Report	Health Environmental
Ashden			
Climate action co-benefits: Cutting carbon and improving people's lives	Policymakers	Report	Health Economic Environmental Social
ISGlobal			
Urban Planning, Environment, and Health Initiative	Policymakers	Report	Health
The Global Climate and Health Alliance			
The health benefits of tackling climate change	Policymakers	Report	Health
Our unpoished dividend: the health benefits of climate action	Policymakers	Report	Health
NCDs and Climate Change: Shared Opportunities for Action	Policymakers	Report	Health
Cradle to Grave:The health harms of fossil fuel dependence and the case for a just phase-out	Policymakers	Report	Health
American Public Health Association			
Climate action webpage	Policymakers	Report	Health Environmental
Natural Resources Defense Council			
NRDC Pathways Report: Nature-Based Solutions Vital to Meeting Climate Goals	Policymakers	Report	Health Economic Environmental
U.S. Environmental Protection Agency			
Environmental Benefits Mapping and Analysis Program – Community Edition (BenMAP-CE)	Policymakers Researchers	Tool	Health Environmental
UrbanEmissions.Info			
Environmental Benefits Mapping and Analysis Program - Community Edition (BenMAP-CE)	Policymakers Researchers	Tool	Health Economic Environmental
International Institute for Applied Systems Analysis (IIASA)			
GAINS-online	Policymakers	Tool	Health Economic Environmental
Urban Nature Atlas			
Urban Nature Atlas	Policymakers	Index Case study	Health Economic Environmental
World Resources Institute (WRI)			
Putting People at the Center of Climate Action	Policymakers	Report	Health Economic Environmental Social
Climate Action Network International			
Report: Co-Benefits of Climate Action	Policymakers	Report	Health Economic Environmental Social
Paris Pact Payoff: Speeding up the green transition for socio-economic co-benefits	Policymakers	Report	Health Economic Environmental Social

Appendix B: FLIP Co-Benefits Taxonomy

The FLIP Co-Benefits Taxonomy provides an index of FLIP co-benefits linked to climate actions. This chart, drawn from C40 Cities' Climate Action Impacts Taxonomy, identifies co-benefits of climate action that occur locally and are realized promptly following implementation. Expanding on C40's work, we have: 1) identified additional FLIP co-benefits that were not included in the original Framework, and; 2) suggested changes to existing categories, including the separation and expansion of the Health Impacts "Theme" from its original position as an "Impact Group" under "Social Impacts."

All changes made to the table are delineated as follows (adapted from the C40 Taxonomy):

BOLD, ITALICS, & TEXT COLOR OF SECTOR = NEW CATEGORY CREATION
BOLD = CHANGED WORDING
BOLD & ITALICS = MOVED CATEGORY

In addition, the Taxonomy identifies case studies from the report that exemplify FLIP co-benefits within Themes and Impact Groups. These co-benefits are marked with specific icons that correspond to case studies as follows:

Case Studies

Agrivoltaics *Boulder, Colorado*	**Urban Greening** *Freetown, Sierra Leone*
Offshore Wind Farm *Block Island, Rhode Island*	**Mangrove Restoration** *Demak, Indonesia*
Community Solar *District of Columbia*	**Community-Centered Sustainable Forestry** *Guatemala*
Distributed Pumped Hydroelectric Storage *Manipur, India*	**Sustainable Urban Design** *Barcelona, Spain*
Building Retrofits *Madison, Wisconsin*	**Climate-Friendly Lunches** *Oakland, California*
Induction Cooking *Ecuador*	**Food Waste Recycling** *South Korea*
Net-Zero Buildings *Silver Spring, Maryland*	**Shade-Grown Coffee** *Oaxaca, Mexico*
Congestion Pricing *London, United Kingdom*	**Alternative Maritime Power®** *Los Angeles, California*
Cycling Infrastructure *Paris, France*	**Clean Construction** *Oslo, Norway*
Bus Rapid Transit *Mexico City, Mexico*	**Data Center Energy Conservation** *Bibai, Japan*
Bus Electrification *Santiago, Chile*	**Circular Economy** *Kalundborg, Denmark*

HEALTH IMPACTS

IMPACT GROUP	IMPACT	FLIP BENEFIT	DESCRIPTION	CASE STUDIES
Physical & mental health	*Resilience to disaster & weather-related hazards*	*Reduced health effects from extreme temperatures*	*Reduced adverse outcomes associated with extreme heat and other extreme temperatures, such as hospitalizations, mortality, negative mental health effects, and adverse birth outcomes.*[24]	
		Reduced health effects from flooding	*Reduced adverse outcomes from flooding, such as mortality and injury from drowning and physical hazards, water- and vector-borne diseases, negative mental health effects, and damage to critical infrastructure.*[193]	
		Reduced health effects from other weather-related disasters	*Reduced adverse outcomes from natural disasters (earthquakes, landslides, wildfires, droughts, hurricanes, and cyclones), such as injury and death due to physical hazards; adverse pulmonary, cardiovascular, and mental health outcomes; and food insecurity and sanitation-related harms.*[194]	
		Reduced climate anxiety	*Decreased mental health damages due to perceived threats of climate change.*[195]	
	Social & behavioral health	*Occupational health*	*Reduced mortality and injury from physical hazards in the workplace and decreased exposure to environmental hazards such heat and chemicals.*	
		Built environment improvements	*Health and safety related improvements to the built environment, such as walkability, traffic-related injuries, physical and mental health benefits of greenspace access, and decreased exposure to extreme heat due to man-made structures or increase of tree canopy.*	
		Socialization	*Access to spaces that encourage socialization and are safe for independent child play.*	
		Access to healthcare	*Removes restricting physical or social boundaries, and prevents disruptions in patient access to healthcare that would otherwise lead to decreased treatment efficacy and adverse health outcomes.*	
		Physical activity	*Regular physical activity improves physical health outcomes – cardiovascular disease, cancer, diabetes, pediatric bone health and cognitive development – as well as mental health and overall well-being.*[196]	
		Diet & nutrition	*Healthy dietary habits protect against malnutrition and non-communicable diseases (NCDs) such as diabetes, heart disease, stroke, and cancer, and improve cognitive development.*[197]	
		Food & Water Security	*Reliable access to safe, nutritious food and clean water protects against malnutrition, waterborne illness, and non-communicable diseases, while supporting cognitive and physical development.*	
	Environmental health	*Reduced health effects from air pollution*	*Reduced adverse respiratory and cardiovascular outcomes, including chronic obstructive pulmonary disease (COPD), heart disease, stroke, and cancer, related to air pollution exposure, such as particulate matter (PM), ozone (O_3), nitrous oxides (NO_x), and sulphur oxides (SO_x).*[25]	
		Reduced health effects from water pollution	*Reduced exposure to waterborne pathogens that cause illnesses such cholera, giardia, and typhoid and chemical and metal contaminants, such as lead, arsenic, and nitrates, associated with adverse effects such as decreased brain function, hormone disruption, and cancer.*[199]	
		Reduced health effects from light pollution	*Reduced exposure to artificial light at night that interrupts the circadian rhythm, decreasing sleep quality, associated with many disorders and diseases such as obesity, mental disorders, and cancer.*[200]	
		Reduced health effects from noise pollution	*Reduced exposure to noise pollution which in addition to hearing damages, is associated with cardiovascular disease, diabetes, and mental health and cognitive function decline.*[201]	
		Reduced health effects from poor Indoor Environmental Quality (IEQ)	*Reduced exposure to indoor environmental hazards such as poor indoor air quality, physical hazards, and biological hazards which are associated with acute injury and illness, decreased cognitive function, and mental health effects.*[202]	
		Reduced vectors and vector-borne disease	*Habitat reduction of vectors such as mosquitos decreases risk of vector-borne disease spread.*	

SOCIAL IMPACTS

IMPACT GROUP	IMPACT	FLIP BENEFIT	DESCRIPTION	CASE STUDIES
Quality of life and livability	Housing	Housing availability	Availability of decent and affordable housing to urban populations.	
		Housing quality	Size of the living area and **quality of housing available.**	
	Standard of living	City/**neighborhood** attractiveness	City's appeal through access to public spaces, aesthetics, and tourism.	
		Olfactory pollution	Decreases exposure to noxious smells causing discomfort, **displeasure.**	
		Rural development	*Quality of life and economic well-being improvements for rural and peri-urban populations.*	
		Electricity access	*Access to reliable energy supply.*	
		Access to greenspace	*Availability of greenspace for all citizens' use and viewing .*	
		Access to and quality of public services and design	*Appeal through public services (transit, healthcare access) and urban design (ex: 15 min city).*	
		Public safety	*Protection against crime, accidents, and environmental hazards.*	
		Work-life balance	***Improved ability to balance work and personal life through reduced commute times, flexible schedules, supportive urban design, etc.***	
		Personal satisfaction	*Increased subjective well-being and satisfaction with daily activities.*	
Culture	Culture richness and heritage	Cultural diversity	Diversity of cultural activities to engage citizens.	
		Cultural heritage protection	Measures for and extent of cultural heritage protection.	
	Education	Education affordability	Cost of and access to education (public or private).	
		Education availability	Proximity to affordable educational institutions and resources.	
		Education quality	Provision of education and quality of instruction by trained staff.	
	Environmental & health awareness and behaviour	Waste education	Citizens' awareness and habits regarding waste (e.g., recycling, littering, composting).	
		Energy use education	Awareness of energy efficiency and household energy use.	
		Water use education	Awareness and habits related to efficient water use.	
		Hygiene and sanitation education	Habits related to handwashing, sanitation, and hygiene.	
		Travel behaviour	Habits and awareness related to transportation mode choices.	
		Sex education	Awareness of family planning and sexual health.	
		Food consumption and diet education	Awareness of food choices, nutrition, and their impacts.	
		Other sustainability education	*Awareness and habits of other activities related to environmental responsibility, resource conservation, and long-term ecological wellbeing.*	
Institutions	**Community empowerment**	Civic participation	Citizens' participation in civic and climate-related actions.	
		Community cohesion	Sense of belonging and solidarity in **local** communities.	
		Decreased out-migration	*Lower migration rates due to improved living conditions, economic opportunity, or safety.*	
	Equity and inclusivity	**Equitable access**	Inclusion of diverse groups in **social benefits, the job market, and** policy-making.	
		Justice	Fairness, impartiality, and independence of legal systems.	
		Environmental justice	*Ensure community members have equal protection from environmental harms and equal access to environmental benefits.*	
		Gender equity	*Justice in treatment of all genders through policies, workshops, and/or resource allocation.*	
	Good governance	Local democracy	Democratic principles and citizen participation.	
		Evidence-based policy-making	Use of tools and data for informed decision-making.	
		Creative governance	*Innovative approaches used in policy-making to address complex climate and societal challenges.*	
		Community engagement	*Increased role of local community groups in planning and implementation of programs.*	
		Catalyst for further policy/action	*Success of the program inspired similar programs or action.*	
		Transparency and accountability	Transparency in institutions, accountability, and anti-corruption.	

ECONOMIC IMPACTS

IMPACT GROUP	IMPACT	FLIP BENEFIT	DESCRIPTION	CASE STUDIES
System & business-level economics	**Economic output**	**Local economic production**	Local income from increase in production/consumption of goods and services.	
		Business profitability	Reduced business expenses and/or increased revenue for businesses.	
		Labour productivity	Production and value-added from jobs and working time.	
	Employment	Job creation	Job creation in existing sectors.	
		Earnings quality	Quality and stability of employee earnings.	
		Job security	Reduced risk of job loss.	
		Workforce development/ technical training	***Strategies and programs that build workers' skills to meet current and future labor market needs.***	
	Economic security	***Energy security***	***Increased grid reliability/resilience.***	
		Infrastructure improvements	***Upgrades or enhancements to physical systems (such as transportation, energy, water, and communication networks).***	
		Self-sufficiency	***Ability of an individual, community, or economy to meet its own needs (ex: food, energy, or essential goods).***	
		Climate resiliency	***Actions that protect individuals and organizations from economic losses associated with weather-related hazards.***	
		Support of small businesses	***Policies, programs, or infrastructure that improve stability, revenue, and viability for small and local enterprises.***	
	Economic innovation, dynamism, and competitiveness	Innovation	New product or service creation, research and development activity. Decreased barrier to entry for further projects.	
		Local sector development and new industries	Emergence of new industries and businesses.	
	Public budget	Available municipal budget	City government budget for policies and programs.	
		Available regional/ state budget	Regional or state-level budgets.	
		Tax revenue	Income from taxation.	
		Non-tax revenue	Government income from non-tax sources.	
		Reduced government social spending	***Reduces costs borne by the government for the delivery of essential services such as healthcare and emergency response.***	
Household-level economics	*Private wealth*	Housing & **energy affordability**	Decreases cost of housing **and energy** to urban populations relative to income.	
		Value of assets	*Household asset accumulation and net worth.*	
		Economic empowerment	***Ability to afford goods/services and build savings.***	

ENVIRONMENTAL IMPACTS

IMPACT GROUP	IMPACT	FLIP BENEFIT	DESCRIPTION	CASE STUDIES
Environmental quality	Biodiversity	Biodiversity protection	Protection of ecosystems and habitats.	
		Ecosystem services	Improves value of benefits provided by ecosystems.	
		Biological diversity	Increases variety and variability of living organisms.	
		Species population	Increases health and size of species populations.	
	Air quality	Indoor air pollution	Improves air quality inside buildings.	
		Outdoor air pollution	Improves ambient air quality, **including improved visibility from reduced haze.**	
	Noise pollution	Indoor noise	Decreases noise exposure inside homes and buildings.	
		Outdoor noise	Decreases noise exposure from traffic and urban activity.	
	Quality of land	Soil pollution	Decreases soil contamination from chemicals and waste.	
		Soil health	Improves soil health and productivity.	
		Soil texture	Improves composition and granularity of soil and improves its stability, decreasing erosion.	
		Land subsidence	***Prevents the gradual sinking or sudden collapse of the ground surface.***	
	Light pollution	Sky glow	Prevents the brightening of the night sky.	
		Light intrusion or trespass	Prevents unwanted artificial light from entering spaces.	
		Glare	Decreases visual discomfort caused by excessive brightness.	
	Water quality	Water pollution	**Decreases presence of harmful chemical and biological pollutants in water.**	
		Water salinisation or acidification	Prevents harmful salt and pH changes in water bodies.	
		Eutrophication	***Reduced nutrient enrichment in bodies of water which would often lead to algal blooms, depleting oxygen levels which reduces water quality and harms aquatic populations.***	
		Water temperature	Effects of temperature on water quality/ecosystems.	
		Water treatment	Municipal actions affecting water potability and sanitation.	
	Temperature	Indoor air temperature	Indoor heat and energy demand.	
		Outdoor air temperature	Urban heat island effect (affected by greenspace and surface materials), heat resilient infrastructure.	
	Resource management	***Natural resources conservation***	***Decreased rate of depletion of renewable and nonrenewable resources.***	
		Waste production and management	*Waste generation and disposal practices.*	

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REFERENCES

1. C40 Cities. (2022). *Urban climate action impacts framework*. https://www.c40.org/wp-content/uploads/2022/02/Urban-Climate-Impact-Framework-%E2%80%93-Defining-the-pathway-methodology-to-map-how-a-climate-action-can-translate-into-multiple-benefits.pdf

2. *Adapted from* Bollen, J., Guay, B., Jamet, S., & Corfee-Morlot, J. (2009). *Co-benefits of climate change mitigation policies: Literature review and new results* (OECD Economics Department Working Papers No. 693). Organisation for Economic Co-operation and Development. https://doi.org/10.1787/224388684356

3. Deslatte, A., Siciliano, M. D., & Krause, R. M. (2023). *Local government managers are on the frontlines of climate change: Are they ready?* Public Administration Review, 83(6), 1506–1511. https://doi.org/10.1111/puar.13726

4. International Federation of Red Cross and Red Crescent Societies. (2019, September 19). *The cost of doing nothing: The humanitarian price of climate change and how it can be avoided* [Technical report]. IFRC. https://www.ifrc.org/document/cost-doing-nothing

5. Bain, P. G., Milfont, T. L., Kashima, Y., Bilewicz, M., Doron, G., … Saviolidis, N. M. (2016). Co-benefits of addressing climate change can motivate action around the world. *Nature Climate Change, 6*(2), 154–157. https://doi.org/10.1038/nclimate2814

6. Castillo, M. D., Anenberg, S. C., Chafe, Z. A., Huxley, R., Johnson, L. S., … Kinney, P. L. (2021). Quantifying the health benefits of urban climate mitigation actions: Current state of the epidemiological evidence and application in health impact assessments. *Frontiers in Sustainable Cities, 3*, 768227. https://doi.org/10.3389/frsc.2021.768227

7. Markandya, A., Sampedro, J., Smith, S. J., Van Dingenen, R., Pizarro-Irizar, … González-Eguino, M. (2018). Health co-benefits from air pollution and mitigation costs of the Paris Agreement: A modelling study. *The Lancet Planetary Health, 2*(3), e126–e133. https://doi.org/10.1016/S2542-5196(18)30029-9

8. Chang, K. M., Hess, J. J., Balbus, J. M., Buonocore, J. J., Cleveland, D. A., … Ebi, K. L. (2017). Ancillary health effects of climate mitigation scenarios as drivers of policy uptake: A review of air quality, transportation and diet co-benefits modeling studies. *Environmental Research Letters, 12*(11), 113001. https://doi.org/10.1088/1748-9326/aa8f7b

9. Rauner, S., Hilaire, J., Klein, D., Strefler, J., & Luderer, G. (2020). Air quality co-benefits of ratcheting up the NDCs. Climatic Change, 163(3), 1481–1500. https://doi.org/10.1007/s10584-020-02699-1.

10. Scovronick, N., Anthoff, D., Dennig, F., Errickson, F., Ferranna, M., Peng, … Budolfson, M. (2021). The importance of health co-benefits under different climate policy cooperation frameworks. Environmental Research Letters, 16(5), 055027. https://doi.org/10.1088/1748-9326/abf2e7

11. Scovronick, N., Budolfson, M., Dennig, F., Errickson, F., Fleurbaey, … Wagner, F. (2019). The impact of human health co-benefits on evaluations of global climate policy. Nature Communications, 10(1), 2095. https://doi.org/10.1038/s41467-019-09499-x

12. Thurston, G. D., & Bell, M. L. (2021). The human health co-benefits of air quality improvements associated with climate change mitigation. In K. E. Pinkerton & W. N. Rom (Eds.), Climate change and global public health (pp. 181–202). Springer International Publishing. https://doi.org/10.1007/978-3-030-54746-2_9

13. McKinsey & Company. (2020, December 15). *Responding to climate risk: Actions for U.S. state and local leaders*. https://www.mckinsey.com/capabilities/sustainability/our-insights/responding-to-climate-risk-actions-for-us-state-and-local-leaders

14. Vandyck, T., Keramidas, K., Tchung-Ming, S., Weitzel, M., & Van Dingenen, R. (2020). Quantifying air quality co-benefits of climate policy across sectors and regions. Climatic Change, 163(3), 1501–1517. https://doi.org/10.1007/s10584-020-02685-7

15. Ekins, P. (1996). How large a carbon tax is justified by the secondary benefits of CO_2 abatement?, *Resource and Energy Economics, 18*(2), 161–187. https://doi.org/10.1016/0928-7655(96)00003-6.

16. Messner, S. (1997). Technological change and the timing of mitigation measures. *Energy Economics, 19*(4), 473–489. https://doi.org/10.1016/S0140-9883(98)00010-3.

17. Intergovernmental Panel on Climate Change (IPCC). (2001). *Climate change 2001: Mitigation* (B. Metz, O. Davidson, R. Swart, & J. Pan, Eds.). Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. https://www.ipcc.ch/report/ar3/wg3/

18. Karlsson, M.; Alfredsson, E.; Westling, N. Climate Policy Co-Benefits: A Review. *Climate Policy* 2020, *20* (3), 292–316. https://doi.org/10.1080/14693062.2020.1724070.

19. World Health Organization. (2021). *WHO health and climate change survey report*. World Health Organization.

20. World Bank & ClimateWorks Foundation. (2014). *Climate-smart development: Adding up the benefits of actions that help build prosperity, end poverty and combat climate change* [Technical report]. International Bank for Reconstruction and Development and ClimateWorks Foundation. https://documents1.worldbank.org/curated/en/794281468155721244/pdf/889080WP0v10RE0Smart0Development0Ma.pdf

21. World Health Organization. (2021). *COP26 special report on climate change and health: The health argument for climate action*. World Health Organization. https://www.who.int/publications/i/item/9789240036727

22. Tyndall Centre for Climate Change Research. (2020). *The Co-benefits of Climate Action: Accelerating City-level Ambition*. CDP Worldwide. https://cdn.cdp.net/cdp-production/cms/reports/documents/000/005/329/original/CDP_Co-benefits_analysis.pdf

23. Kleiman, G., Anenberg, S., Chafe, Z., Appiah, D., Assefa, T., … Thomas, C. (2022). Enhanced integration of health, climate, and air quality management planning at the urban scale. *Frontiers in Sustainable Cities, 4*, Article 934672. https://doi.org/10.3389/frsc.2022.934672

24. Ebi, K. L., Capon, A., Berry, P., Broderick, C., de Dear, R., … Jay, O. (2021). Hot weather and heat extremes: Health risks. *The Lancet, 398*(10301), 698–708. https://doi.org/10.1016/S0140-6736(21)01208-3

25. World Health Organization. (n.d.). *Air quality, energy and health: Health impacts*. https://www.who.int/teams/environment-climate-change-and-health/air-quality-energy-and-health/health-impacts

26. Boehm, S., Jeffery, L., Hecke, J., Schumer, C., Jaeger, J., ... Masterson, M. (2023). *State of climate action 2023*. Bezos Earth Fund; Climate Action Tracker; Climate Analytics; ClimateWorks Foundation; NewClimate Institute; United Nations Climate Change High-Level Champions; World Resources Institute. https://doi.org/10.46830/wrirpt.23.00010

27. U.S. Environmental Protection Agency. (2011, March). *The benefits and costs of the Clean Air Act from 1990 to 2020: Second prospective study* (Section 812 Prospective Analysis No. 812-R-11-001). U.S. EPA, Office of Air and Radiation. https://www.epa.gov/clean-air-act-overview/benefits-and-costs-clean-air-act-1990-2020-second-prospective-study

28. Project Drawdown. (2020). *The Drawdown Review 2020: Climate solutions for a new decade*. https://drawdown.org/drawdown-review

29. Global Commission on the Economy and Climate. (2018). *Unlocking the inclusive growth story of the 21st century: Accelerating climate action in urgent times*. New Climate Economy. https://newclimateeconomy.net/sites/default/files/2023-11/NCE_2018_ExecutiveSummary_FINAL_8.pdf

30. Hoegh-Guldberg, O., Jacob, D., Taylor, M., Bindi, M., Brown, S., ... & Zhou, G. (2019). The human imperative of stabilizing global climate change at 1.5°C. *Science, 365*.

31. IPCC. (2023). *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]*. (S. 35–115). Intergovernmental Panel on Climate Change (IPCC). https://doi.org/10.59327/IPCC/AR6-978929169164

32. Çam, E., Hungerford, Z., Schoch, N., Pinto Miranda, F., & Yáñez de León, CD. (2024). *Electricity 2024*, International Energy Agency. https://www.iea.org/reports/electricity-2024

33. Jack's Solar Garden. (n.d.). *Jack's Solar Garden*. Retrieved August, 2025, from https://www.jackssolargarden.com/

34. U.S. Energy Information Administration. (2023). *Colorado electricity profile 2023*. Retrieved August, 2025, from https://www.eia.gov/electricity/state/colorado/

35. U.S. Energy Information Administration. (2023). *Coal consumption by sector, Colorado*. Retrieved August, 2025, from https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_fuel/html/fuel_cf.html&sid=CO

36. Peterson, S. & Kolbeck-Urlacher, H. (2024, March). Fact sheet: Making the case for crops & solar. *AgriSolar Clearinghouse.* https://www.agrisolarclearinghouse.org/fact-sheet-making-the-case-for-crops-solar/

37. Nabhan, G. (2024, October 17). Crops uniquely suited to growth in agrivoltaic settings. *AgriSolar Clearinghouse*. https://www.agrisolarclearinghouse.org/crops-uniquely-suited-to-growth-in-agrivoltaic-settings/

38. Peterson, S. (2024, September). Solar panel shade and potential health impacts. *AgriSolar Clearinghouse.* https://www.agrisolarclearinghouse.org/solar-panel-shade-and-potential-health-impacts/

39. Siegner, K., Wentzell, S., Urrutia, M., Mann, W., & Kennan, H. (2019). *Maximizing land use benefits from utility-scale solar*. Yale Center for Business and the Environment. https://cbey.yale.edu/research/maximizing-land-use-benefits-from-utility-scale-solar

40. Sprout City Farms. (n.d.). Sprout City Farms. Retrieved August, 2025, from https://sproutcityfarms.org/

41. Research And Markets. (2024, April). *Agrivoltaics market — A global and regional analysis: Focus on product, application, and competitive landscape, 2023–2033*. https://www.researchandmarkets.com/reports/5954821/agrivoltaics-market-global-regional-analysis

42. Rumery, S., Hay, C., Smith, M., Norris, J., Thompson, T., & Hyman, C. (2024, September). *Understanding barriers to agrivoltaics: A survey approach*. Solar and Storage Industries Institute. https://www.ssii.org/farms-project/

43. Ashoka. (2024, March 21). *Solar is here to stay—let's do it right*. Forbes. https://www.forbes.com/sites/ashoka/2024/03/21/solar-is-here-to-stay-lets-do-it-right/

44. El Khayat, M., Halwani, D. A., Hneiny, L., Alameddine, I., Haidar, M. A., & Habib, R. R. (2022). Impacts of climate change and heat stress on farmworkers' health: A scoping review. Frontiers in Public Health, 10, 782811. https://doi.org/10.3389/fpubh.2022.782811

45. The Nature Conservancy. (1992). *Island of Hope*. https://www.nature.org/media/rhodeisland/ncmagazine_1992_blockisland.pdf

46. RMI. (2015, June 19). *From diesel to wind on Block Island*. https://rmi.org/blog_2015_06_19_from_diesel_to_wind_on_block_island/

47. Brungard, E. & Fraser, C. (2025, January 31). Community benefits snapshot: Block Island Wind Farm community benefits agreement. *WRI.* https://www.wri.org/snapshots/community-benefits-snapshot-block-island-wind-farm-community-benefits-agreement

48. U.S. Environmental Protection Agency. (2025, February 14). *Learn about the impacts of diesel exhaust and the Diesel Emissions Reduction Act (DERA)*. Retrieved August, 2025, from https://www.epa.gov/dera/learn-about-impacts-diesel-exhaust-and-diesel-emissions-reduction-act-dera

49. American Lung Association. (2025, June 9). *Ozone*. Retrieved August, 2025, from https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/ozone

50. Rhode Island Office of Energy Resources. (n.d.). *Offshore Wind Energy*. Retrieved August, 2025, from https://web.archive.org/web/20140507061512/http://www.energy.ri.gov/renewable/offshore/

51. Harvey, A. (December, 2017). *Nation's first offshore wind farm releases community from decades of diesel*. POWER. https://www.powermag.com/nations-first-offshore-wind-farm-releases-community-from-decades-of-diesel/

52. Ørsted. (n.d.). *Block Island Wind Farm*. Retrieved August, 2025, from https://us.orsted.com/renewable-energy-solutions/offshore-wind/block-island-wind-farm

53. Dong, L., & Lang, C. (2022). Do views of offshore wind energy detract? A hedonic price analysis of the Block Island wind farm in Rhode Island. *Energy Policy, 167*, 113060. https://doi.org/10.1016/j.enpol.2022.113060

54. Carey, D. A., Wilber, D. H., Read, L. B., Guarinello, M. L., Griffin, M., & Sabo, S. (2020). Effects of the Block Island Wind Farm on Coastal Resources: LESSONS LEARNED. *Oceanography*, *33*(4), 70–81. https://www.jstor.org/stable/26965751

55. Gibbons, B. M. (2013). Second wind: A legal and policy-based evaluation of the Block Island Wind Farm and the legislation that saved it. *Connecticut Law Review, 45*(4), 1457–1490. https://opencommons.uconn.edu/law_review/203

56. Drollette Jr., D. (2019). *Tilting toward windmills*. Bulletin of the Atomic Scientists. https://thebulletin.org/2019/09/special-report-tilting-toward-windmills/

57. U.S. Army Corps of Engineers. (2014). *Environmental assessment: Block Island Wind Farm and Block Island Transmission System*. (NAE-2009-789 and NAE-2012-2724). https://www.nae.usace.army.mil/portals/74/docs/topics/deepwaterwind/ea17sep2014.pdf

58. Frumkin, H., & Thun, M. J. (2001). Diesel exhaust. CA: A Cancer Journal for Clinicians, 51(3), 193–198. https://doi.org/10.3322/canjclin.51.3.193

59. Brungard, E., & Fraser, C. (2025, January 31). *Community benefits snapshot: Block Island Wind Farm Community Benefits Agreement*. World Resources Institute. https://www.wri.org/snapshots/community-benefits-snapshot-block-island-wind-farm-community-benefits-agreement

60. Mayor's Office of Racial Equity. (2024). *Districtwide 2024 Racial Equity Action Plan.* Government of the District of Columbia. https://ore.dc.gov/sites/default/files/dc/sites/ore/page_content/attachments/ORE-REAP-2024-a.pdf

61. APPRISE Incorporated. (2020). *DC OPC Energy Affordability Study: Population Characterization Report*. Office of the People's Counsel of the District of Columbia. https://opc-dc.gov/wp-content/uploads/2022/03/DC-OPC-Energy-Affordability-Study-Population-Characterization-Report-FINAL-12-18-20.pdf

62. District of Columbia Sustainable Energy Utility. (n.d.). *DC's Solar for All program to complete 150 home solar projects for income-qualified families*. Retrieved March 12, 2025, from https://www.dcseu.com/news/dcs-solar-for-all-program-to-complete-150-home-solar-projects-for-income-qualified-families

63. District of Columbia Department of Energy and the Environment. (2024, July 30). *Fiscal Year 2022 Solar for All Program and Renewable Portfolio Standard Expansion Amendment Act of 2016 Annual Report*. https://doee.dc.gov/sites/default/files/dc/sites/doee/service_content/attachments/FY%2022%20SFA%20Report%20Final%20Version.pdf

64. Asthma Free DC. (n.d.). *The Impact of Asthma in DC*. Retrieved January 24, 2023, from http://www.asthmafreedc.org/wp-content/uploads/2017/08/asthma_facts_poster_web.pdf.

65. District of Columbia Department of Energy & Environment. (n.d.). *Solar for All*. Retrieved May 21, 2025, from https://doee.dc.gov/node/1226501.

66. U.S. Department of Energy. (n.d.). *Community solar basics*. Office of Energy Efficiency & Renewable Energy. Retrieved May 21, 2025, from https://www.energy.gov/eere/solar/community-solar-basics

67. Clean Air Fund. (n.d.). *India*. Retrieved August, 2025, from https://www.cleanairfund.org/geography/india/

68. United Nations India. (n.d.). *Climate change, clean energy and disaster resilience*. Retrieved August, 2025, from https://india.un.org/en/171990-climate-change-clean-energy-and-disaster-resilience

69. The Economic Times. (2025, January 9). India added 24.5 GW solar and 3.4 GW wind capacity in 2024, sets new records. *The Economic Times*. https://economictimes.indiatimes.com/industry/renewables/india-added-24-5-gw-solar-and-3-4-gw-wind-capacity-in-2024-sets-new-records/articleshow/117085849.cms

70. Basu, M. (2023, April 15). This village in Manipur has become a green energy model. *Thomson Reuters Foundation.* https://scroll.in/article/1047196/this-village-in-manipur-has-become-a-green-energy-model

71. Chanda, P. (2023, August 21). *Distributed pumped hydro storage – A case study*. https://energycentral.com/c/cp/distributed-pumped-hydro-storage-%E2%80%93-case-study

72. Maguire, G. (2024, March 12). India's coal-fired electricity output, emissions hit record highs. *Reuters*. https://www.reuters.com/markets/commodities/indias-coal-fired-electricity-output-emissions-hit-record-highs-2024-03-12/

73. Lam, N. L., Smith, K. R., Gauthier, A., & Bates, M. N. (2012). Kerosene: a review of household uses and their hazards in low- and middle-income countries. *Journal of toxicology and environmental health. Part B, Critical reviews, 15*(6), 396–432. https://doi.org/10.1080/10937404.2012.710134

74. City of Madison. (2024, August 26). *Efficiency Navigator celebrates latest building upgrades*. City of Madison Mayor's Office. https://www.cityofmadison.com/mayor/blog/2024-08-26/efficiency-navigator-celebrates-latest-building-upgrades

75. Cohen, O. (2019, August 7). *Three reasons to prioritize energy efficiency in affordable multifamily housing*. Housing Matters. https://housingmatters.urban.org/articles/three-reasons-prioritize-energy-efficiency-affordable-multifamily-housing

76. C40 Cities. (2024). *Community-Driven Building Retrofit Programs - City of Madison Case Study*. https://c40.my.salesforce.com/sfc/p/#36000001Enhz/a/Vo000000455x/Y0BeqqQQQJuQn_NosGfeH9CUNzxVLqpI3mroJRNZ0ds

77. City of Madison. (n.d.). *Residential efficiency programs*. City of Madison Sustainability & Resilience. Retrieved May 21, 2025, from https://www.cityofmadison.com/sustainability/energy/buildings/residential-efficiency-programs#

78. Dimitroulopoulou, S., Dudzińska, M. R., Gunnarsen, L., Hägerhed, L., Maula, H., …Haverinen-Shaughnessy, U. (2023). Indoor air quality guidelines from across the world: An appraisal considering energy saving, health, productivity, and comfort. *Environment International, 178*, 108127. https://doi.org/10.1016/j.envint.2023.108127

79. Wilson, J., Jacobs, D., Reddy, A., Tohn, E., Cohen, J., & Jacobsohn, E. (2016, December). *Home Rx: the health benefits of home performance* (No. DOE/EE-1505). National Center for Healthy Housing, US Department of Energy. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Home%20Rx%20The%20Health%20Benefits%20of%20Home%20Performance%20-%20A%20Review%20of%20the%20Current%20Evidence.pdf

80. C40 Cities. (2023, September). *Healthy and Efficient Retrofitted Buildings Tool (HERB)*. C40 Knowledge Hub. https://www.c40knowledgehub.org/s/article/Healthy-and-Efficient-Retrofitted-Buildings-Tool-HERB?language=en_US

81. Figari, A., & Gómez, X. (2015). *Promoting Induction Cooking in Ecuador*. International Partnership on Mitigation and MRV. https://api.knack.com/v1/applications/5b23f04fd240aa37e01fa362/download/asset/5c9392a9fc8c902edf363b17/20142013inductioncooking_ecuador.pdf

82. Gould, C. F., Bejarano, M. L., De La Cuesta, B., & Burke, M. (2023). Climate and health benefits of a transition from gas to electric cooking. *Proceedings of the National Academy of Sciences, 120*(34), e2301061120. https://doi.org/10.1073/pnas.2301061120

83. Galindo, Y. (2023, August 15). *Benefits of electric stoves on health and environment in Ecuador*. UC San Diego News Center. https://today.ucsd.edu/story/benefits-of-electric-stoves-on-health-and-environment-in-ecuador

84. C40 Cities. (n.d.). *Co-benefits of zero-carbon buildings*. C40 Knowledge Hub. Retrieved April 7, 2025, from https://www.c40knowledgehub.org/s/topic/0TO1Q000000UBHWWA4/cobenefits-of-zero-carbon-buildings?language=en_US

85. U.S. Green Building Council. (2020, February). *Case study: United Therapeutics Unisphere*. https://www.usgbc.org/sites/default/files/2020-02/UT%20Unisphere_Case%20Study_Feb2020_0.pdf

86. C40 Cities. (2019, May). *Why transitioning to zero-carbon buildings is a vital, urgent and rewarding investment for cities*. C40 Knowledge Hub. https://www.c40knowledgehub.org/s/article/Why-transitioning-to-zero-carbon-buildings-is-a-vital-urgent-and-rewarding-investment-for-cities?language=en_US

87. Fister Gale, S. (2020). Balance of Power: Unisphere's Massive Net-Zero Building Delivers ROI that's Good for the Grid. PM Network, 34(4), 24–29

88. U.S. Environmental Protection Agency. (2018, August). *Estimating the environmental effects of green roofs: A case study in Kansas City, Missouri* (EPA Publication No. 430-S-18-001). https://www.epa.gov/sites/default/files/2018-09/documents/greenroofs_casestudy_kansascity.pdf

89. U.S. General Services Administration. (n.d.). *Indoor environmental quality*. https://www.gsa.gov/governmentwide-initiatives/federal-highperformance-buildings/highperformance-building-clearinghouse/health/indoor-environmental-quality

90. Figueiro, M. G., Steverson, B., Heerwagen, J., Kampschroer, K., Hunter, C. M., …Rea, M. S. (2017). The impact of daytime light exposures on sleep and mood in office workers. *Sleep Health, 3*(3), 204–215. https://doi.org/10.1016/j.sleh.2017.03.005

91. Hafner, M., Stepanek, M., Taylor, J., Troxel, W. M., & Van Stolk, C. (2017). Why sleep matters—the economic costs of insufficient sleep: a cross-country comparative analysis. *Rand health quarterly*, *6*(4), 11.

92. Satish, U., Mendell, M. J., Shekhar, K., Hotchi, T., & Sullivan, D. P. (2012). *Associations of cognitive function scores with carbon dioxide, ventilation, and VOC exposures in office workers: A controlled exposure study*. Environmental Health Perspectives, 124(9), 1499–1505. https://doi.org/10.1289/ehp.1510037

93. Cazzola, P., & Crist, P. (2020). *Good to Go? Assessing the Environmental Performance of New Mobility*. International Transport Forum. https://www.itf-oecd.org/sites/default/files/docs/environmental-performance-new-mobility.pdf

94. Dajnak, D., Evangelopoulos, D., Kitwiroon, N., Beevers, S., & Walton, H. (2021). *London health burden of current air pollution and future health benefits of mayoral air quality policies*. Environmental Research Group, Imperial College London. https://erg.ic.ac.uk/research/home/resources/ERG_ImperialCollegeLondon_HIA_AQ_LDN_11012021.pdf

95. U.S. Environmental Protection Agency. (n.d.). *Smog, soot, and other air pollution from transportation*. Retrieved April 7, 2025, from https://www.epa.gov/transportation-air-pollution-and-climate-change/smog-soot-and-other-air-pollution-transportation

96. Transport for London. (n.d.). *Air quality*. Retrieved May 21, 2025, from https://tfl.gov.uk/corporate/about-tfl/air-quality#:~:text=How%20road%20transport%20harms%20our,cause%20of%20London's%20air%20pollution

97. C40 Cities. (2024, September). *How road pricing is transforming London and what your city can learn*. C40 Knowledge Hub. https://www.c40knowledgehub.org/s/article/How-road-pricing-is-transforming-London-and-what-your-city-can-learn?language=en_US

98. Greater London Authority. (2023, October 31). *New report shows ULEZ expansion is working with 95 per cent of vehicles across inner and outer London now compliant with clean air standards*. Mayor of London, London Assembly. https://www.london.gov.uk/new-report-shows-ulez-expansion-working-95-cent-vehicles-across-inner-and-outer-london-now-compliant

99. Mayes J. and Shankleman J.(2024, March 25). *Why Mayor Sadiq Khan's ULEZ car pollution charge has Londoners divided*. Bloomberg. https://www.bloomberg.com/news/articles/2024-03-25/why-mayor-sadiq-khan-s-ulez-car-pollution-charge-has-londoners-divided

100. Fichera, E., Beshir, H., & Serna Castaño, A. (2023). *Low emission zones improve air quality, physical health and mental well-being*. Institute for Policy Research, University of Bath. https://www.bath.ac.uk/publications/low-emission-zones-improve-air-quality-physical-health-and-mental-well-being/attachments/Low_Emission_Zones_improve_air_quality__physical_health_and_mental_well-being.pdf

101. Transport for London. (n.d.). *Why do we have a ULEZ?* Retrieved April 7, 2025, from https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/why-we-have-ulez

102. Ellerbeck, S. (2023, March 13). *London's low emissions zone has reduced pollution levels by more than a quarter, new study finds*. World Economic Forum. https://www.weforum.org/stories/2023/03/london-low-emissions-zone-pollution

103. Peters, A. (2017, April 4). Inside Paris Mayor Anne Hidalgo's ambitious plans to create the post-car city. *Fast Company*. https://www.fastcompany.com/3069004/the-mayor-of-pariss-quest-to-get-rid-of-cars

104. City of Paris. (2024, April 9). *A new cycling plan for a 100% bikeable city*. Retrieved May 15, 2025, from https://www.paris.fr/pages/un-nouveau-plan-velo-pour-une-ville-100-cyclable-19554

105. City of Paris. (2024). *10 Ans de Transformation de Paris*. City of Paris. https://cdn.paris.fr/presse/2024/03/23/e7aae00b974d33c0240a5e4fcf31e45.pdf

106. Gonzalez, S. (2024, April 24). *The cycling revolution in Paris continues: Bicycle use now exceeds car use. El País.* https://english.elpais.com/lifestyle/2024-04-24/the-cycling-revolution-in-paris-continues-bicycle-use-now-exceeds-car-use.html

107. City of Paris. (2024). *Plan Climat Air Energie de Paris 2024-2030.* City of Paris. https://cdn.paris.fr/paris/2024/12/18/planclimatparis2024-2030_controlelegalite-DKwD.pdf

108. Woodcock, J., Franco, O. H., Orsini, N., & Roberts, I. (2011). Non-vigorous physical activity and all-cause mortality: Systematic review and meta-analysis of cohort studies. *International Journal of Epidemiology, 40*(1), 121–138. https://doi.org/10.1093/ije/dyq104.

109. Energy Policy Institute (EPIC). (2023, August 28). *Mexico City: ProAire (1990).* University of Chicago. Retrieved May 21, 2025, from https://aqli.epic.uchicago.edu/policy-impacts/mexico-city-proaire-1990/#:~:text=In%201992%2C%20the%20United%20Nations,Pollution%20(PICCA)%20in%201990.

110. Barclay, E. (2007, June 23). *Clearing the smog: Fighting air pollution in Mexico City, Mexico, and São Paulo, Brazil.* Disease Control Priorities Project. Archived at https://web.archive.org/web/20081209030638/http://www.dcp2.org/features/47/clearing-the-smog-fighting-air-pollution-in-mexico-city-mexico-and-so-paulo-brazil

111. Santos-Reyes, J., Ávalos-Bravo, V., & Padilla-Pérez, D. (2017). Bus Rapid Transit Systems Road Safety: A Case Study of Mexico City. In H. Yaghoubi (Ed.), *Urban Transport Systems.* IntechOpen. https://doi.org/10.5772/65583

112. Deng, T., & Nelson, J. D. (2010). Recent Developments in Bus Rapid Transit: A Review of the Literature. Transport Reviews, 31(1), 69–96. https://doi.org/10.1080/01441647.2010.492455

113. UN-Habitat. (n.d.). *Annexure C – Long case study: Metrobus – BRT of Mexico City & carbon financing (Module 6: Climate change and urban mobility).* https://unhabitat.org/sites/default/files/download-manager-files/Module%206%20-%20Annexure%20C%20long%20case%20study%20BRT%20in%20Mexico%20City.pdf

114. Bel, G., & Holst, M. (2018). Evaluation of the impact of Bus Rapid Transit on air pollution in Mexico City. *Transport Policy, 63*, 209–220. https://doi.org/10.1016/j.tranpol.2018.01.001

115. Wöhrnschimmel, H., Zuk, M., Martínez-Villa, G., Cerón, J., Cárdenas, B., Rojas-Bracho, L., & Fernández-Bremauntz, A. (2008). The impact of a Bus Rapid Transit system on commuters' exposure to benzene, CO, $PM_{2.5}$ and PM_{10} in Mexico City. *Atmospheric Environment, 42*(35), 8194–8203. https://doi.org/10.1016/j.atmosenv.2008.07.062

116. Carrigan, A., King, R., Velasquez, J. M., Raifman, M., & Duduta, N. (n.d.). *Social, environmental and economic impacts of BRT systems: Bus rapid transit case studies from around the world.* EMBARQ. https://environmentaldocuments.com/embarq/Social-Environmental-Economic-Impacts-BRT-Bus-Rapid-Transit-EMBARQ.pdf

117. Lobo, A. (2015, March 17). *$150 million to transform sustainable transport in Mexico City.* World Resources Institute. Retrieved May 21, 2025, from https://www.wri.org/insights/150-million-transform-sustainable-transport-mexico-city

118. C40 Cities. (2023, October). *Pipeline of electric bus projects in Latin America: An overview of 32 cities.* https://www.c40.org/wp-content/uploads/2023/04/FINAL-Pipeline-of-Electric-Bus-Projects-in-Latin-America-compressed.pdf

119. CCAC secretariat. (2021, July 22). *Chile charts successful climate and clean air integration, becoming leader in region.* Climate and Clean Air Coalition. https://www.ccacoalition.org/news/chile-charts-successful-climate-and-clean-air-integration-becoming-leader-region

120. United Nations Environment Programme. (2019, May 27). *Electric buses put Chile on the path to a healthier tomorrow.* https://www.unep.org/news-and-stories/story/electric-buses-put-chile-path-healthier-tomorrow

121. Todorov, Y. (n.d.). *Simulations drive the electric bus revolution.* VTT Technical Research Centre of Finland. https://www.vttresearch.com/en/news-and-ideas/simulations-drive-electric-bus-revolution

122. Vilela, A. (n.d.). *Chile consolidates with the largest electric bus fleet outside of China.* Latam Mobility. https://latamobility.com/en/chile-consolidates-with-the-largest-electric-bus-fleet-outside-of-china/

123. Galarza, S. (2020). *From pilots to scale: Lessons from electric bus deployments in Santiago de Chile.* ZEBRA (Zero Emission Bus Rapid-deployment Accelerator) partnership. https://iea.blob.core.windows.net/assets/db408b53-276c-47d6-8b05-52e53b1208e1/e-bus-case-study-Santiago-From-pilots-to-scale-Zebra-paper.pdf

124. C40 Cities. (2023, October 19). *Latin America's e-bus market is booming – new research shows where to invest.* https://www.c40.org/news/latin-americas-e-bus-market/

125. Enel X. (n.d.). *The flexibility of Enel X's solutions for electric fleets.* https://corporate.enelx.com/en/stories/2023/12/revolutionizing-public-transportation-solutions

126. C40 Cities Climate Leadership Group, C40 Knowledge Hub, Hubbard, E., & City of Freetown. (2022, May). *Freetown's highly replicable way of self-financing urban reforestation.* C40 Cities. Retrieved May 15, 2025, from https://www.c40knowledgehub.org/s/article/Freetown-s-highly-replicable-way-of-self-financing-urban-reforestation?language=en_US&language%3Den_US=

127. Bechauf, R., Carlucci, E., Guzzetti, M., & Kapetanakis, M. (2025). *Tree planting for climate resilience in Freetown, Sierra Leone: An economic valuation of the "Freetown the Treetown" initiative.* International Institute for Sustainable Development. https://nbi.iisd.org/wp-content/uploads/2025/01/tree-planting-freetown-sierra-leone.pdf

128. Kanosvamhira, T. (2024, October 31). *#FreetownTheTreeTown Campaign: Activating innovative financing models for nature-based solutions.* InfraHub. https://www.infrahub.africa/case-studies/freetownthetreetown-campaign

129. Ulmer, J. M., Wolf, K. L., Backman, D. R., Tretheway, R. L., Blain, C. J. A., … & Frank, L. D. (2016). Multiple health benefits of urban tree canopy: The mounting evidence for a green prescription. *Health & Place, 42*, 54–62. https://doi.org/10.1016/j.healthplace.2016.08.011

130. Taylor, M. (2022, September 22). *Indonesia's coastal villages look to mangroves to combat flooding. Here's how it works.* World Economic Forum. https://www.weforum.org/agenda/2022/09/indonesia-coastal-villages-mangroves-flooding/

131. Wetlands International. (2022, September 3). *Building with nature in Indonesia: Restoring an eroding coastline and inspiring action at scale (2015–2021)*. https://indonesia.wetlands.org/publications/building-with-nature-in-indonesia-restoring-an-eroding-coastline-and-inspiring-action-at-scale-2015-2021/

132. Wetlands International. (2020, June 10). *Ocean Forum empowers Demak community groups for coastal restoration*. https://www.wetlands.org/blog/ocean-forum-empowers-demak-community-groups-for-coastal-restoration/

133. United Nations Environment Programme. (n.d.). *10 flagship initiatives boosting nature and livelihoods around the world*. Retrieved August, 2025, from https://www.unep.org/interactive/flagship-initiatives-boosting-nature-livelihoods/#9

134. Christina, B. (2022, January 20). *Indonesia aims to get mangrove restoration back on track in 2022. Thomson Reuters Foundation*. https://news.trust.org/item/20220120065748-uvgv2/

135. Building with Nature Indonesia. (December 14, 2016). *Building with Nature Indonesia*. https://buildingwithnatureindonesia.exposure.co/building-with-nature-indonesi

136. Zhong, S., Yang, L., Toloo, S., Wang, Z., Tong, S., … Huang, C. (2018). *The long-term physical and psychological health impacts of flooding: A systematic mapping. Science of The Total Environment, 626*, 165–194. https://doi.org/10.1016/j.scitotenv.2018.01.041

137. Pearce, F. (2020, June 18). *Parks vs. people in Guatemala: Communities take best care of the forest. Yale Environment 360*. https://e360.yale.edu/features/parks-vs-people-in-guatemala-communities-take-best-care-of-the-forest

138. Rainforest Alliance. (2022, June 1). *Community: The secret to stopping deforestation in Guatemala*. https://www.rainforest-alliance.org/in-the-field/community-the-secret-to-stopping-deforestation-in-guatemala/

139. Porter-Bolland, L., Ellis, E. A., Guariguata, M. R., Ruiz-Mallén, I., Negrete-Yankelevich, S., & Reyes-García, V. (2012). Community managed forests and forest protected areas: An assessment of their conservation effectiveness across the tropics. *Forest Ecology and Management, 268*, 6–17. https://doi.org/10.1016/j.foreco.2011.05.034

140. United Nations Development Programme. (2025). *Guatemala*. UNDP Climate Promise. Retrieved August, 2025, from https://climatepromise.undp.org/what-we-do/where-we-work/guatemala

141. Allen, W. (2012, October 8). *In the land of the Maya, a battle for a vital forest. Yale Environment 360*. https://e360.yale.edu/features/in_the_land_of_the_maya_a_battle_for_a_vital_forest

142. Council on Foreign Relations. (2024, October 3). *Six highlights from our conversation with Guatemala's President Bernardo Arévalo*. https://www.cfr.org/article/six-highlights-our-conversation-guatemala-president-bernardo-arevalo

143. James, S. (2021, March 23). *Guatemala's Maya Biosphere Reserve is leading the way in responsible forest management. Preferred by Nature*. https://www.preferredbynature.org/news/guatemalas-maya-biosphere-reserve-leading-way-responsible-forest-management

144. U.S. Environmental Protection Agency. (n.d.). *Health effects attributed to wildfire smoke*. Retrieved August, 2025, from https://www.epa.gov/wildfire-smoke-course/health-effects-attributed-wildfire-smoke

145. Roberts, D. (2019, April 9). Barcelona wants to build 500 superblocks. Here's what it learned from the first ones. *Vox*. https://www.vox.com/energy-and-environment/2019/4/9/18273894/barcelona-urban-planning-superblocks-poblenou

146. Mueller, N., Rojas-Rueda, D., Khreis, H., Cirach, M., Andrés, D., … Nieuwenhuijsen, M. (2020). Changing the urban design of cities for health: The superblock model. *Environment International, 134*, 105132. https://doi.org/10.1016/j.envint.2019.105132

147. Ajuntament de Barcelona. (n.d.). *Superilles,* Retrieved August, 2025, from https://ajuntament.barcelona.cat/superilles/es/content/asi-seran-las-nuevas-plaza-y-ejes-verdes-eixample

148. Hu, W. (2016, September 30). What New York can learn from Barcelona's 'superblocks'. *The New York Times*. https://www.nytimes.com/2016/10/02/nyregion/what-new-york-can-learn-from-barcelonas-superblocks.html

149. Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F. N., & Leip, A. (2021). Food systems are responsible for a third of global anthropogenic GHG emissions. *Nature Food, 2*(3), 198–209. https://doi.org/10.1038/s43016-021-00225-9

150. Lesk, C., Rowhani, P., & Ramankutty, N. (2016). Influence of extreme weather disasters on global crop production. *Nature, 529*(7584), 84–87. https://doi.org/10.1038/nature16467

151. Myers, S., Smith, M., Guth, S., Golden, C., Vaitla, B. … & Huybers, P. (2017). Climate change and global food systems: Potential impacts on food security and undernutrition. *Annual Review of Public Health, 38*, 259–277. https://doi.org/10.1146/annurev-publhealth-031816-044356

152. Clark, M., Domingo, N., Colgan, K., Thakrar, S., … & Hill, J. (2020). Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets. *Science, 370*(6517), 705–708.

153. Bezner Kerr, R., T. Hasegawa, R. Lasco, I. Bhatt, D. Deryng, A. Farrell, … P. Thornton, 2022: Food, Fibre, and Other Ecosystem Products. In: *Climate Change 2022: Impacts, Adaptation, and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, … B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 713-906, doi:10.1017/9781009325844.007.

154. Kim, B., Neff, R., Santo, R., & Vigorito, J. (2015, December). *The importance of reducing animal product consumption and wasted food in mitigating catastrophic climate change*. Johns Hopkins Center for a Livable Future. https://clf.jhsph.edu/sites/default/files/2020-09/reducing-animal-product-consumption-wasted-food.pdf

155. Hamerschlag, K., & Kraus-Polk, J. (2017, February). *Shrinking the carbon and water footprint of school food: A recipe for combating climate change*. Friends of the Earth. https://foe.org/wp-content/uploads/2017/11/FOE_FoodPrintReport_7F.pdf

156. National Institutes of Health. (2019, April 2). *Prescribing healthy foods could bring cost-effective benefits*. Retrieved August, 2025, from https://www.nih.gov/news-events/nih-research-matters/prescribing-healthy-foods-could-bring-cost-effective-benefits

157. Oakland Unified School District. (2025). *Nutrition services*. https://www.ousd.org/nutrition-services

158. Centers for Disease Control and Prevention. (2021, April). *Benefits of healthy eating for children*. Retrieved August, 2025, from https://www.cdc.gov/nutrition/php/resources/healthy-eating-benefits-for-children.html

159. Marshall, S. (2022, July 19). *South Korea's food waste system is a model for developed nations. Korea Economic Institute of America*. https://keia.org/the-peninsula/south-koreas-food-waste-system-is-a-model-for-developed-nations/

160. Jeong, A. & Yoon, J. (2024, August 9). *South Korea recycles 98% of its food waste. What can it teach the world?. The Washington Post.* https://www.washingtonpost.com/world/2024/08/09/south-korea-food-waste-composting/

161. Kim, M. (2023, August 24). *How South Korea's composting system became a model for the world. Los Angeles Times*. https://www.latimes.com/world-nation/story/2023-08-24/how-south-koreans-composting-system-became-a-model-for-the-world

162. Intergovernmental Panel on Climate Change. (2023). *Climate change 2021: The physical science basis*. Cambridge University Press. https://doi.org/10.1017/9781009157896

163. Lamb, W. F., Wiedmann, T., Pongratz, J., Andrew, R., Crippa, M., … & Minx, J. (2021). A review of trends and drivers of greenhouse gas emissions by sector from 1990 to 2018. *Environmental Research Letters, 16*(7), 073005. https://doi.org/10.1088/1748-9326/abee4e

164. C40 Cities. (2023, April). *Why port cities should include ports and shipping in climate action plans*. C40 Knowledge Hub. https://www.c40knowledgehub.org/s/article/Why-port-cities-should-include-ports-and-shipping-in-climate-action-plans?language=en_US

165. Mueller, N., Westerby, M., & Nieuwenhuijsen, M. (2023). Health impact assessments of shipping and port-sourced air pollution on a global scale: A scoping literature review. *Environmental Research,* 216, 114460.

166. Port of Los Angeles. (2024). *Facts and figures*. Port of Los Angeles, City of Los Angeles. Retrieved May 20, 2025, from https://www.portoflosangeles.org/business/statistics/facts-and-figures

167. Merk, O. (2014, December). *Shipping emissions in ports* (Discussion Paper No. 2014-20). International Transport Forum. https://www.itf-oecd.org/sites/default/files/docs/dp201420.pdf

168. California Air Resources Board. (2020, August 26). *Control measure for ocean-going vessels at berth*. California Environmental Protection Ageny, State of California. Retrieved May 20, 2025, from https://ww2.arb.ca.gov/resources/fact-sheets/control-measure-ocean-going-vessels-berth

169. Port of Los Angeles. (n.d.). *Alternative Maritime Power® (AMP)*. Port of Los Angeles, City of Los Angeles. Retrieved May 20, 2025, from https://www.portoflosangeles.org/environment/air-quality/alternative-maritime-power-%28amp%29

170. U.S. Environmental Protection Agency. (2022, December). *Shore power technology assessment at U.S. ports – 2022 update* (EPA-420-R-22-037). https://aapapowers.com/wp-content/uploads/2023/04/Shore-Power-Technology-Assessment-2022-Update.pdf

171. Starcrest Consulting Group, LLC. (2024, August). *Inventory of Air Emissions 2023* [Technical report]. Port of Los Angeles. https://www.portoflosangeles.org/getmedia/3fad9979-f2cb-4b3d-bf82-687434cbd628/2023-Air-Emissions-Inventory

172. United States Environmental Protection Agency. (2023, August 8). Clean Air Act Title IV - Noise Pollution. Retrieved April 7, 2025, from https://www.epa.gov/clean-air-act-overview/clean-air-act-title-ivnoise-pollution

173. C40 Cities. (2025). *How Oslo is driving a transition to zero emission construction sites*. C40 Knowledge Hub. Retrieved April 7, 2025, from https://www.c40knowledgehub.org/s/article/How-Oslo-is-driving-a-transition-to-clean-construction?language=en_US

174. Havnevik Giske, E., Christiansen, P., Mortensen, P., & Huseby, M. (2025, April). *Barriers and key success factors for zero emission construction in Oslo* (Version 0.1) [Technical report]. https://www.klimaoslo.no/wp-content/uploads/sites/2/2025/04/Barriers-and-key-success-factors-for-zero-emission-construction-in-Oslo.pdf

175. C40 Cities. (2025, January 29). *Clean construction could create millions of jobs and drive inclusive growth in cities, new C40 research shows*. https://www.c40.org/news/clean-construction-jobs-growth/

176. C40 Cities. (2025, January 10). *Exploring the future of clean construction in Oslo*. https://www.c40.org/news/future-of-clean-construction-oslo/

177. C40 Cities. (2025, January). *Building Greener Cities: Green Job Opportunities in Clean Construction*. https://c40.my.salesforce.com/sfc/p/#36000001Enhz/a/Vo000000Q8y1/Bn3zzj95tP1U3MCW8vZqKdnISx_Efgb1YkFPOuhm8DI

178. Sørensen, H., Kolding, S., Frederik, K., & Wechsler, M. (2024, August). *Oslo's market landscape for clean construction: Barriers and opportunities for small and medium enterprises*. https://drive.google.com/file/d/1YU_tnVYbS97i75jOtUBxKEXLSP3owUHQ/view

179. Vereide, I. (2024, February 29). *The advantages of an emission-free construction site*. KlimaOslo. https://www.klimaoslo.no/the-advantages-of-an-emission-free-construction-site/

180. Niranjan, A. (2025, January 10). *Sites without sound: Oslo leads in quiet, low-emission electric construction*. The Guardian. https://www.theguardian.com/world/2025/jan/10/oslo-leads-quiet-low-emission-electric-vehicles-building-sites

181. Han, Y., Wu, Z., Li, P., Wierman, A., & Ren, S. (2024, December 9). *The unpaid toll: Quantifying the public health impact of AI* [Preprint]. Cornell University. https://doi.org/10.48550/arXiv.2412.06288

182. Moises, H. (2022, September 9). *White data center in Japan has turned to snow for cooling. W.Media*. https://w.media/white-data-center-in-japan-has-turned-to-snow-for-cooling/

183. Judge, P. (2022, April 8). *Japanese snow-cooled data center opens an eel farm. Data Center Dynamics*. https://www.datacenterdynamics.com/en/news/japanese-snow-cooled-data-center-opens-an-eel-farm/

184. Goldman Sachs. (2025, February 4). *AI to drive 165% increase in data center power demand by 2030*. https://www.goldmansachs.com/insights/articles/ai-to-drive-165-increase-in-data-center-power-demand-by-2030

185. Halper E. & O'Donovan, C. (2024, November 1). *As data centers for AI strain the power grid, bills rise for everyday customers. The Washington Post*. https://www.washingtonpost.com/business/2024/11/01/ai-data-centers-electricity-bills-google-amazon/

186. U.S. Environmental Protection Agency. (2025, February 6). *Human health and environmental impacts of the electric power sector*. Retrieved August, 2025, from https://www.epa.gov/power-sector/human-health-environmental-impacts-electric-power-sector

187. Japan Beyond Coal. (n.d.). *Map of coal-fired power plants in Japan*. Retrieved August, 2025, from https://beyond-coal.jp/en/map-and-data/

188. Health Effects Institute. (2019). State of Global Air 2019. www.stateofglobalair.org//sites/default/files/soga_2019_japan.pdf.

189. Kalundborg Symbiosis. (2025). *Kalundborg Symbiosis*. Retrieved August, 2025, from https://www.symbiosis.dk/en/

190. National Academy of Engineering. (1997). The industrial symbiosis at Kalundborg, Denmark. In *The industrial green game: Implications for environmental design and management* (pp. 116–123). National Academies Press. https://doi.org/10.17226/4982

191. Brears, R. C. (2023, July 26). *Industrial symbiosis and wastewater: Exploring the success of Kalundborg eco-industrial park*. *Medium*. https://medium.com/mark-and-focus/industrial-symbiosis-and-wastewater-exploring-the-success-of-kalundborg-eco-industrial-park-631329cf86df

192. Brender, J. D., Maantay, J. A., & Chakraborty, J. (2011). Residential proximity to environmental hazards and adverse health outcomes. *American journal of public health, 101 Suppl 1*(Suppl 1), S37–S52. https://doi.org/10.2105/AJPH.2011.300183

193. World Health Organization. (n.d.). *Floods*. Retrieved August, 2025, from https://www.who.int/health-topics/floods

194. Benevolenza, M. A., & DeRigne, L. (2018). The impact of climate change and natural disasters on vulnerable populations: A systematic review of literature. *Journal of Human Behavior in the Social Environment*, *29*(2), 266–281. https://doi.org/10.1080/10911359.2018.1527739

195. Dodds, J. (2021). The psychology of climate anxiety. *BJPsych Bulletin, 45*(4), 222–226. https://doi.org/10.1192/bjb.2021.18

196. World Health Organization. (n.d.). *Physical Activity.* https://www.who.int/news-room/fact-sheets/detail/physical-activity

197. World Health Organization. (n.d.). *Healthy diet.* Retrieved August, 2025, from https://www.who.int/news-room/fact-sheets/detail/healthy-diet

198. World Health Organization. (n.d.). *Air quality, energy and health: Health impacts*. Retrieved August, 2025, from https://www.who.int/teams/environment-climate-change-and-health/air-quality-energy-and-health/health-impacts

199. NRDC. (January 11, 2023). *Water Pollution: Everything you Need to Know.* https://www.nrdc.org/stories/water-pollution-everything-you-need-know

200. Cao, M., Xu, T., & Yin, D. (2023). Understanding light pollution: Recent advances on its health threats and regulations. *Journal of Environmental Sciences*, *127*, 589–602. https://doi.org/10.1016/j.jes.2022.07.030

201. Dutchen, S. Harvard medicine. (2022) *Noise and Health.* Retrieved August, 2025, from https://magazine.hms.harvard.edu/articles/noise-and-health

202. Wu, F., Jacobs, D., Mitchell, C., Miller, D., & Karol, M. H. (2007). Improving indoor environmental quality for public health: Impediments and policy recommendations. *Environmental Health Perspectives*, *115*(6), 953–957. https://doi.org/10.1289/ehp.8986

203. Stecula, D. A., & Merkley, E. (2019). Framing climate change: Economics, ideology, and uncertainty in American news media content from 1988 to 2014. *Frontiers in Communication, 4*, 6. https://doi.org/10.3389/fcomm.2019.00006

204. Sarofim, M. C., Waldhoff, S. T., & Anenberg, S. C. (2017). Valuing the ozone-related health benefits of methane emission controls. *Environmental and Resource Economics, 66*(1), 45–63. https://doi.org/10.1007/s10640-015-9937-6

205. West, J. J., Fiore, A. M., Horowitz, L. W., & Mauzerall, D. L. (2006). Global health benefits of mitigating ozone pollution with methane emission controls. *Proceedings of the National Academy of Sciences of the United States of America, 103*(11), 3988–3993. https://doi.org/10.1073/pnas.0600201103

206. Vrijheid M. (2000). Health effects of residence near hazardous waste landfill sites: a review of epidemiologic literature. *Environmental health perspectives, 108 Suppl 1*(Suppl 1), 101–112. https://doi.org/10.1289/ehp.00108s1101

207. Toledo and Moguel (2012), Coffee and Sustainability: The Multiple Values of Traditional Shaded Coffee, *Journal of Sustainable Agriculture, 36*(3), 353-377. http://dx.doi.org/10.1080/10440046.2011.583719