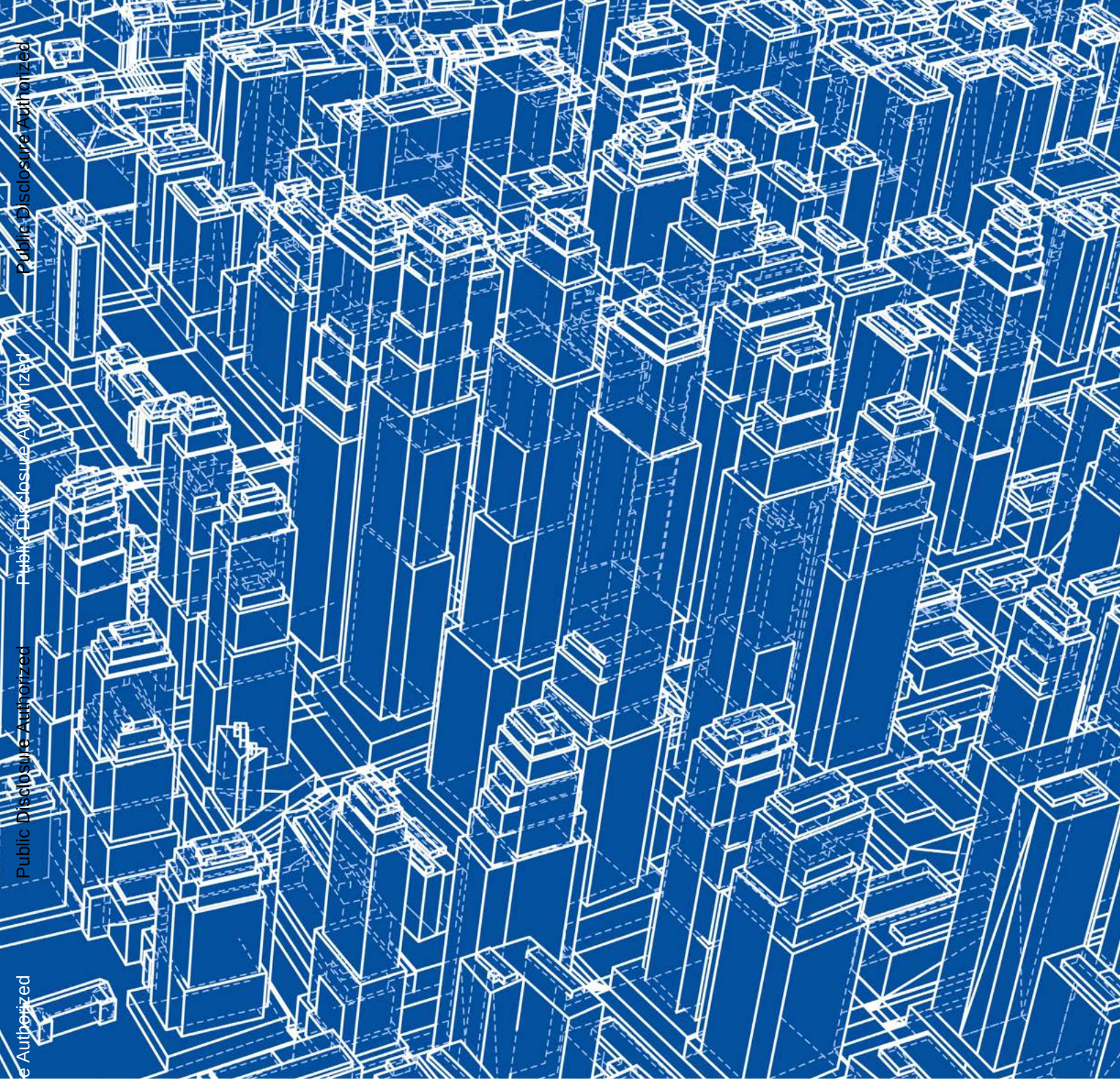


POLLUTION MANAGEMENT
AND THE MAKING OF PROSPEROUS CITIES

PMEH POLLUTION MANAGEMENT & ENVIRONMENTAL HEALTH
For Healthy Living

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

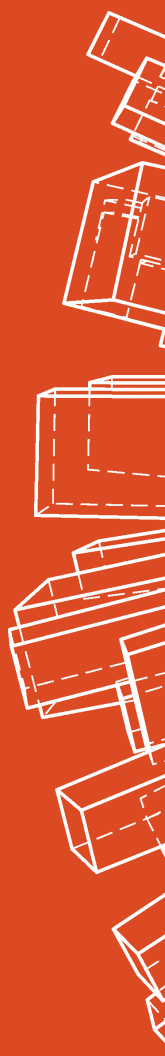
1818 H Street NW

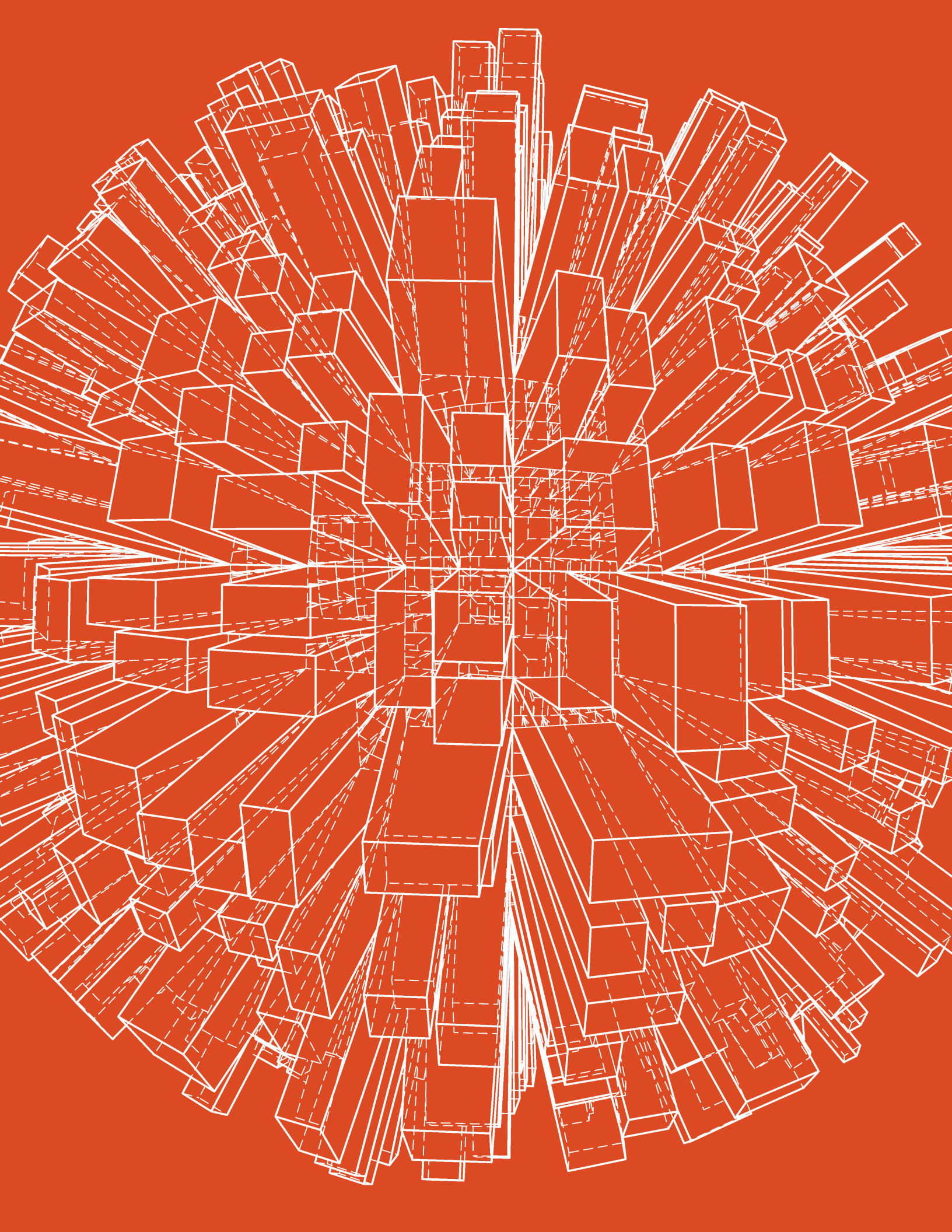
Washington DC 20433

Telephone: 202-473-1000

Internet: www.worldbank.org

Cover illustration by Cherezoff - Adobe Stock





CONTENTS

ACRONYMS

ASA	Advisory Services and Analytics
BAPA	Bangladesh Poribesh Andolon
CAP	Clean Air Plan
CBE	Community-Based Enterprises
CEA	Country Environmental Analysis
COD	Chemical Oxygen Demand
DNCC	Dhaka North City Corporation
DSCC	Dhaka South City Corporation
DoE	Department of Environment
ECA-95	Environment Conservation Act of 1995
ECR-97	Environment Conservation Rule of 1997
EIA	Environmental Impact Assessment
EMA-15	Environmental Management Act of 2015
EMSDA-96	Environmental Management for Sustainable Development Act of Zanzibar
EPA	Environmental Protection Agency
EU	European Union
EV	Electric Vehicles
FEPTIWUK	Federation of Petty Traders
FGD	Focus Group Discussions
GCAP	Greenest City Action Plan
GDP	Gross Domestic Product
HOT	Humanitarian OpenStreetMap Team
IAQGGMP	Integrated Air Quality and Greenhouse Gas Management Plan
ITS	Intelligent Transport System
KCCA	Kampala Capital City Authority
LEZ	Low Emission Zone
LMA	Liberia Marketing Association
LMP	Liberian National Police
MCC	Monrovia City Corporation
MLME	Ministry of Lands, Mines, and Energy
MOEFCC	Ministry of Environment, Forests and Climate Change
MPW	Ministry of Public Works
MRSP	Metropolitan Region of Sao Paulo
NEA	National Environment Act
NEMA	National Environmental Management Authority
NEP-92	National Environmental Policy of 1992
NGO	Non-governmental Organizations
ODK	OpenDataKit
OECD	Organisation for Economic Co-operation and Development
OMK	OpenMapKit
PM 2.5	Particulate Matter 2.5
PMEH	Pollution Management and Environmental Health
RAJUK	Capital Development Authority (Rajdhani Unnayan Kartipakkha)
RGoZ	Revolutionary Government of Zanzibar
SME	Small Medium Enterprises
SWM	Solid Waste Management
UN	United Nations
WtE	Waste to Energy
WHO	World Health Organization
ZEMA	Zanzibar Environmental Management Authority
ZEP-13	Zanzibar Environmental Policy of 2013

ACKNOWLEDGMENTS

This report was produced as part of the program on Pollution and the Making of Prosperous Cities Advisory Services and Analytics (ASA), under the umbrella of the Pollution Management and Environmental Health (PMEH) program. The report was prepared by a team led by Nancy Lozano-Gracia (Senior Economist, SMNDR) and Soraya Goga (Lead Urban Specialist, SAFU1), under the supervision of Maitreyi B Das (Practice Manager, SURGP) and overall guidance of Sameh Wahba (Global Director, SURDR). The team consisted of Maria Edisa Soppelsa (ET Consultant, SURGP), Giuliana De Mendiola (ET Consultant, SLCUR), Anna Gueorguieva (Senior Economist, PA9SS) David Ryan Mason (Urban Development Specialist, SSAU1), Qingyun Shen (Urban Specialist, SAFU1) and Swati Sachdeva (Consultant, SAFU1). The team worked in collaboration with researchers at University of Southern California (USC), BRAC Uganda, Makerere University, University of California San Diego (UCSD), IPA, Humanitarian OpenStreetMap (HOT), and iLab Liberia. Substantive contributions were made by Vittorio Bassi, Teevrat Garg, Matthew E. Kahn, Tommaso Porzio, Leire Sarasola Santiago, Jiong Gao, Usman Gauss, Raffaela Muoio, Valentina Saavedra Gomez, Deo Okure, Engineer Bainomugisha, Camilo Villa Van Cotthem, Esau Tugume, Zhen Liu, and Asif Mohammed Zaman. Valuable guidance was provided by Ernesto Sanchez-Triana (Lead Environmental Specialist, SENDR), Yewande Aramide Awe (Senior Environmental Engineer, SENGL) and Iain Shuker (Practice Manager, SAFE2). Claudia P. Pacheco Florez (Program Assistant, GSU10) and Marco Gallardo (Program Assistant, SCAUR) provided overall administrative assistance.

The team thanks Somik Lall (Lead Urban Economist/Global Lead, Territorial and Spatial Development, SURDR), Urvashi Narain (Lead Economist, SSAEN), Martin Heger (Senior Environmental Economist, SMNEN), and Ayah Mahgoub (Senior Urban Development Specialist, SLCUR) for peer review inputs. Richard Damania (Chief Economist, GGSCE) provided guidance and comments on background papers.

The report was edited by Samuel Ashworth. The report layout and graphic design is credited to Carlos Plaza Design Studio.

This work is part of the Pollution Management and Environmental Health program (PMEH) supported under TF0A3415. The PMEH program focuses on providing technical assistance to countries, facilitating pollution management, promoting public awareness, and helping them reduce the negative effects of pollution on health.

EXECUTIVE SUMMARY

As engines of productivity and economic growth, cities are essential to the growth and competitiveness of nations and regions. Abundant empirical research finds that the co-location of firms and workers in cities provides additional benefits through economies of agglomeration, which are integral to development. However, as rapid urbanization and economic growth go hand in hand, the negative effects of increased density, including among others congestion, pollution, and urban sprawl, may threaten cities' competitiveness. These "demons of density," can affect not only quality of life but also productivity, which in turn constrains a city's competitiveness. In this report we focus on one of these demons: pollution.

While the economic literature has established links between pollution and quality of life and health, much less has been done to understand the links between pollution, productivity, and, in turn, city competitiveness. Human capital is key to boosting city competitiveness, but pollution can diminish this boost by harming workers' health, productivity, and development. Environmental regulations can help internalize pollution costs, yet implementation could be challenging, costly, and not always appealing to policy makers. Examining these links can then reveal cities' main issues and limitations, including lack of public awareness and/or reliable pollution data, helping them to better manage pollution and improve competitiveness.

The work summarized in this report fills a knowledge gap by contributing to an improved understanding of the links between competitiveness and pollution. Specifically, it argues that pollution need not be an inevitable consequence of development. Indeed, there are examples of cities that have been able to manage pollution while transitioning through different development stages. Recognizing, however, that policy makers are often grappling with how to negotiate this balance, the report also provides policy makers with options to strengthen competitiveness in their cities while mitigating the negative effects of pollution.

This report summarizes the findings of the Pollution Management and the Making of Prosperous Cities Program, which had a three part objective: (i) to generate information and knowledge that would be helpful to mayors and other city and national level decision makers in urban planning and economic competitiveness; (ii) to increase understanding and capacity among pollution-related decisionmakers; and (iii) to produce outputs and tools to support policy makers in managing both pollution and competitiveness. In order to build a knowledge base around the links between competitiveness and pollution, and provide policymakers with useful tools for decision making, this work uses new empirical evidence, city case studies, and international best practices.

Using a global cross-city analysis to compare cities' performance and air pollution levels, background work done for this report[1] finds that the relationship between pollution and city growth varies at different stages of development. It's often assumed that in the course of development, pollution is unavoidable, but this report argues that this is not necessarily the case for all cities. In fact, avoiding the high costs of pollution can help firms increase productivity levels and strengthen a city's competitiveness. Analysis focusing on African cities[2] confirms that pollution negatively affects firm performance.

Four developing cities—Kampala, Dhaka, Zanzibar, and Monrovia—were selected to illustrate the challenges that fast-urbanizing cities face in managing pollution and the several channels through which pollution can affect competitiveness. Different types of analysis were conducted in each city, assessing both the various vectors of pollution and the institutions and regulations that manage pollution at the national and local level.

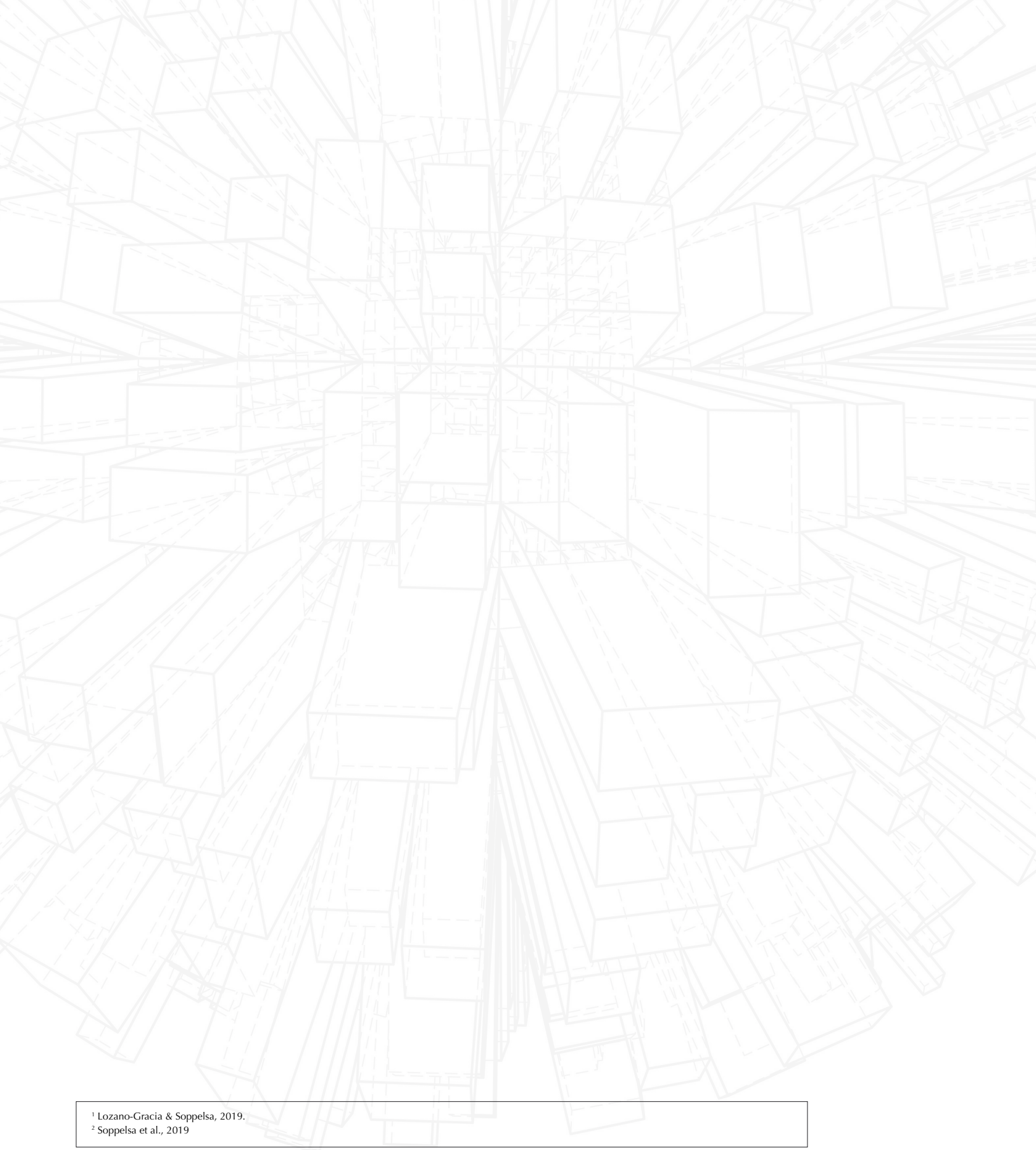
In Kampala, the analysis examined the effects of outdoor air pollution on firm productivity. To measure air pollution, static and mobile monitors were placed across the city creating Uganda's first air pollution monitoring network. Results show that pollution is higher at rush hours (early morning and evening), when it consistently reaches levels above World Health Organization (WHO) standards. Combining this information with firm-level survey data suggests that while most firms are in more polluted areas of Kampala, they also enjoy better market access, hinting at the tradeoffs that firms face in deciding where to locate. Our institutional analysis suggests that the most important binding constraints for reducing the negative effects of pollution on the city are: the lack of national guidelines for pollution management; limited availability of information; and low local capacity – including financial capacity – for managing pollution vectors.

In Dhaka, one of the most polluted cities in the world, the analysis pushed the boundaries by conducting a field experiment to assess the impact of indoor air pollution on workers' productivity in manufacturing firms. 40 garment factories were randomly selected for the experiment: 20 air purifiers and 20 air quality monitors (which measure AQI, PM 2.5, and PM 10 levels) were allocated to 20 firms (treatment group). The remaining firms constituted a control group. Early results show that indoor air pollution levels in factories in Dhaka are at unhealthy levels according to World Health Organization guidelines. The use of filters appears to lead to important decreases of more than 20% in PM 2.5 ($\mu g/m^3$). Before the experiment was put on hiatus by the COVID-19 pandemic, initial comparisons of worker productivity in treatment and control groups hint at how productivity may be affected by pollution. The institutional analysis demonstrates that limited financial resources and capacity to address responsibilities for managing pollution are significant national factors. At the local level there is limited technical capacity for management of pollution vectors. Overlapping mandates among the different institutions exacerbate the challenges.

The Zanzibar study focused on understanding the links between water and ocean pollution and the tourism sector, informed by survey data collection. Results find that the higher tourists rate the island's overall cleanliness, the more willing they are to return. However, two thirds of tourists expressed a poor opinion of the island's cleanliness, and half of residents and business providers think that overall cleanliness has not changed or has gotten worse in the last 10 years. However, one of the most significant contributors to pollution in the city is the tourism sector. The institutional analysis suggests that while Zanzibar has policies and institutions dedicated to environmental protection and pollution management, it struggles to monitor and enforce of its policies and regulations. Limited public awareness and the lack of community sensitization make it more difficult for the government to protect the environment and manage pollution.

The Monrovia analysis was slightly different in that it assessed the links between the management of pollution vectors and the productivity of the informal Duala Market (one of the most important economic zones in the city), measured primarily through trader earnings and rent revenues. Quantitative surveys, qualitative focus groups, drone mapping, and infrastructure assessments were used in the course of research. The vectors of pollution analyzed were: (i) solid waste; (ii) wastewater and sanitation; (iii) food waste; and (iv) traffic and congestion. Results show that poor management of these vectors contributes to inefficiencies within the market. Addressing food loss, including improved solid waste management, could increase vendors' gross profit by 9 percent. Additionally, improved market management could lead to a 3- to 7-fold increase in market revenues. The institutional assessment demonstrated that Monrovia's limited financial and staffing capacity, coupled with lack of enforcement and lack of clear mandates and responsibilities (even through laws and regulations are in place), undermine the effective management of pollution vectors.

As demonstrated by these case studies, pollution can impair city competitiveness through different channels. Thus, it is crucial for policy makers to understand where the challenges lie and how to address them. A successful and comprehensive pollution management approach as part of an overall development and growth strategy can contribute to improved city competitiveness. To support decision-making by policy makers, a gap analysis was developed for the four case study cities. Challenges were grouped in three categories: (i) regulatory framework gaps, (ii) human and financial capacity gaps, and (iii) coordination gaps. Results show that the key constraints across the cities are: limited sectoral policies and lack of enforcement; serious capacity limitations due to inability to recruit staff with the necessary technical skills, as well as inadequate funding; and lack of coordination among stakeholders at the local and national levels, and across sectors. Finally, selected international best practices cases are put forward using the Competitive Cities Framework (World Bank, 2016) to help provide practical examples that can inform the design of successful pollution management strategies. The selected cities were chosen because they have been able to implement different programs with the same goal: to improve pollution while enhancing competitiveness. The international examples highlight how strengthened regulations and enforcement, strong institutions and local capacity for implementing regulations and managing pollution, and smooth coordination across sectors are the core components of controlling urban pollution levels while ensuring a city remains competitive.



[1] Lozano-Gracia & Soppelsa, 2019.
[2] Soppelsa et al., 2019

INTRODUCTION

Competitive cities are engines of economic growth. They contribute to a nation's development by attracting firms and generating jobs. But some cities can become victims of their own success, and often face the many well-known challenges brought by the high concentration of firms and people in cities. The so called "demons of density" have been amply described (Glaeser, 2012; Ciccone, 1993; Graham, 2007). Rising traffic congestion, higher crime rates, and increased pollution are just some of the "demons" that growing cities must face.

When these "demons" are not well managed, cities' competitiveness can be negatively affected. First, they can reduce the cities' ability to attract firms and qualified workers, slowing down growth and job creation. Second, they can reduce the productivity of workers and firms due, for example, to time wasted in traffic congestion or the negative impacts of pollution on health. Third, they can affect cities' quality of life or livability, to a point where residents and firms may "vote with their feet" and decide to leave the city and relocate elsewhere.

Pollution is one of the biggest "demons of density," and it is significantly affecting rapidly urbanizing cities around the world. Approximately 65 percent of cities, most of which are located in developing countries, have an annual mean concentration of PM 2.5 that is above the level considered acceptable by the World Health Organization. The links between high levels of pollution and severe health and environmental problems have been widely studied (Hammer, 2011; Carmichael et al., 2017). Not only is air pollution one of the world's leading risk factors for death, but it also influences people's emotions and behaviors. Pollution is also associated with greenhouse gases which lead to warmer temperatures and all the consequences of climate change including rising sea levels and more extreme weather. Moreover, today air pollution is in the forefront as the COVID-19 pandemic develops. While causation is yet to be proven, early literature points at links between air pollution and the spread of the disease (Xiao et al., 2020 & Ogen, 2020).

However, the literature on the effects of pollution on city competitiveness is scant. The purpose of this report is to contribute to filling this gap through empirical analysis and city case studies, which speak to the challenges faced by cities in the developing world. Based on the evidence, and using the World Bank's Competitive Cities Framework, this work also presents a toolkit as a resource for urban managers and planners to support the implementation of pollution management measures and programs that can help their city be more competitive and livable.

The first chapter of the report examines the links between city competitiveness and pollution, synthesizing the findings of three background papers.[3] The chapter starts by providing an overview of the existing literature on the links (or lack thereof) between pollution and city competitiveness. This first background paper provides an improved understanding of where the research frontier lies in terms of the link between these two topics, and establishes the clear unknowns (Kahn et al., 2019). To put the hypothesis of an existing link between pollution and city competitiveness to the test, the chapter then summarizes the results of a descriptive analysis outlined in the second background paper (Lozano-Gracia & Soppelsa, 2019) to assess the existence of such links using information from a large set of countries. Finally, the chapter concludes with empirical evidence of the links between air pollution and firm productivity in African cities, as put forward by the third background paper (Soppelsa, et al., 2019).

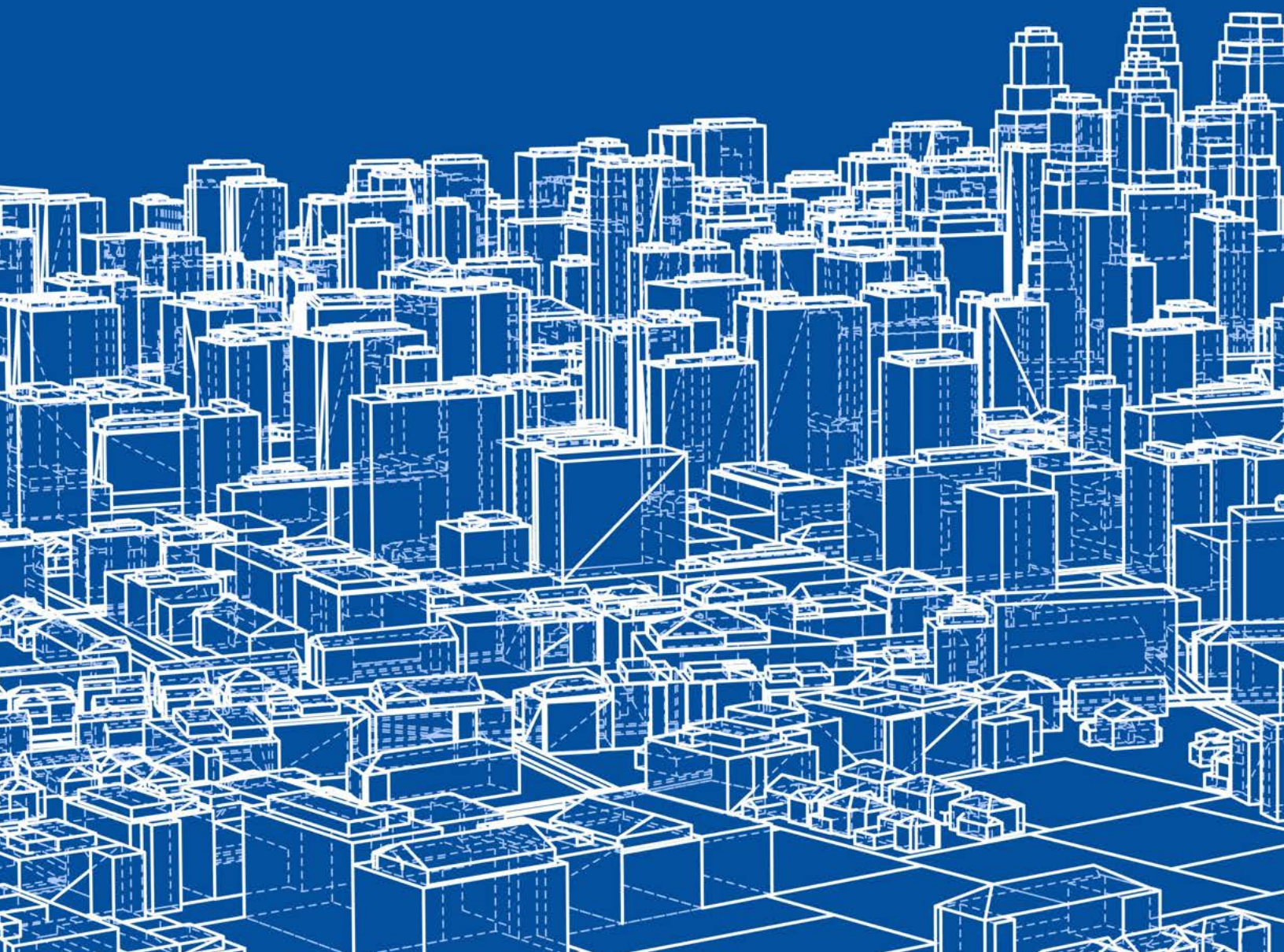
The second chapter goes on to provide in-depth empirical evidence and discussion of pollution challenges using case studies of four rapidly urbanizing cities: Kampala, Dhaka, Zanzibar and Monrovia. Different types of analysis were conducted in each city, partly because all four presented different challenges in terms of the possible impacts of pollution on city competitiveness. Ideally, this approach will yield a broader view of the vast set of challenges pollution may bring, and the various sets of channels through which it may affect a city's competitiveness. In Kampala, the analysis focused on examining the effects of outdoor air pollution on firm productivity. In Dhaka, the work assessed, in an experimental setting, the impact of indoor air pollution on workers' productivity in manufacturing firms. In Zanzibar, the study focused on understanding the links between water and ocean pollution and the tourism sector, informed by survey data collection. In Monrovia the analysis was based on a qualitative assessment of the impact of different pollution vectors on the productivity of the Duala Market. Each case study is complemented with an analysis of the institutional setup for environmental and pollution management in the city of focus, and the main challenges faced.

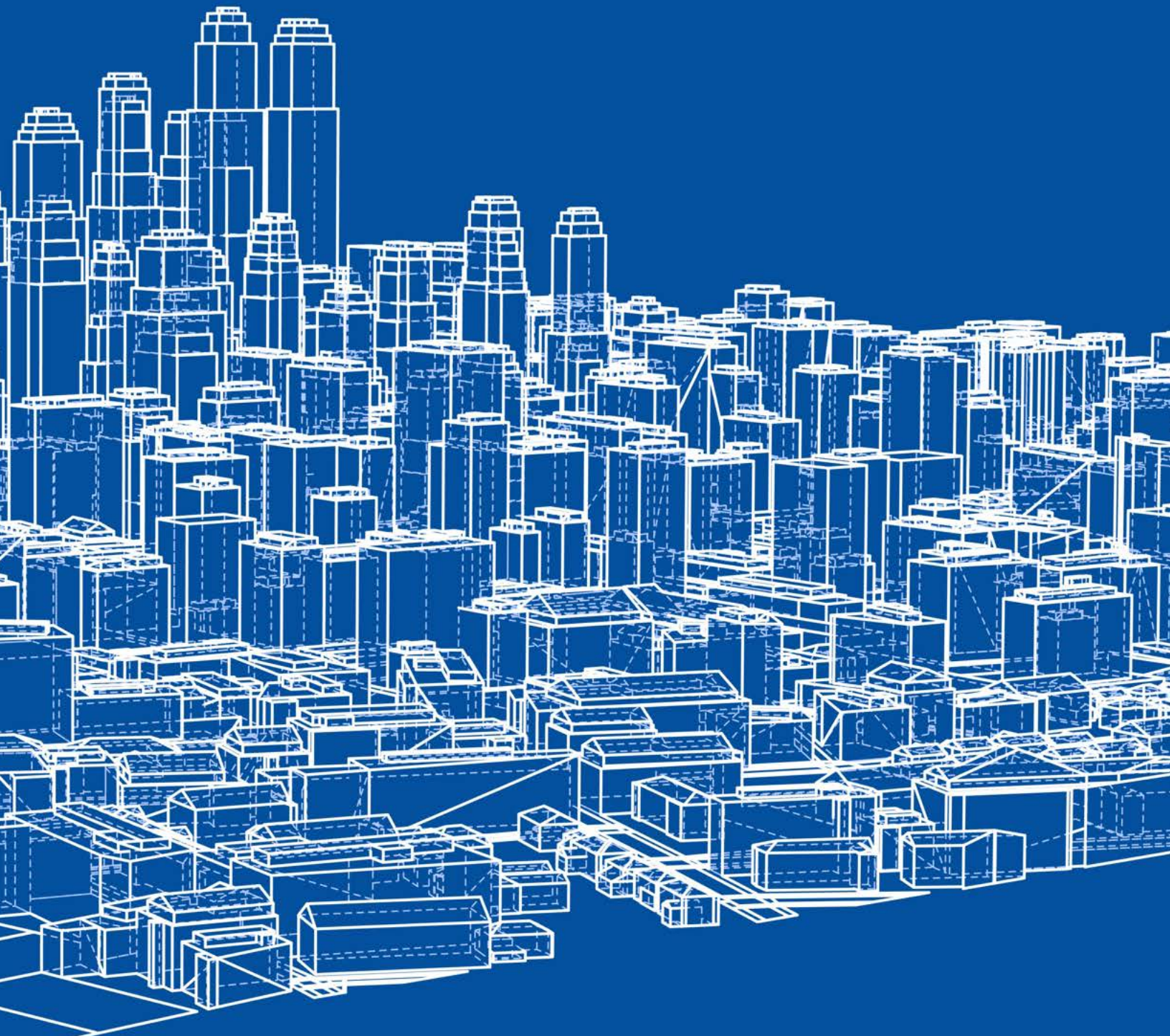
The third chapter distills the main institutional gaps identified in the city case studies to understand were the main obstacles lie in terms of regulations, capacity and coordination. Further it presents a series of best practices using the Competitive Cities Framework but with an eye on policies for the management of pollution. Drawing from a review of international examples of best practice, it analyses possible avenues to manage pollution in cities, and thereby, ensure the strengthening of city competitiveness.

[3] Lozano-Gracia & Soppelsa, 2019; Kahn et al., 2019; Soppelsa, et al., 2019.

CHAPTER 1

POLLUTION AND COMPETITIVENESS





BOX 1.1:
WHAT DO COMPETITIVE CITIES LOOK LIKE?.

The 2016 World Bank Competitive Cities for Jobs and Growth analyzes what do competitive cities look like, who are the competitive cities and how do they achieve their success. It looks at data from the largest 750 urban agglomerations or metropolitan areas across the world from 2005 to 2012. While they find that cities vary greatly on their characteristics and their economic performance, there are four key factors that make competitive cities stand apart from the rest. These are:

- Accelerated economic growth: the top 10 percent of cities achieved almost three times higher annual gross domestic product (GDP) per capita than the average city.
- Impressive job creation: the top 10 percent of cities achieved almost five times higher annual job growth than the remaining 90 percent of cities.
- Higher incomes and productivity: households in the top 10 percent of cities increased their average disposable income by 9.8 percent annually.
- Attraction of foreign direct investment (FDI): the top 5 percent of cities achieved as much FDI as the bottom 95 percent.

By looking at specific cases of competitive cities, it becomes evident that to achieve success, cities not only need an economic development strategy, but also strong implementation mechanisms and delivery systems. This means that cities need comprehensive policies and regulations that are systematically enforced, strong human and resource capacity, and coordination between national and local level institutions as well as with the private sector and civil society.

Source: World Bank, 2016.

WHAT IS A COMPETITIVE CITY?

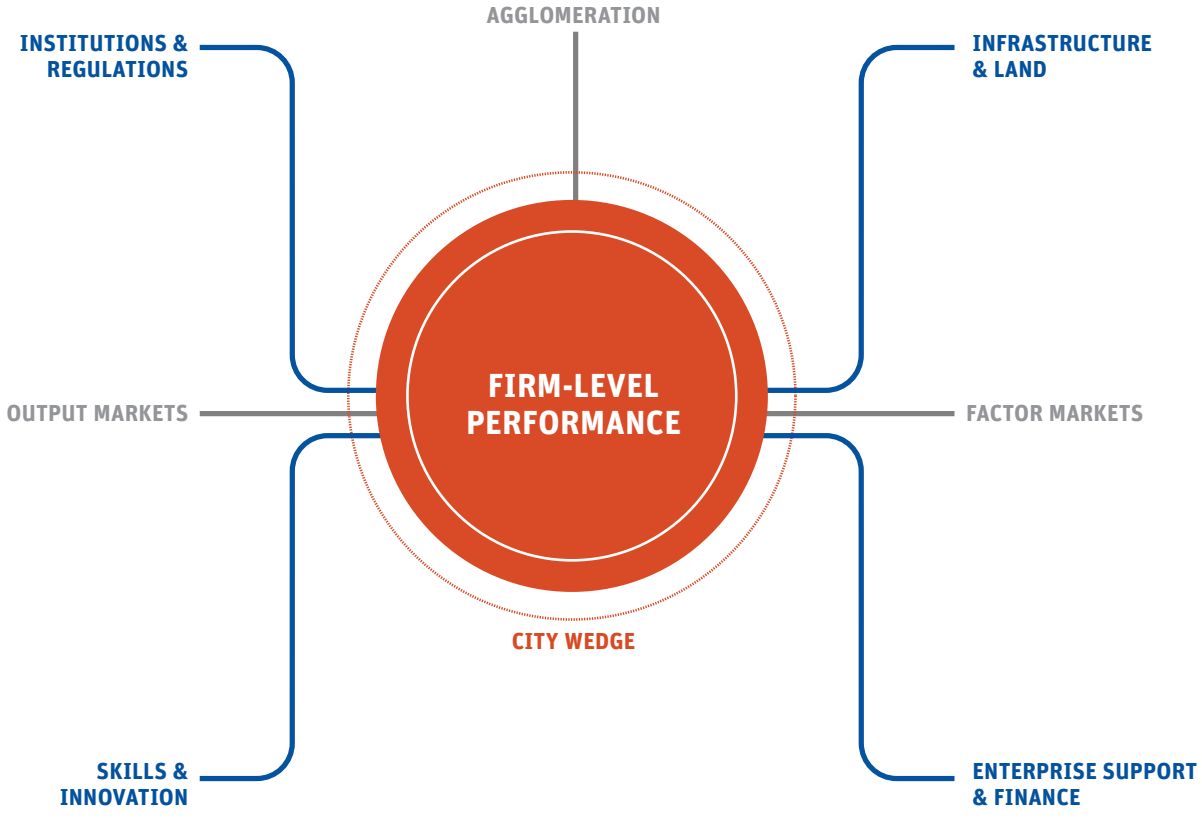
The contribution of cities to economic growth is now well accepted in both the economic and public policy literature. Estimates suggest that they contribute as much as 80 percent of global Gross Domestic Product (GDP). By providing a spatial environment where firms and people meet, cities facilitate trade and interactions, help connect different stages of production, and allow the exploitation of economies of scale. The agglomeration of people and firms that cities bring is crucial for development, pushing countries to grow faster (Duranton, 2008; Glaeser, 2014). Cities that succeed at attracting new firms, workers, and investment are identified as competitive cities. They often grow faster and are more productive; they exhibit foreign direct investment (FDI) success and growth of their domestic firms; they emphasize tradeable sectors; and they create a disproportionate number of private sector jobs (World Bank, 2016). Box 1.1 explains these characteristics in more detail.

To guide city leaders and urban managers as they build and strengthen city competitiveness, the Competitive Cities report develops a framework that establishes the building blocks of city competitiveness. By leveraging four categories of interventions - Institutions and Regulations, Infrastructure and Land, Skills and Innovation, and Enterprise support and Finance - cities can increase their competitiveness.

- Institutions and regulations: taxes, licenses, duties, legal regulation, promotion and branding
- Infrastructure and land: roads, electricity, water, sanitation, transportation, communications, and land (including colocation arrangements for similar firms)
- Skills and innovation: basic education, vocational training and workforce development, and innovation networks
- Enterprise support and finance: access to capital, subsidies, incentives, export assistance, and capacity development for operational activities (legal, financial, administrative)

As stressed in the report, equally important to the interventions themselves are the channels employed by competitive cities to accomplish them: the mayor's wedge, or the power and capacity to ensure successful interventions; the growth coalitions wedge, or the capacity of the city to nurture public-private coalitions to solve particular problems; and the intergovernmental relations wedge, or the use of external leverage with neighboring jurisdictions and other tiers of government. By combining and balancing these factors, cities can foster the agglomeration process and ultimately boost firm-level performance. Figure 1.1 provides a graphic representation of these factors and interactions (World Bank, 2016).

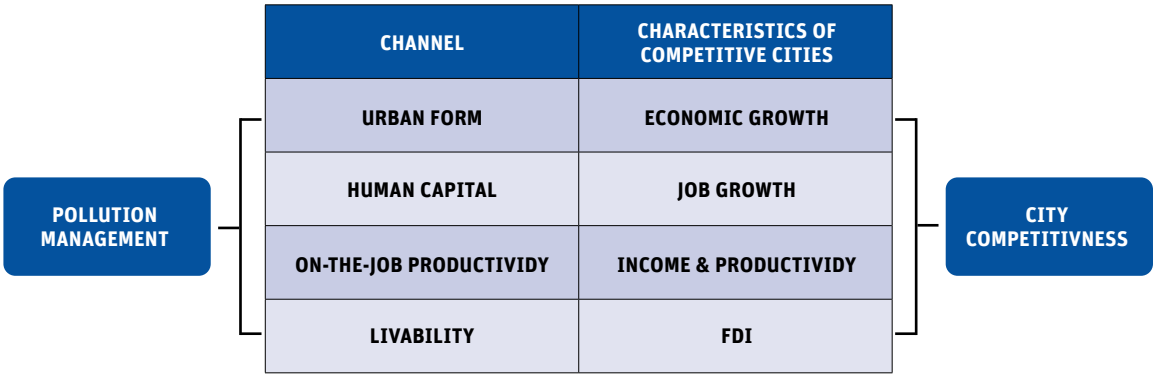
FIGURE 1.1: COMPETITIVE CITIES: COMPONENTS AND THEIR INTERACTIONS



Source: World Bank, 2016

This framework provides a compelling case for understanding and managing city competitiveness, but it does not delve into the negative effects of urbanization – including congestion, pollution, urban sprawl, and the loss of ecosystems on which cities depend. This is an important omission, because these negative effects, or costs of urbanization, have the potential to significantly harm competitiveness (Stockholm International Water Institute). Increasing city competitiveness must go hand in hand with mitigating these negative effects. Thus, it is crucial to understand the implications of each of these "demons of density." This report takes a step forward in that direction by focusing on better understanding the links between pollution, pollution management and the elements of city competitiveness discussed earlier. First, pollution management supports economic growth by managing the urban form. When a city is managed for lower pollution through higher density of settlements, the agglomeration diseconomies can be reduced. Second, pollution management can contribute, through environmental health, to a stronger human capital, which in turn can contribute to job growth. Third, pollution management affects incomes and productivity through its effects on human capital, and more directly through on the-job productivity and at the firm level, through improved resource effectiveness. Fourth, the livability of the city is expected to have an impact on FDI (see Figure 1.2).

FIGURE 1.2: LINKS BETWEEN POLLUTION MANAGEMENT AND CITY COMPETITIVENESS



Source: Author's elaboration

The next sections offer a deeper understanding of this link by assessing the existing literature and knowledge frontier, describing the patterns using global data, and testing the relationship between competitiveness and pollution with a focus on African cities.

FINDING THE LINKS BETWEEN COMPETITIVENESS AND POLLUTION

Pollution is often overlooked as a negative externality, since the links between productivity and pollution are often hard to identify. The negative effects of pollution on health are well documented, and early evidence has even tied air pollution to the recent pandemic (see Box 1.2). However, the relationship between pollution and city competitiveness and productivity have been less studied. There is not much evidence on how pollution affects workers and firm productivity, how pollution reduction can enhance city competitiveness, or what are the costs associated with a green agenda, to name a few.

In work done for this report, Kahn et al., (2019) conduct a thorough survey of recent literature pertaining to the links between city competitiveness and pollution, and identify areas where further work is needed to better understand such links. With an emphasis on developing countries, this work demonstrates the role that urban quality of life, clean air and water, local greenness, and regulations play in enhancing a city's competitiveness. It dives into three main questions: First, why does pollution hinder urban competitiveness? Second, why is this effect likely to grow in importance over time? Third, why have cities been slow to adopt cost-effective regulatory strategies?

BOX 1.2:
COVID-19 AND AIR POLLUTION IN CITIES

In the context of the COVID-19 pandemic, air pollution is on the spotlight once again. Cities that usually experience dangerous daily levels of air pollution have seen these levels drop significantly. A recent study from IQAir shows that for some cities, declines in air pollution levels have reached up to 60 percent compared to the previous year. Several lockdown measures have reduced the economic activity in many cities and as a consequence, the quality of air has improved. For example, in Kampala, daily measures of air quality improved by approximately 40 percent, compared to previous days without lockdown. These findings have also provided more evidence on which are the major sources of air pollution and the magnitude of this challenge for the cities (see for example a recent article on the Wall Street Journal: "Coronavirus Offers a Clear View of What Causes Air Pollution".

Moreover, the negative effects associated with air pollution have become clearer as a result of the COVID-19 pandemic. Prolonged exposure to air pollution is associated with lung and heart diseases, killing approximately 4.2 million people per year. Given the evolution of the virus, people living in cities with higher levels of pollution are at higher risk of COVID-19 complications and death. A few recent studies have established some early links between air pollution and COVD-19 deaths. For example, Xiao et al. (2020) have found that an increase of 1 μg/m^3 is associated with an 8percent increase in the COVID-19 deaths rate, and Ogen (2020) has shown that almost 80percent of the deaths in Italy, Spain, France and Germany have occurred in the 5 most polluted regions.

Source: Xiao et al., 2020 & Ogen, 2020.

One of the main findings that this review highlights the importance of human capital for boosting city competitiveness and how pollution can affect this boost. Cities with higher levels of human capital tend to grow faster, but pollution can threaten this path through three channels. First, pollution negatively impacts the health and development of the city's human capital. A child that is sick learns less in school and struggles to achieve her full potential. At the same time, highly polluted cities have more trouble attracting qualified workers as firms may need to pay them more. Second, pollution has a negative effect on workers' productivity by affecting their ability to think or increasing the number of days lost due to sickness. Third, pollution increases inequality in living standards, because skilled workers can opt to work in less polluted cities, while less skilled workers will have to remain in areas with worse air quality, where their productivity will be negatively affected, increasing the gap between these two groups.

Pollution can also influence cities' economic activity, making them more specialized in certain sectors. Cities that specialize in less polluting activities, such as service jobs or clean industries, or cities with natural beauty, will have a competitive advantage to attract skilled workers and firms in a variety of sectors. On the other hand, cities with high levels of pollution run the risk of attracting more "dirty" industries. Firms in these cities will need to pay higher wages to compensate their workers for the poor conditions. The evidence suggests that in time, "cleaner" firms will leave the city and "dirty" firms will relocate in more polluted cities. Beach and Hanlon (2016) use a city level panel dataset to present a dynamic equilibrium where cities that focus on energy intensive industries ("dirty firms") get more specialized in time (Kahn et al., 2019). This industrial specialization can make these cities more vulnerable to external shocks, affecting their ability to grow in time.

Environmental regulation can help mitigate the costs of pollution and through that, help the city achieve a more heterogeneous sectoral composition. However, successfully implementing these regulations can be challenging in developing countries given political economy issues compounded by low capacity and resource constraints. Regulations can also be costly and depending on which economic actors are made to bear the burden, city officials may be less likely to implement them. Moreover, because these regulations can only be enforced on the formal economy, they could push firms into the unregulated sector, exacerbating informality, worsening pollution, and affecting the city's economic development.

DESCRIBING THE LINKS BETWEEN COMPETITIVENESS AND POLLUTION LEVELS

As cities grow and face the natural challenges of development, they also deal with the negative consequences of this rapid growth. Fast growing cities attract firms and workers, which increases traffic and congestion. Moreover, as a natural consequence of this increase in the number of firms and people, the city usually sees its levels of pollution raise. Often, pollution is considered as a secondary problem and managing its effects is postponed into the future. However, evidence has shown that putting off dealing with these issues can affect the city's livability and in turn, its productivity and competitiveness.

Lozano-Gracia & Sopelsa (2019) offer a global cross-city analysis that compares cities' performance and air pollution levels across the world. In order to do this, the authors combine three datasets in an innovative way. These datasets include economic indicators of 775 cities from the Oxford Economics Dataset, city location from the Global Rural-Urban Mapping Project, and surface-level measures of air pollution estimated by van Donkelaar et al. (2016) from satellite data. By building this dataset, the authors compare cities and classify them into four different categories in terms of performance and pollution levels, which reveals patterns that clarify the relationship between these two variables.

The analysis suggests that there is a non-linear relationship between air pollution (measured through PM 2.5) and GDP per capita at the city level. Earlier studies had shown a similar relation between air pollution and GDP at the country level. This relationship between pollution and city growth shows a simple correlation between PM 2.5 and different stages of city development (through city GDP per capita) that varies for different levels of development. The results are in line with the literature that has generally found inverted U relationships between economic development and particulate matter. As such, it does not consider nor explain the dynamics behind. Among the many critiques put forward in the early literature putting forward the EKC, are the transboundary nature of pollution, which makes it hard to assign pollution levels to a single city, in particular for cities that are in the "zone of influence" of each other.

This concept assumes that the rise in pollution is possibly a result of industrialization and that when higher income levels are reached, pollution falls again. Cities that are developing fast often tend to sacrifice environmental quality because they benefit from fast industrialization but suffer from lack of regulation or institutions to consider the long-term effects of pollution on health and the environment. However, other factors can change this relationship. Advances in technology and innovation show that building a city's economy on heavy industry is a short-sighted growth strategy, and paths to development that manage pollution are also possible.

An important point to consider is the dynamics of this inverted U-shape relationship and how location decisions of firms can influence it. Several studies have focused on this "pollution haven effect" finding mixed results (Levinson and Taylor, 2006). For example, Levinson (1996) shows that location decisions of large manufacturing firms are more sensitive to environmental regulations. List et al. (2003) find evidence of an inverse relationship between the stringency of environmental regulations and plant births, and Becker and Henderson (2000) find evidence that differentials in regulations reduce birth of polluting industries in 26-45 percent. However, Greenstone (2002) question the fact that despite increasing firms' costs, the regulation effect could translate into plant relocation (due to sunk costs, for example).

Although this is the most common pattern observed in cities' pathway to development, no absolute typology emerges in terms of city competitiveness and pollution. Cities at different stages of development and competitiveness are experiencing both low and high levels of pollution. This suggests that it is possible to strengthen economic growth, foster employment and job creation, and improve living standards without facing high air pollution levels.

In this context, the role a city's overall management and government strategy plays a central role in pollution management while building competitiveness: Cities that are successful at maintaining their competitiveness (measured through economic and employment growth) are usually proactive in terms of managing pollution. These cities focus on understanding the leading causes and sources of pollution to identify the biggest challenges. This translates into specifically-designed regulations that are often able to successfully reduce pollution levels. In contrast, cities with no long-term planning often do not reach the same results and keep fighting increasing levels of pollution and, although they can still be competitive, the costs of environmental degradation can be high and have a measurable impact on their GDP. Institutions and their capacity to successfully coordinate efforts and enforce regulations are also key in effectively managing pollution.

TESTING THE LINKS BETWEEN COMPETITIVENESS AND POLLUTION LEVELS IN AFRICAN CITIES

In the last two decades, African cities have played a vital role in strengthening African economies and driving their development. African economies have grown at an average annual rate above 5 percent, and their total factor productivity has also shown a positive growth rate. Cities have been the engines behind this growth, growing fast and pushing national development. They are projected to host 50 percent of the African population by 2050.

While there are many benefits from agglomeration economies, these cities are also confronting the challenges that come with fast growth. They need to accommodate a growing population, provide a good environment for firms to thrive, and manage increasing levels of congestion and pollution. For example, between 1990 and 2013, air pollution levels have risen dramatically in Africa, increasing annual deaths attributable to air pollution by 36 percent.

In this context, African cities are at a crucial point where they need to take action, learn what factors affect their competitiveness the most and how to manage these factors successfully. But because the negative consequences of fast growth may hinder city competitiveness, these cities would benefit from a deeper understanding of which factors can improve (or jeopardize) their competitiveness.

Soppelsa et al., (2019) shed some light into these issues by exploring the links between city competitiveness and two of these factors: air pollution and business environment characteristics. First, the authors conduct a global analysis to capture how these factors relate to city competitiveness across world regions, and then move the focus to Africa to learn if regional characteristics play a part.

The authors take an intriguing approach in that they choose to focus on firm performance and use that as a proxy for city competitiveness. In particular, the authors look at firm employment growth and firm labor productivity growth. Firm performance (or productivity) is a good proxy for city competitiveness because more productive firms, which naturally seek access to better amenities and highly productive workers, tend to cluster in more competitive cities. Moreover, competitive cities usually offer better quality of life and living standards, which are determined by the productivity of the economy. Therefore, using firm-level data on employment growth and labor productivity growth can help assess city competitiveness. By adding estimated surface-level data on air pollution, the authors analyze a bigger picture in which these two factors (business environment characteristics and air pollution) may affect firm productivity (and city competitiveness) in different ways.

The analysis finds different patterns when looking at firms across the world versus African firms specifically. First, at the global level, there is a distinction between air pollution's effects on employment growth and on labor productivity growth. In the first case, the relationship is negative, at all levels of pollution. In the second case, the relationship is positive at lower levels of pollution and then it turns negative as pollution levels rise (inverted U-shape). Given that approximately 70 percent of the firms are located in areas where pollution levels exceed what is considered safe by WHO, simple elasticities can be calculated to estimate the change in productivity that would be observed if pollution were to decline. For example, for a representative firm in an area where PM 2.5 levels are fourteen-times above the safe standard values (that is, PM 2.5=140 μg/m^3), labor productivity could be almost 2.5 percent lower compared to a firm in a city where PM 2.5 levels are twice above the safe standards (PM 2.5=20 μg/m^3). Firms in the tradable sector would be most impacted since they will find it more difficult to pay 'combat pay' to attract skilled workers into a city with high pollution levels.

For African firms, two differences can be noted. First, the relationship between air pollution and both measures of firm productivity seems to follow a similar pattern. Second, that pattern is slightly different compared to those found at the global level. . When air pollution is very low, the correlation with firm performance is negative. Then, as pollution raises, this relationship turns positive first, and then negative again, similar to results found at the global level. The authors estimate that this second turn into a negative relationship happens at a relatively low concentration of air pollution (a concentration of PM 2.5 of approximately 25 μg/m^3), stressing the importance of keeping pollution levels beyond WHO standards when we look at firm productivity.

Another interesting result shows a strong effect of capacity agglomeration on labor productivity growth for African firms. In fact, capacity agglomeration is the only business environment characteristic that affects African firms differently. A slightly increase of 0.12 percentage points in capacity agglomeration results in an increase of almost 2 percentage points in labor productivity growth.

These findings suggest that African cities may face a few different challenges compared to cities in other regions. The fact that the relationship between air pollution and firm performance turns negative at relatively low levels of pollution should be a source of serious concern. As African cities are growing fast and evolving from agrarian towns to more industrialized urban centers, pollution levels are naturally rising. The challenge for these cities, then, is to manage pollution levels without slowing their own growth and hindering their competitiveness. Addressing this challenge will require a deeper look into the specific drivers of pollution in the city, extensive data collection on pollution concentration levels, and a deeper understanding on the sources of pollution. Future research could focus on these topics to try to better quantify the impact of pollution on firm performance and city competitiveness.

The analysis finds different patterns when looking at firms across the world versus African firms specifically. First, at the global level, there is a distinction between air pollution's effects on employment growth and on labor productivity growth. In the first case, the relationship is negative, at all levels of pollution. In the second case, the relationship is positive at lower levels of pollution and then it turns negative as pollution levels rise (inverted U-shape). Given that approximately 70 percent of the firms are located in areas where pollution levels exceed what is considered safe by WHO, simple elasticities can be calculated to estimate the change in productivity that would be observed if pollution were to decline. For example, for a representative firm in an area where PM 2.5 levels are fourteen-times above the safe standard values (that is, PM 2.5=140 µg/m^3), labor productivity could be almost 2.5 percent lower compared to a firm in a city where PM 2.5 levels are twice above the safe standards (PM 2.5=20 µg/m^3). Firms in the tradable sector would be most impacted since they will find it more difficult to pay 'combat pay' to attract skilled workers into a city with high pollution levels.

For African firms, two differences can be noted. First, the relationship between air pollution and both measures of firm productivity seems to follow a similar pattern. Second, that pattern is slightly different compared to those found at the global level. When air pollution is very low, the correlation with firm performance is negative. Then, as pollution raises, this relationship turns positive first, and then negative again, similar to results found at the global level. The authors estimate that this second turn into a negative relationship happens at a relatively low concentration of air pollution (a concentration of PM 2.5 of approximately 25 µg/m^3), stressing the importance of keeping pollution levels beyond WHO standards when we look at firm productivity.

Another interesting result shows a strong effect of capacity agglomeration on labor productivity growth for African firms. In fact, capacity agglomeration is the only business environment characteristic that affects African firms differently. A slightly increase of 0.12 percentage points in capacity agglomeration results in an increase of almost 2 percentage points in labor productivity growth.

These findings suggest that African cities may face a few different challenges compared to cities in other regions. The fact that the relationship between air pollution and firm performance turns negative at relatively low levels of pollution should be a source of serious concern. As African cities are growing fast and evolving from agrarian towns to more industrialized urban centers, pollution levels are naturally rising. The challenge for these cities, then, is to manage pollution levels without slowing their own growth and hindering their competitiveness. Addressing this challenge will require a deeper look into the specific drivers of pollution in the city, extensive data collection on pollution concentration levels, and a deeper understanding on the sources of pollution. Future research could focus on these topics to try to better quantify the impact of pollution on firm performance and city competitiveness.

[4] https://www.worldbank.org/en/topic/urbandevelopment/overview#:~:text=Withpercent 20morepercent 20thanpercent 2080percent 25percent 20of,andpercent 20newpercent 20ideaspercent 20topercent 20emerge.&text=Citiespercent 20acrosspercent 20thepercent 20globepercent 20are,withpercent 20thepercent 20COVIDpercent 2D19percent 20pandemic.

[5] COVID-19 AIR QUALITY REPORT 2019. Coronavirus pandemic lockdowns result in unprecedented reductions in deadly particle pollution. Publication date: Apr. 22, 2020. https://www2.iqair.com/sites/default/files/documents/REPORT-COVID-19-Impact-on-Air-Quality-in-10-Major-Cities_V6.pdf?_ga=2.242349954.1479314001.1591722668-1630740484.1591722668

[6] https://www.airqo.net/blog

[7] https://www.wsj.com/articles/coronavirus-offers-a-clear-view-of-what-causes-air-pollution-11588498200

[8] World Health Organization. https://www.who.int/health-topics/air-pollution#tab=tab_1

[9] Xiao Wu, Rachel C. Nethery, Benjamin M. Sabath, Danielle Braun, Francesca Dominici. (2020) "Exposure to air pollution and COVID-19 mortality in the United States: A nationwide cross-sectional study". doi: https://doi.org/10.1101/2020.04.05.20054502.

[10] Ogen, Yaron. "Assessing nitrogen dioxide (NO2) levels as a contributing factor to the coronavirus (COVID-19) fatality rate." Science of The Total Environment (2020): 138605.

[11] For a discussion on the theory of compensating differentials, see Rosen 2002.

[12] Several studies have documented, for example, how specific regulations on pollution can force actors to take measures or behave in such a way that allow them to avoid these regulations. For example, not phasing out plants to avoid paying the new capital tax (Nelson et al. 1993),or increase substitution of firms into the informal (unregulated) sector in the developing world (Kahn and Pfaff, 2000).

[13] This is a well-known result referred in the academic literature as the Environmental Kuznets Curve. It was first introduced by the seminal work of Grossman and Krueger (1993).

[14] The literature indicates that the functional form between economic development and pollution, depends on the type of pollution (air, water, land pollution) one looks at, and also what pollutant one looks at (e.g. while SOx has been often found to follow the inverted U shape form, ozone or CO2 have not, quite the opposite). A deeper look into this relationship can raise other questions such as the fact that pollution in a city can also come as a consequence of cross-boundary spillover (and not only as a by-product of city's activity). See Kahn et al. (2019) for a review on the literature addressing this issue when estimating the effects of pollution on economic growth.

[15] The literature indicates that the functional form between economic development and pollution, depends on the type of pollution (air, water, land pollution) one looks at, and also what pollutant one looks at (e.g. while SOx has been often found to follow the inverted U shape form, ozone or CO2 have not, quite the opposite). A deeper look into this relationship can raise other questions such as the fact that pollution in a city can also come as a consequence of cross-boundary spillover (and not only as a by-product of city's activity). See Kahn et al. (2019) for a review on the literature addressing this issue when estimating the effects of pollution on economic growth.

[16] Jaffe et al. (1995) reviews the early literature. Copeland and Taylor (2004) and Brunnermeir and Levinson (2004) review the newer studies (Levinson and Taylor, 2006).

[17] For details on the data used and the methodology, see Soppelsa et al. (2019).

[18] While we recognize that this work cannot claim a causal effect, the correlations established by the empirical analysis are strong in all cases.

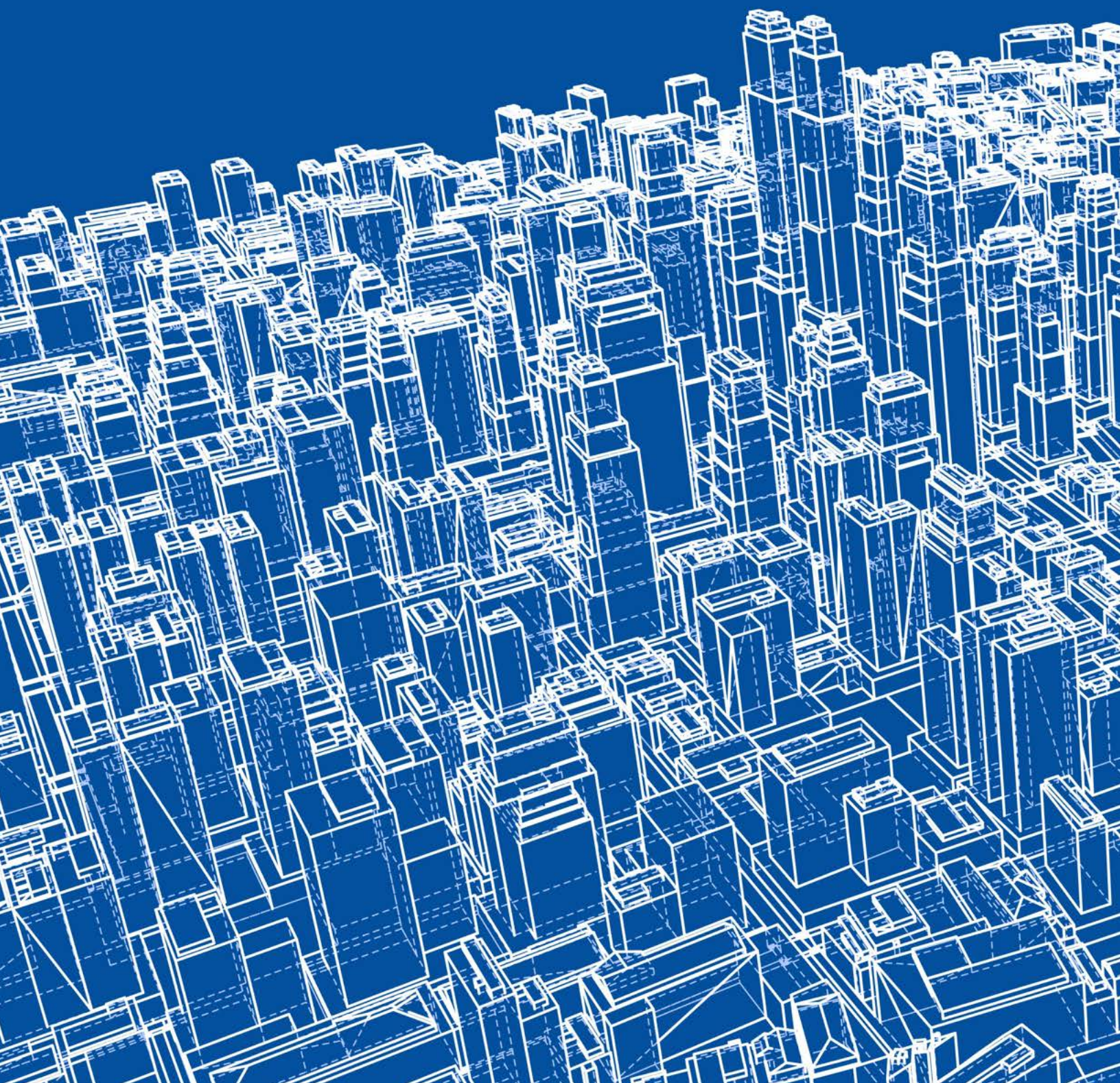
[19] PM 2.5 annual mean below 10 $\mu g/m^3$.

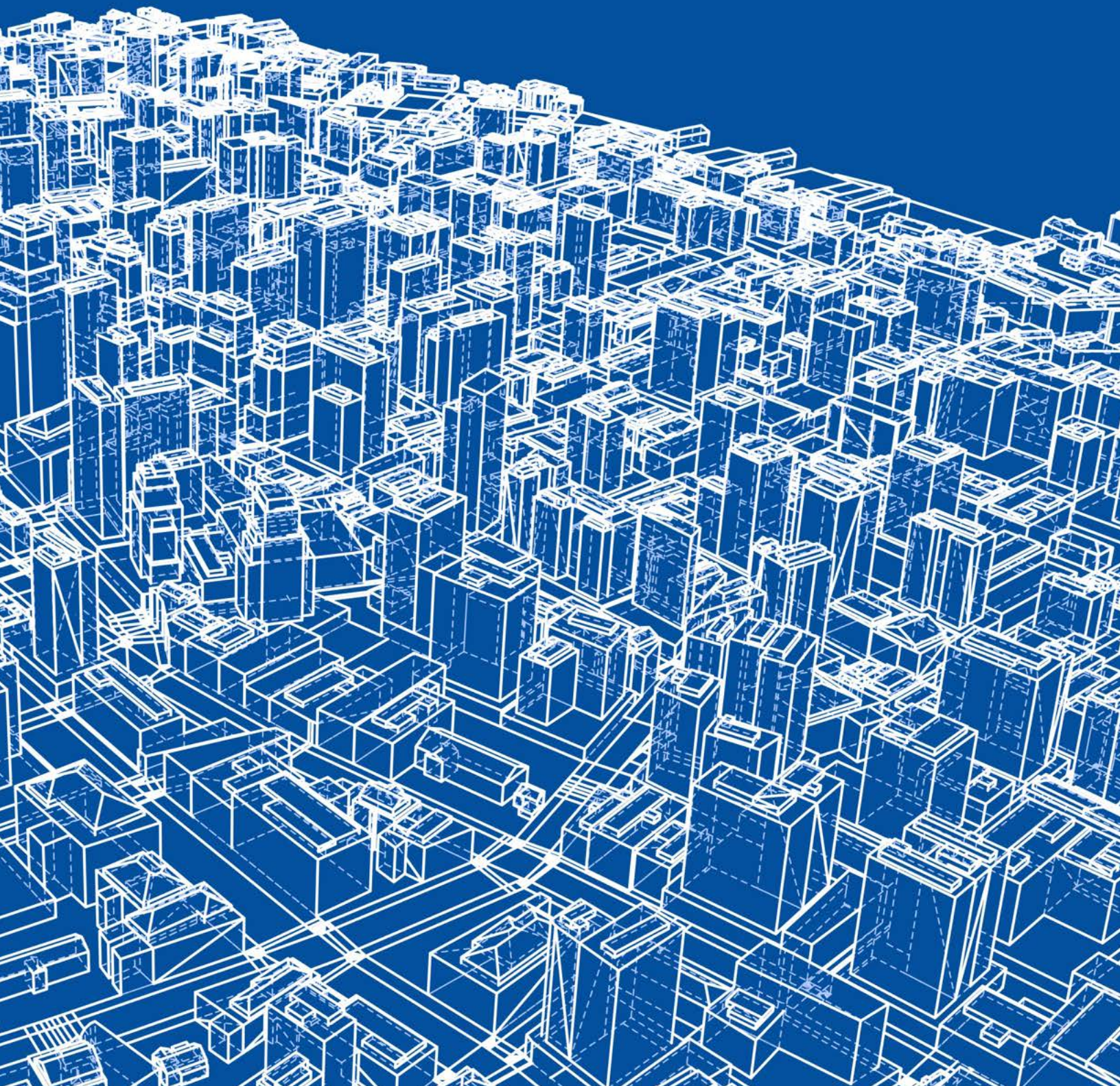
[20] Since firms in the tradable sector are price taking, they cannot adjust wages to a decrease in productivity.

[21] Global pollution data from van Donkelaar relies on ground truthing to interpolate satellite measures. Given the limited number of ground monitors in Africa, the interpolation for cities in Africa may have large standard errors associated to them.

[22] These results should do not imply a causal relationship between pollution and firm performance. Further work is needed to deeply understand this relationship and to find the main drivers of these results. Further, estimating the effects between pollution and firm performance using simple OLS estimation techniques may raise concerns of omitted variables bias. Kahn et al. (2019) have surveyed the literature and present some examples of how to deal with this issue.

CHAPTER 2
CITY CASE STUDIES





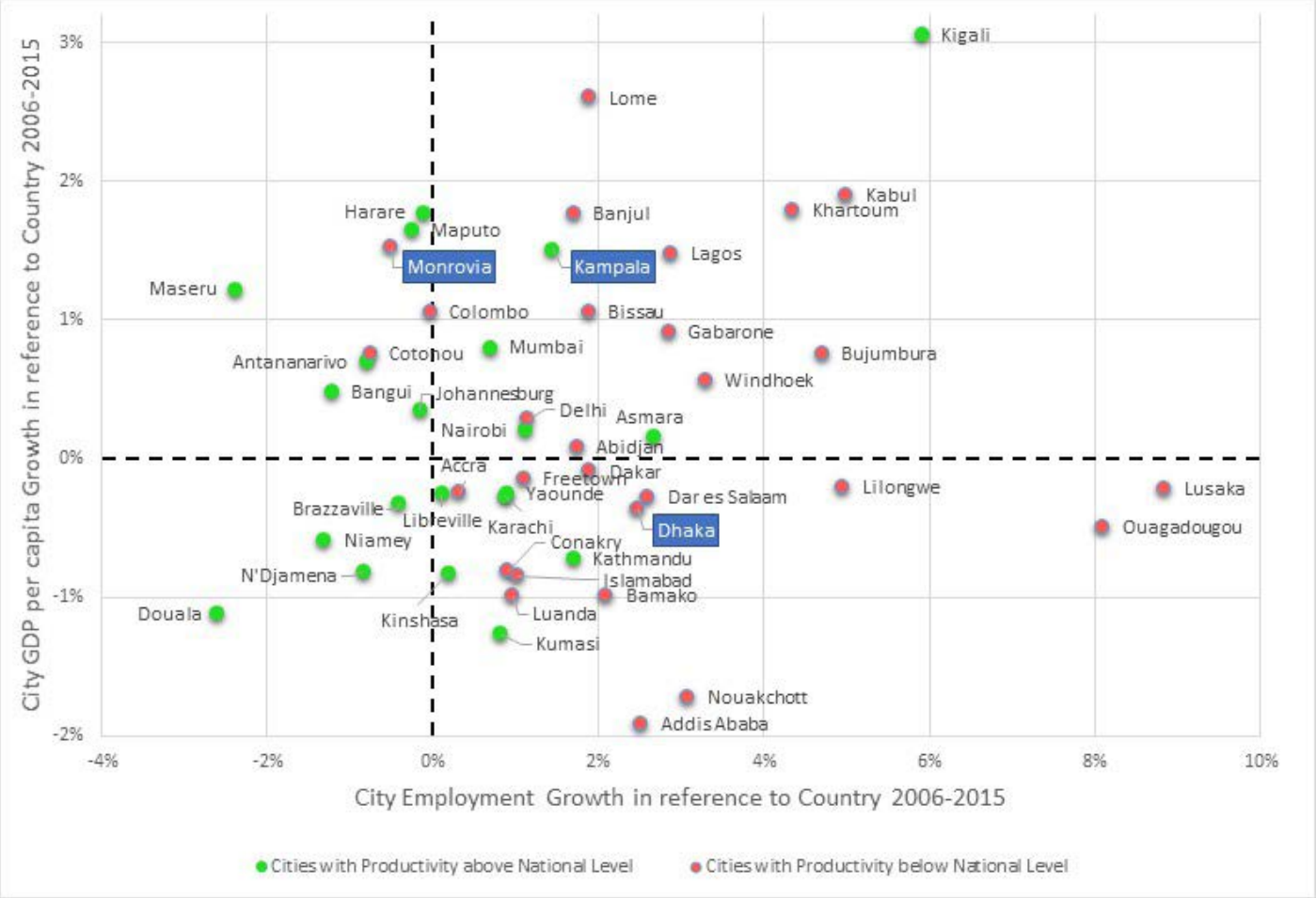
To illustrate some of the challenges that cities in the developing world face in managing pollution and strengthening their competitiveness, this chapter looks at four rapidly urbanizing cities: Kampala, Dhaka, Zanzibar, and Monrovia. Case study cities were selected to leverage and complement existing dialogue and operational engagements.

As mentioned in the previous chapter, a competitive city is one that generates jobs, attracts investment, and fosters opportunities to raise its inhabitants' income levels. Because competitive cities are often performing above the national average, looking at three specific indicators can help identify a city as competitive: GDP per capita growth, employment growth, and productivity growth. Figure 2.1 shows African and South Asian capital cities and their average annual growth in terms of GDP per capita, employment, and productivity between 2006 and 2015. Each dot represents a city. Red dots indicate cities with productivity growth below their national average and green dots indicate cities with productivity growth above their national average. Hence, cities above the x-axis (top) have GDP per capita growth above their national average; cities below have GDP per capita growth below their national average. Cities to the right of the y-axis have employment growth above their national average; cities to the left have employment growth below their national average. This report's featured cities are highlighted, with the exception of Zanzibar for which no information is available.

As suggested in Figure 2.1, Kampala, seen in the upper right quadrant, is performing well compared to other African capitals and major cities. The city is outperforming the national average in all three indicators (city in green). Kampala, along with Nairobi (Kenya), Kigali (Rwanda), and Asmara (Eritrea) are the only four African cities that outperform other cities in their own country. Dhaka, located in the lower right quadrant, shows some mixed results. On average, while the city is overperforming at the national levels in terms of employment growth, it is underperforming at national level in terms of productivity growth and GDP growth. While limited data availability does not allow a similar comparison for Zanzibar's estimated GDP growth for the period spanning between 2013 and 2018, suggests that its annual real GDP growth rate has been very similar to that of Tanzania. However, in the past decade, unemployment rates have increased in Zanzibar while decreasing in mainland Tanzania. Lastly, Monrovia, seen in the upper left quadrant of Figure 2.1, has only been performing above the national level in terms of GDP growth. This is consistent with the fact that most of the country's economic activity is located in the city. However, employment growth and productivity growth have fallen behind national levels.

To better understand how pollution might be affecting these four cities' competitiveness, deeper analysis was conducted in each one of them. In what follows, we summarize the focus of each case study, first by providing an overview of the city's challenges, and then by summarizing the institutional setup and key institutional challenges of each city.

FIGURE 2.1: PERFORMANCE OF AFRICAN AND SOUTH ASIAN CAPITALS AND LARGEST CITIES



Source: Author's elaboration based on data from Oxford Economics Dataset.

Note: Each dot represents a city. Red dots indicate cities with productivity growth below their national level and green cities indicate cities with productivity growth above their national level. Cities above the x-axis (top) are those cities with GDP per capita growth above their national average (cities below are those with GDP per capita growth below their national average). Cities to the right of the y-axis are those with employment growth above their national average (cities to the left are those with employment growth below their national average).

KAMPALA:

THE EFFECTS OF AIR POLLUTION ON WORKERS' PRODUCTIVITY

POLLUTION MANAGEMENT

KAMPALA, A THRIVING CITY

The city of Kampala has an estimated population of 1.75 million residents and an estimated daily work force of 4.5 million. As the capital city of a country that is urbanizing fast , Kampala experiences an annual demographic growth rate of approximately 3.9 percent. Moreover, with approximately 10 percent of the country's population (including daily work force), Kampala's role as an engine of growth is crucial; it contributes approximately 65 percent of the national GDP. Between 2006 and 2015, Kampala's GDP per capita grew at an annual average of 5 percent and the city created on average 4.5 percent additional jobs per year.

In Kampala, air pollution has increased in the past years reaching levels well above what it is considered safe by the WHO. A recent study (Kirenga et al., 2015) has found that the daily mean concentration level of PM 2.5 is approximately 132.1 µg/m^3. As highlighted in this study, the main sources of air pollution in Kampala are dust from unpaved roads, car emissions, and garbage burning.

One of the main problems Kampala has faced is the scarcity of pollution data in the city and in Uganda in general. For many years, there was only one monitor of air pollution in Uganda, located at the US Embassy in Kampala. With only one measure of pollution for the entire country, it has been difficult to fully identify the negative effects of pollution as well as understand possible spatial variation of pollution and long-term pollution sources. Despite efforts from recent studies to gather measures of pollution for short periods of time, a systematic data collection effort has been absent. Lack of data has limited the understanding of the extent to which air pollution is a problem in Kampala, and prevented the assessment of the links that exist between pollution levels and the city's competitiveness.

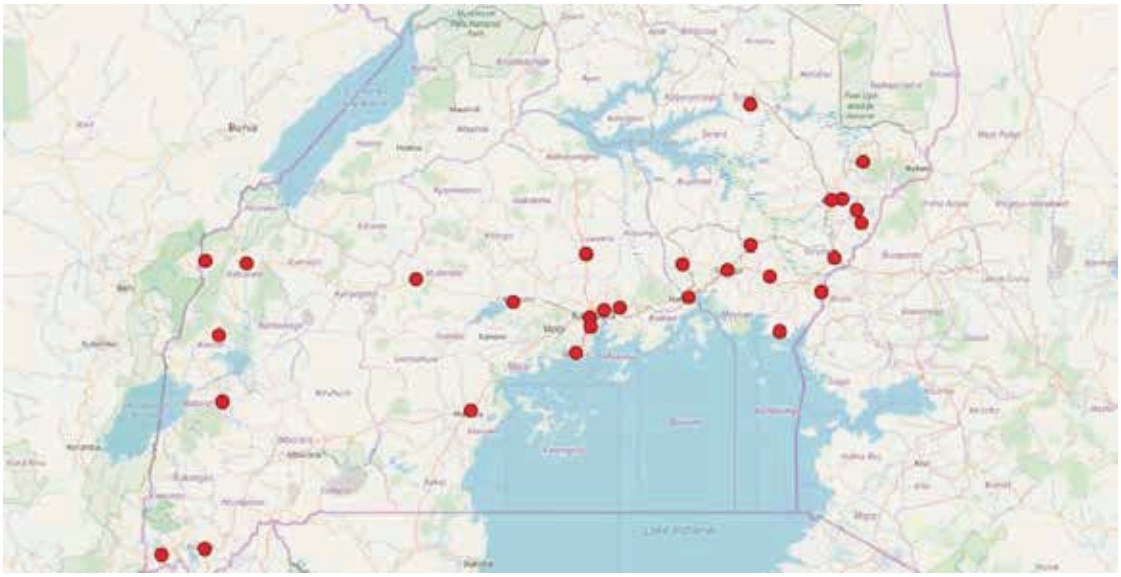
To address these gaps, the work done for this report (and summarized in this note) follows three key lines of work: First, we carry out an extensive data collection effort to assess air pollution levels. Second, combining information on air pollution at granular levels with information from a small firm survey in Kampala (with a focus on small manufacturing firms), we provide initial insights on the impact that pollution can have on firm productivity. To better understand the effects of air pollution on city competitiveness, the background study looked at the relationship between pollution and other key variables such as firm productivity, workers' response in terms of sickness or absence from work, and measures of pollution awareness, including the use of prevention strategies. Third, we complement the analysis with an institutional assessment to draw a map of the entities involved in pollution management decisions in the city, characterize responsibilities, and through that, identify areas that could contribute to improving pollution management in the city. In what follows, we provide a summary of the main results of this analysis, and put forward some suggestions to strengthen the city's competitiveness while minimizing the impacts of air pollution.

AIR POLLUTION – DATA COLLECTION AND METHODOLOGY

As previously discussed, one of the main issues that arises when trying to understand the state of air pollution in Kampala is the lack of systematic measurement. To address this gap, this work launched a collection effort jointly with Makerere University to gather information for a period of six months through a set of low-cost static air quality monitors deployed in different Kampala locations as well as other key urban areas throughout Uganda. Figure 2.2 shows the locations selected to place these monitors (red dots). To complement the information from the static monitors, ten mobile monitors installed in motorcycle taxis (boda-boda) collected air pollution measures while following their regular routes. Figure 2.3 shows the routes of the boda-boda (each route is a sequence of light red dots).

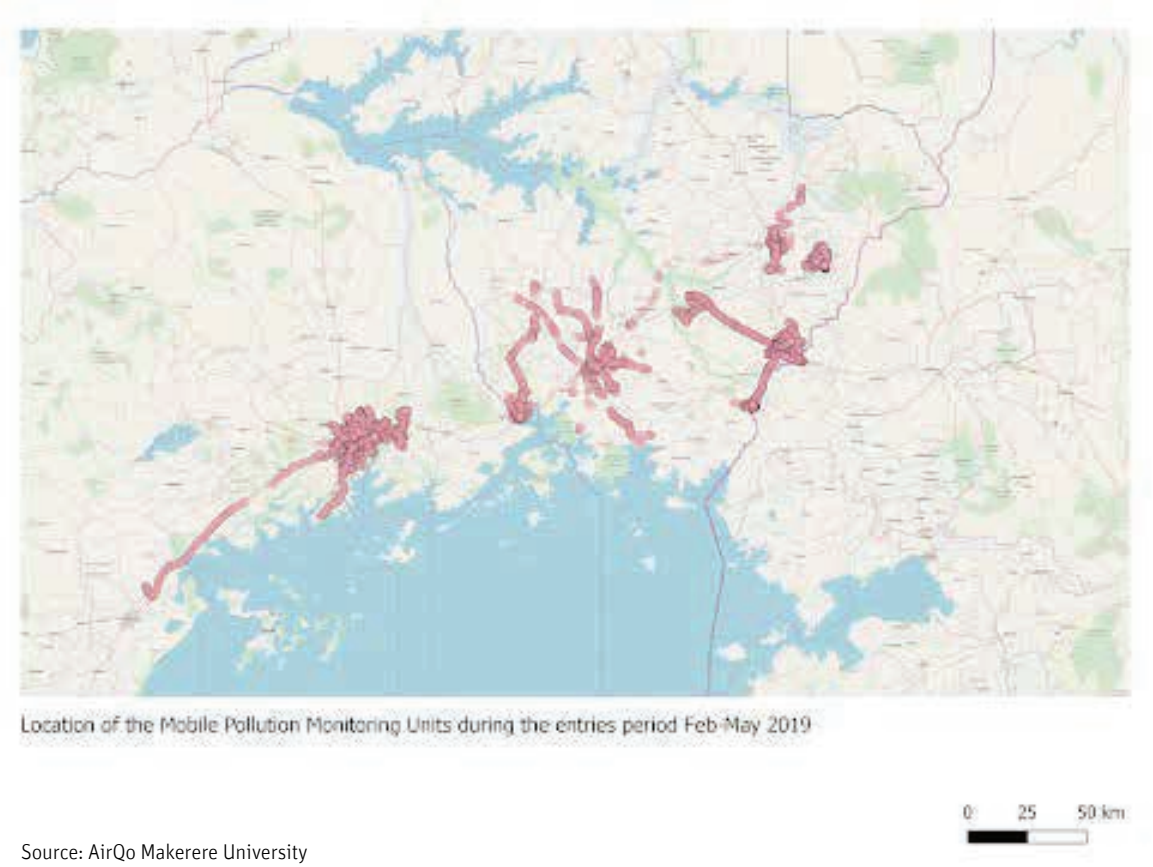
For this study, the static monitors collected measures on PM 2.5 and PM 10 every 60-90 seconds, for an initial period of six months (between January and June, 2019). Each of the mobile monitors have collected the same air pollution measures, with a similar interval, for a minimum of 2 days (between February and May, 2019).

FIGURE 2.2: LOCATION OF STATIC MONITORS ACROSS UGANDA



Source: AirQo Makerere University. Red dots indicate the location of static air quality monitors

FIGURE 2.3: MOBILE MONITORS' ROUTES ACROSS UGANDA

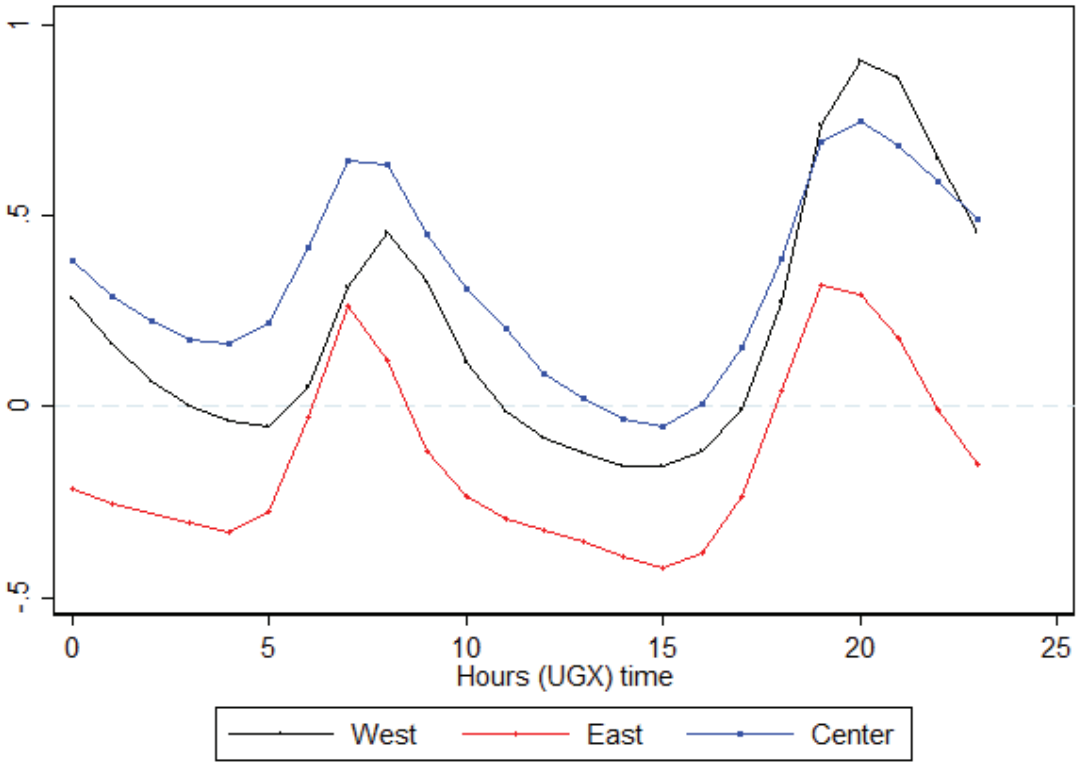


Source: AirQo Makerere University

The data gathered for this work suggests that Kampala experiences high levels of pollution, above WHO guidelines at almost all hours of the day. However, pollution levels are higher during early morning and late evening. Figure 2.4 shows how PM 2.5 varies throughout the day, for the three Uganda regions: Center, East, and West. All three regions follow a similar pattern: higher levels in early morning, between 6am and 9am, and late evening, between 7pm and 10pm. The fact that higher pollution is observed during rush hours may indicate that one of the main sources of pollution in Uganda could be related to automobile traffic. Although further analysis is needed before confirming this statement, this early finding is in line with what has been suggested by previous studies (Sjodin et al., 1998; Zhang & Batterman, 2013).

Moreover, pollution levels are higher in central Uganda compared to the Western and Eastern regions. Figure 2.4 shows that for most hours of the day, PM 2.5 levels are higher in Central Uganda. This region includes the City of Kampala and Wakiso, which are highly urbanized areas. This finding confirms the expected positive correlation between air pollution and level of urbanization: more urbanized areas usually show higher levels of air pollution.

FIGURE 2.4: STANDARDIZE PM 2.5 LEVELS BY HOUR AND REGION

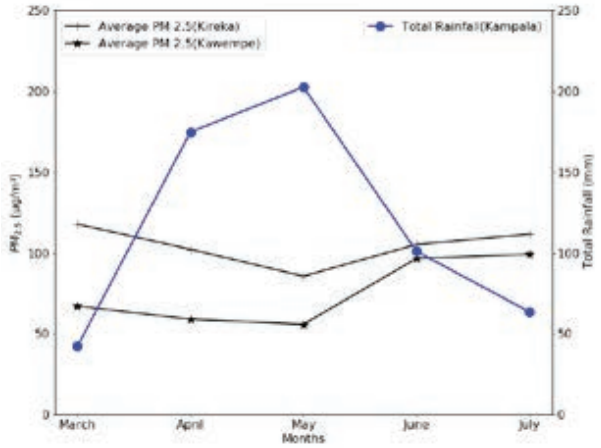


Source: Bassi et al., 2019

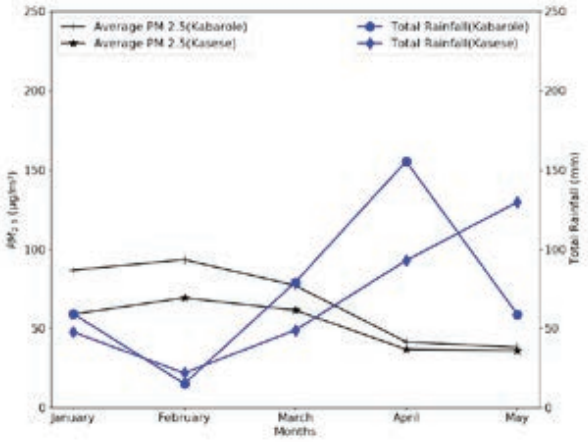
Note: Region-wide hourly variation in PM 2.5 (Bassi et al. 2019). The y-axis shows the standardized coefficients resulting from regressing PM 2.5 levels on a set of variables indicating date, time, and monitor fixed effects, a dummy for mobile monitors, and region-hour interaction terms. The x-axis shows hours, in Uganda time. The three lines shows variation of PM 2.5 for the three regions: Center (blue), East (red) and West (black).

Another interesting insight that arises from this analysis is that pollution levels drop during the rainy season suggesting there may be a washout effect. Figure 2.5 a, b and c shows the monthly average of PM 2.5 (in black) and monthly total rainfall (in blue) for some areas in the three Uganda regions (Figure 2.5a: Kampala and Wakiso in Center Uganda; Figure 2.5b: Soroti and Tororo in Eastern Uganda; Figure 2.5c: Kabarole and Kasese in Western Uganda). In all three regions, levels of PM 2.5 are lower during the months were the total rainfall peaks. This is more noticeable in Central and Western Uganda (Figure 2.5a and 2.5c). This is important because it may suggest rain could be helping reduce air pollution in some areas to acceptable levels. Given variability in rains, this may prompt local governments to concentrate more on air quality during the dry season.

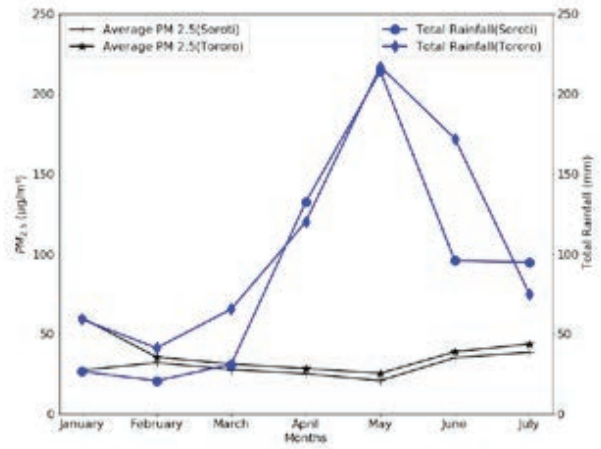
FIGURE 2.5: MONTHLY AVERAGE OF PM 2.5 AND TOTAL RAINFALL



a) Kampala and Wakiso



c) Western Uganda



b) Eastern Uganda

Source: Okure et al., 2019

Note: Monthly PM 2.5 average (black, left y-axis) and total rainfall (blue, right y-axis) (Okure et al., 2019). Figures a through c show levels of PM 2.5 and rainfall for the three regions in Uganda: Center, East, and West.

THE EFFECTS OF AIR POLLUTION ON FIRM PRODUCTIVITY

To better understand the links between air pollution and firm productivity, a firm-level survey gathered information for 1059 firms in Uganda (Center, East and West regions), 391 of them located in Kampala. The survey focused on firm productivity as a proxy for city competitiveness (Lozano-Gracia and Soppelsa, 2019). It also collected information on firms' pollution awareness (for employees and managers), possible precautionary measures taken (such as use of masks), and health problems experienced due to pollution exposure (see Box 2.1).

The analysis suggests that workers understand the negative impacts that pollution may bring and are willing to pay to mitigate such effects. In fact, workers at firms located in more polluted areas in Kampala are more willing to donate to mitigate the effects of pollution. The survey finds that if workers experiencing higher levels of pollution at work are given the choice of donating money to environmental organizations focused on pollution management and reduction, versus donating money to other environmental organizations, they choose the former, which provides some insight into the value workers assign to air quality (Bassi et al., 2019).

Further, the survey provides some initial evidence of the links between air pollution and health effects on workers. Higher levels of PM 2.5 significantly increase the probability of a worker experiencing chest tightness, dizziness or skin irritation. However, these effects seem to be reduced for workers with higher salaries, suggesting that workers in the higher end of the income distribution may be taking additional preventive or corrective measures that minimize their symptoms. While the information in the survey does not provide further evidence on such preventive measures, it is possible that these workers may be able to use masks or other protection mechanisms to avoid the negative effects of pollution (Bassi et al., 2019).

BOX 2.1:
MEASURING POLLUTION IN UGANDA

As part of the data collection effort, monitors to measure air pollution have been deployed in several areas in Uganda. They currently cover not only the Greater Kampala area but also other cities and towns such as Kabale and Kasese in the Western regions and Mbale and Jinja in the Eastern region, to name a few (see Figure 2.5 for other locations). This effort has helped achieve thorough understanding of the state of air pollution in the country.

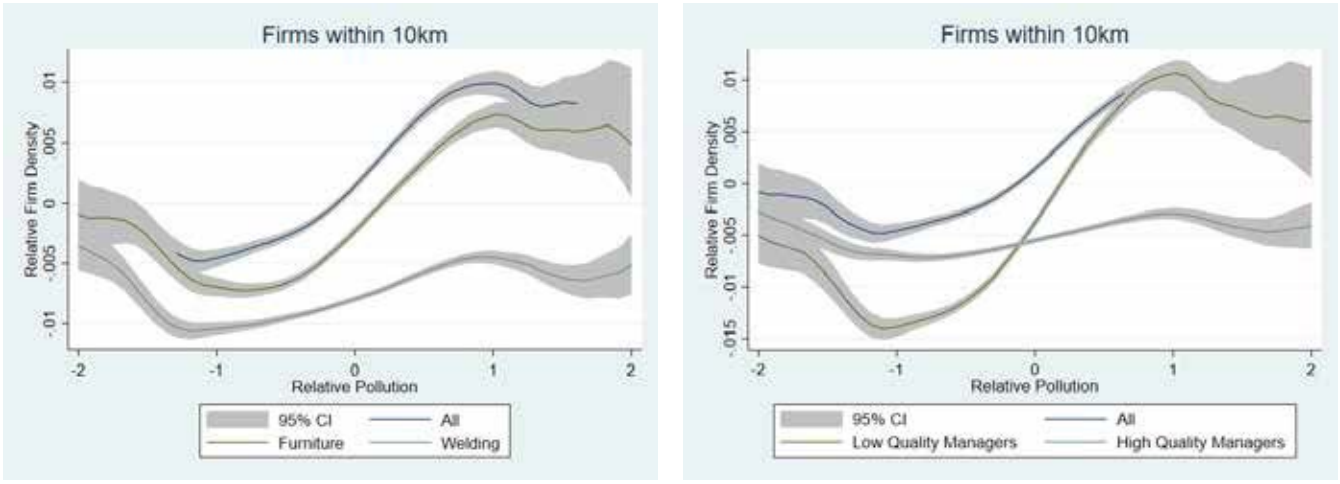
The air pollution data collected shows that the Central region is where pollution levels are the highest. This covers the Wakiso District, where the city of Kampala is located. On a given day, PM 2.5 in this area can reach values that are two or three times the values found in other regions of the country (Okure et al., 2019). Evidently, high levels of urbanization and road congestion play an important role in raising pollution levels.

However, an interesting exception in the Eastern region is Mbale. This area often shows high levels of PM 2.5, comparable to those found in the Wakiso District. Mbale area concentrates firms specialized in manufacturing furniture products and grain mill products. High levels of pollution in this area could be associated with industrial activity.

Source: Okure et al., 2019.

The information gathered also provides some initial evidence of firms located in areas that are also more polluted. Figure 2.6 shows different levels of pollution (measured by the mobile monitors) and the number of firms within a 10 km radius of that monitor/measure. The positive relationship found for all firms suggests that on average, firms tend to cluster in more polluted areas. Additional analysis also looked into firm location through an accessibility lens, finding that firms tend to locate on large roads and intersections. Future work will aim at identifying the mechanisms for such location decisions. The initial patters may already point at the tradeoffs that firms have to face -choosing between clean air and good market access, when they decide where to locate within cities. The relationship is less evident when looking at firms grouped by the quality of the managers (Figures 2.6a and 2.6b). For those firms where the managers scored above the median, and hence can be labeled as high quality managers, firms do not necessarily cluster in highly polluted areas. This may be due to the fact that firms in more polluted areas may need to pay higher wages to attract more qualified managers (combat pay) and that better managers, more aware of pollution, may be able to choose to work in "cleaner" areas.

FIGURE 2.6: PM 2.5 LEVELS AND NUMBER OF FIRMS WITHIN A 10 KM RADIUS



Source: Authors elaboration based on pollution data collected through mobile monitors and firm level data collected through a survey on 1059 firms located in Center, East and West regions in Uganda.

Note: The x-axis shows the normalized residuals obtained from regressing PM 2.5 (log) on fixed effects by date, time, and parish. The y-axis shows the normalized residuals obtained from regressing the number of firms within a 10 km radius (log) on fixed effects by date, time, and parish. In the left figure, the blue line shows the relationship between these two residuals for all firms, the green line for firms in the furniture sector, and the gray line for firms in the Welding sector. In the right figure, the blue line shows the relationship between these two residuals for all firms, the green line for firms where the manager scored below the median, and the gray line for firms where the manager scored above the median.

THE ROLE OF INSTITUTIONS

The scarcity of pollution data and the lack of public awareness have most likely influenced Kampala's response to air pollution in the last years. Although there is no explicit legislation that addresses air quality in Uganda, there are a few institutions that have recently focused more efforts on tackling air pollution and various policies, laws, and regulations with provisions intended to manage air quality. Looking at the institutional framework, regulations, and key stakeholders involved in managing pollution helps identify the main issues that the city faces. It also helps to highlight the main challenges and the gaps that are preventing policymakers from successfully addressing pollution. This section provides an overview of the roles and responsibilities of key institutions, as well as the challenges and bottlenecks they face.

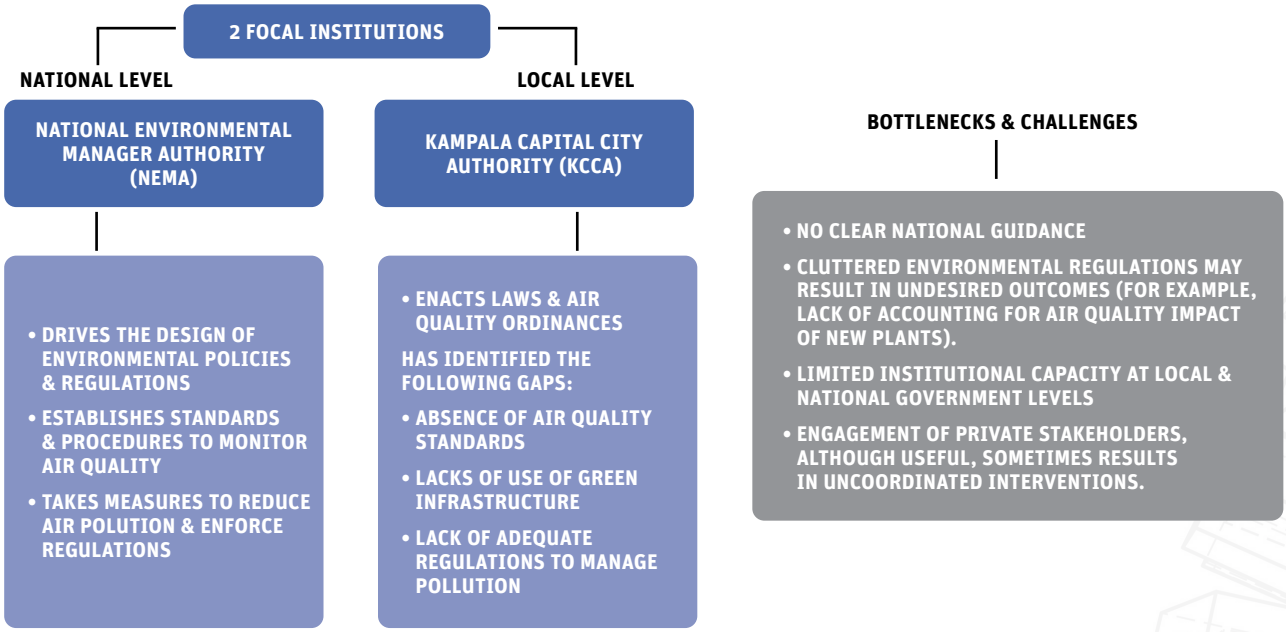
Two focal institutions arise as key points for managing air pollution. At the national level, the National Environmental Management Authority (NEMA) is "an autonomous institution established by the National Environment Act (NEA), Cap.153, in 1995, to coordinate, monitor, regulate and supervise all matters on environment in Uganda." It drives the design of environmental policies and regulations, as well as establishes standards and procedures to monitor air quality. As the lead agency that oversees environmental management in Uganda, its remit extends to the district and community level not only in setting guidelines, but also in taking measures to reduce air pollution and enforce regulations by denying/revoking permits, requiring redesign and cleaning of plants to comply with existing standards, or even shutting down facilities. In 2019, the 1995 National Environment Act was amended, enabling NEMA to prepare a National Environment Action Plan to replace the existing plan (dated in 1995), which is also intended to be periodically reviewed every five years.

At the local level, the Kampala Capital City Authority (KCCA) is the governing body of the city of Kampala. Regarding pollution management, it has legislative power to enact laws and air quality ordinances in line with the national regulatory framework established by NEMA. To that end, the KCCA has conducted a preliminary assessment to identify gaps and clarify internal roles and responsibilities related to pollution management in the city. Part of the challenges identified are the absence of air quality standards, the lack of use of green infrastructure, and, more generally, the lack of adequate regulations governing different pollution vectors. As a response, the KCCA developed the Air Quality Governance Framework in 2018 to provide a better understanding of the state of pollution management and also guide air quality management roles within various directorates. It has also developed other regulations, such as a Green Infrastructure Ordinance to ensure livability in the city by regulating, for example, the use of green infrastructure and the inclusion of green spaces in new developments; it is also in the process of drafting a statutory instrument to restrict movement of heavy goods vehicles that will help reduce congestion and pollution in the city.

Some other efforts have been made to tackle air pollution at the source by addressing road infrastructure and improving the transportation network. For example, to reduce dust, KCCA has worked on upgrading the unpaved road network to tarmac. Approximately 210 km have been upgraded to date. Moreover, an existing project focusing on prioritizing non-motorized transport along a 7 km road (Namirembe Road) aims at reducing congestion. Finally, the National Transport Master Plan puts forward plans to invest in low-carbon transport modes, such as rail, in the Greater Kampala Metropolitan Area.

Although there have been recent efforts to develop a better institutional framework and address existing gaps, the system still faces many challenges. The institutional setup and main bottlenecks and challenges are summarized in Figure 2.7. The main constraints are related to the lack of national guidance for pollution management. The new Environmental Action Plan has not been approved and the existing cluttered environmental regulations often result in undesired outcomes (for example, lack of accounting for air quality impact of new plants). The scarcity of air pollution data has certainly played a role in the state of regulations and institutions, but the new efforts to maintain access to real-time pollution data throughout Kampala is expected to help the city move in the right direction. Moreover, due to the limited institutional capacity in local and national government, officials often seek support from development partners, civil society organizations, local institutions, and other stakeholders. Although engagement of these various stakeholders is often useful and can help raise public awareness, it could result in uncoordinated interventions, which can wind up being counterproductive.

FIGURE 2.7: INSTITUTIONAL SETUP AND MAIN CHALLENGES FOR POLLUTION MANAGEMENT IN KAMPALA



Source: Author's elaboration

CONCLUSIONS

The city of Kampala faces a considerable challenge in managing air pollution. Its pollution levels are high, significantly above WHO guidelines, posing a risk to health and human capital formation, as well as the city's power to attract qualified workers and investment. Although the city is still performing above its national average, pollution still has a negative impact on city competitiveness.

Looking into some of these negative effects, the background studies found that although workers and managers seem to be aware of these higher levels of pollution, they may not be always able to take the necessary precautionary measures. Low income workers, as well as less qualified managers, often struggle to apply preventive measures or are somehow restricted to working at firms located in more polluted areas. Pollution thus affects poorer sectors more, reducing their productivity.

Taking action to lower pollution levels is crucial. Although there are some institutions in the city aiming at managing pollution, as well as a legal framework and some regulations, there is still a long way to go. The efforts to develop and maintain systematic measures on air pollution are a good start and can help raise awareness of city leaders, stakeholders, and the public. This will certainly help the push for better planning and tailored regulations that can boost city competitiveness and may even have redistributive effects, improving living conditions for low-income sectors.

[23] The selection of case studies was based on two elements: i) how to leverage World Bank engagements and ii) which cities were given higher priority from the donor.

[24] "Competitive Cities for Jobs and Growth. What, Who, and How", World Bank, 2016.

[25] Productivity growth is measured as Gross Value Added per worker.

[26] In the five-year period, annual real GDP growth rate in Zanzibar averaged 6.6 percent, while that of mainland Tanzania stood at 6.7 percent.

[27] Ngoga, Thierry Hoza, "The potential for tenure-responsive land use planning in Kampala", Policy Brief, International Growth Center, January 2018.

[28] Uganda's actual urban population of approximately 25 percent is projected to reach 45 percent by 2050 (United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization Prospects: The 2018 Revision).

[29] From the "Strategic Plan 2014/15-2018/19, Laying the Foundation for Kampala City Transformation." KCCA, Kampala Capital City Authority).

[30] From the "Strategic Plan 2014/15-2018/19, Laying the Foundation for Kampala City Transformation." KCCA, Kampala Capital City Authority)

[31] Based on Oxford Economics Dataset.

[32] The study measured PM 2.5 concentration levels in 15 sites in Kampala and 3 sites in Jinja, for a sampling period of an average of approximately 21 hours and 15 minutes, between June 30th and July 27th, 2014. See Kirenga et al. 2015.

[33] For this effort, The World Bank has partnered with AirQo from Makerere University to deploy the monitors, manage data collection, and display real-time measures through a web platform (see https://www.airqo.net/) and an app

[34] Due to specific location of static monitors, all background pollution may not be picked up in this study. Hence, causality cannot be inferred from this exercise and results should be interpreted as correlations.

[35] This effort was conducted in collaboration with BRAC Uganda and researchers from USC and Columbia University. From more than 3000 firms contacted, 1059 answered the pollution section of the questionnaire. These firms correspond to the following manufacturing sectors: 506 manufacture of furniture products (Furniture), 396 manufacture of structural metal products (Welding), and 154 manufacture of grain mill products (Maize). Details regarding the methodology and representativeness of the sample can be found in the Sampling Report.

[36] http://nema.go.ug/aboutus/nema-uganda

[37] Kampala Institutional Assessment, 2020.

Aerial view of crowded dusty market street in Kampala, Uganda, Africa - Photo by Zach - Adobe Stock

DHAKA:

THE EFFECTS OF INDOOR AIR POLLUTION IN FIRM COMPETITIVENESS

POLLUTION MANAGEMENT

DHAKA, A CITY STRUGGLING TO RAISE ITS CITIZENS' QUALITY OF LIFE

With a third of the urban population in Bangladesh concentrated in Dhaka, the capital city has emerged as one of the world's fastest growing megacities. One in ten Bangladeshi has migrated to Dhaka in the last 5 years and the city provides two-fifths of urban jobs in the country. However, Dhaka has growing environmental concerns and struggles to provide livable conditions for its people. The city has one of the lowest air quality levels in the world and is ranked among the lowest in terms of livability (Chaity, 2018). Environmental concerns range from surface water pollution to groundwater depletion to energy and resource inefficiency to solid waste management and occupational health and safety. Some of these concerns are not new. For example, in 2006 it was reported that industrial pollution accounts for 60 percent of pollution in the Dhaka watershed area, and the textile industry is the second largest contributor after tanneries (World Bank, 2006). More recently, it was estimated that there were 719 washing, dyeing, and finishing factories discharging as much as 200 metric tons of wastewater per ton of fabric to rivers in Dhaka (World Bank, 2015). It has also been estimated that Chemical Oxygen Demand (COD) from textile industry could reach around 1,881 thousand tons per year by 2030 (WRG, 2015).

With regards to the measures of competitiveness, Dhaka has been performing below the national average in terms of GDP per capita growth and productivity growth. Most parts of Dhaka city are badly affected by traffic, resulting in high congestion costs, and pollution is a growing concern: PM 2.5 annual averages are up to 6 times WHO guidelines. In this context, this city presents opportunities to deepen the analysis on how pollution is affecting productivity and competitiveness of the workers. To better understand the links between indoor air pollution and worker's productivity, this work zoomed into small-scale textile firms on the outskirts of Dhaka.

Most studies on the effects of air pollution on outcomes of interest such as mortality or worker productivity are based on observational data, employing quasi-experimental techniques to causally estimate the effect of air pollution. The counterfactual in these studies is a state of the world with lower levels of ambient pollution. In practice, despite prevalent regulations on emissions, compliance levels remain abysmally low (Duflo et al., 2018). Defensive investments such as air purifiers or masks can provide temporary relief from air pollution – for example, air purifiers may be installed at home and/or the office, but individuals are still exposed to ambient air pollution levels for the rest of the day. Yet, the evidence of the role of defensive investments in reducing the effects of air pollution remains limited (Deschênes et al., 2017). Better understanding of the impact of these defensive investments is important, for when effective, they can provide a short-term prevention strategy to minimize impacts on productivity while broader regulations on emissions are enacted and enforced, which may take longer due to legislative and political hurdles.

ESTIMATING THE IMPACT OF AIR POLLUTION ON FACTORIES' PRODUCTIVITY IN DHAKA

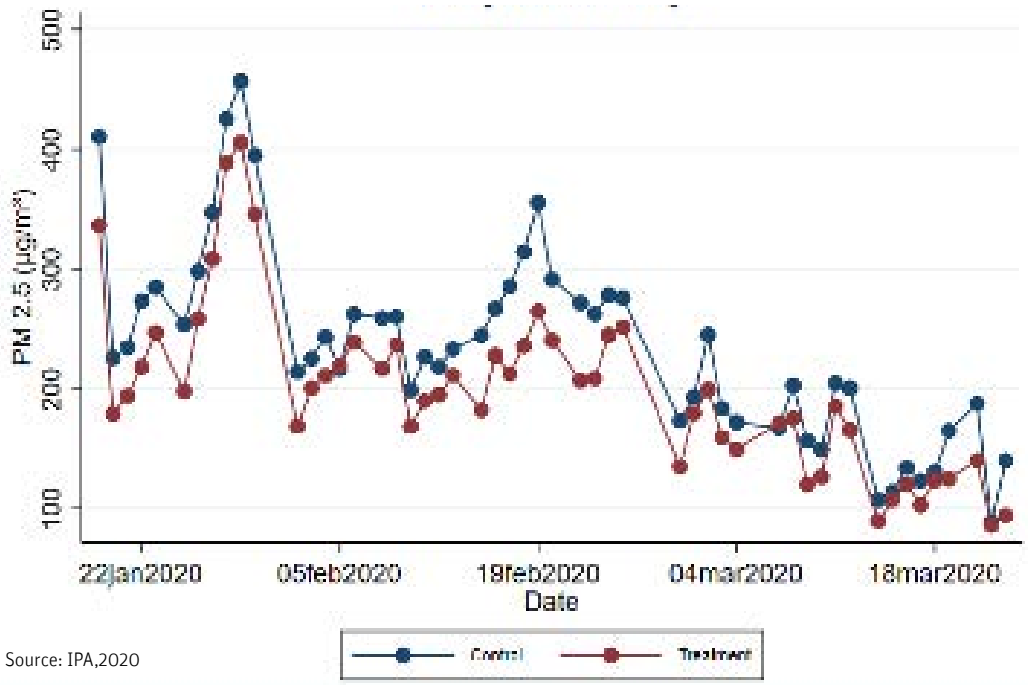
To assess the impact of air pollution on productivity and the extent to which defensive mechanisms alter that relationship, background work for this report used a randomized design to allocate air filters to different firms in Bangladesh, effectively generating exogenous variation in air pollution at the firm level. To test the links between air pollution and workers' productivity, 40 garment factories in Dhaka were recruited with at least 8-10 employees, who are paid piece rate wages, and where daily productivity records are maintained. The allocation of air-purifiers was randomized to the firms: 20 air purifiers and 20 air quality monitors (which measures AQI, PM 2.5 and PM 10 levels) were randomly allocated to 20 firms (Treatment). The remaining firms formed the control group (Control).

A baseline survey was collected to establish the pre-intervention status of the main outcome indicators of the study: air quality and labor productivity. It included factory level indicators like temperature, PM 2.5, PM 10 and humidity. The survey also included socio-economic indicators for the workers themselves: working hours, piece rate wage, total wage, total production and break times. During the first week of the intervention, a survey was conducted to establish the baseline information about the factories as a foundation for the analysis. In the weeks to follow, the field plan continued: daily air quality and labor productivity data was collected and analyzed for both the treatment and control groups every week. A simple comparison of productivity means—captured by pieces produced/worker-day—between Treatment and Control—after controlling for seasonality and day of week effects, estimates the impact of air filters on productivity and can contribute to providing a better understanding of how air pollution affects worker productivity.

KEY FINDINGS FROM AIR POLLUTION AND PRODUCTIVITY DATA

Overall results show that indoor air pollution levels in factories are at unhealthy levels according to WHO guidelines. For factories where no filters were installed (Control), average PM 2.5 levels were above 200: 232.83 without standardizing in/out times. Meanwhile, for factories where filters were installed (Treatment), the average PM 2.5 level was 199.73. This represents a 14.22 percent decrease in PM 2.5 (µg/m³) in the treatment group compared to the control group. After standardizing the time there was a 20.78 percent decrease in PM 2.5 (µg/m³) in the treatment group compared to the control group. Figure 2.8 shows the daily air quality over the time of the intervention for both the control and the treatment group.

FIGURE 2.8: DAILY AIR QUALITY OVER 2 MONTH



Source: IPA,2020

To measure workers' productivity, information was collected on the number of hours worked in a day and output produced per hour. This was then used to create measures of productivity per hour per worker. Working hours per day were calculated from workers in/out time at the factories. Power cut duration and break time were subtracted from the total working hours. To generate a per hour output, workers' total production was divided by their working hours. Pre-treatment data shows that treatment and control groups are comparable in terms of productivity (hours worked per day and output). This comparison confirms that the sample of the two groups is balanced, and the experiment is well designed. Hence, conclusions can be derived about differences after the introduction of the treatment. Similar results are observed when comparing productivity by the different types of workers analyzed in the study.

Initial results suggest that introduction of filters leads to differences in productivity among workers. Cumulative exposure to pollution over the years and the fact that levels of pollution are considerable high (even with filters) may be some of the reasons why these differences are not too high. However, productivity for the two groups is still different and additional data and analysis may provide more power to this estimation. When the sample is restricted to only those types of workers that receive piece rate wages, the broad category of tailors and seamstresses show the largest differences in productivity (see Table 2.1). Distinction between these two types of workers is important to understand if the effect of pollution on productivity varies by the type of tasks performed. The productivity of tailors and seamstresses was significantly higher in the factories where filters were installed compared to the control group.

TABLE 2.1: PRODUCTIVITY OF SEAMSTRESSES AND TAILORS (WITHOUT CLUSTERING AT THE FIRM LEVEL)

		(1)		(2)		(3)	t-test
		Treatment Group		Control Group		Total	Difference
Variable	N	Mean/SE	N	Mean/SE	N	Mean/SE	(1)-(2)
Seamstress	2006	0.750	2860	0.526	4866	0.618	0.224***
		[0.009]		[0.010]		[0.007]	
Tailors	2825	0.729	3836	0.677	6661	0.699	0.052***
		[0.008]		[0.011]		[0.007]	

THE ROLE OF INSTITUTIONS

The environmental institutional landscape in Bangladesh is complex, which often makes pollution management a difficult task. Since 2006, when the World Bank's first Country Environmental Analysis (CEA) for Bangladesh was published, the country has made important progress in developing environmental policies and legislation (World Bank, 2018). However, efforts need to be strengthened to arrest the significant effects of pollution and environmental degradation in the city.

The overarching environmental legislative framework is provided by the Environment Conservation Act of 1995 (ECA-95). It includes laws for conservation of the environment, improvement of environmental standards, and control and mitigation of environmental pollution. ECA-95 is implemented through the Environment Conservation Rule 1997 (ECR-97) and is the main legislative tool in Bangladesh for environmental regulation of emissions/effluents and permitting for industries. ECR-97 outlines: (i) the requirement and procedures to obtain and renew Environmental Clearances; and (ii) the National Environmental Quality Standards for ambient air, various types of water, industrial effluents, emissions, noise, vehicular exhaust, etc. The Environment Court

Act 2010 was passed to establish Environment Courts in each district with a Joint District Judge. However, to date no Environment Court has been established at the district level. More recently, the Bangladesh Clean Air Act has been drafted but not approved. The Act proposes a cross-sectorial approach to combat air pollution and it holds public and private sector offenders to account. The Act also requires the Department of Environment (DoE) prepare a National Air Quality Management Plan.

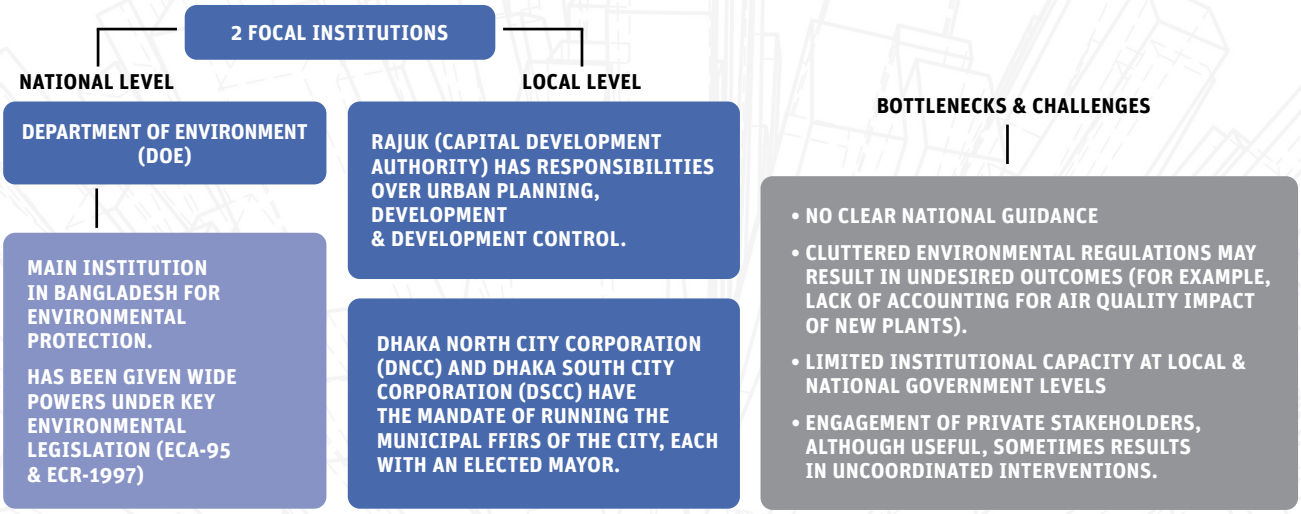
In terms of institutions, the DoE is the only institution in Bangladesh with a mandate for environmental regulation and it has been given wide powers under the ECA-95 and ECR-1997. The DoE, under the Ministry of Environment, Forests and Climate Change (MOEFCC), is responsible for: (i) reviewing Environmental Impact Assessment (EIA) reports and awarding environmental clearance certificates to industries; (ii) inspecting industrial units; (iii) monitoring compliance and enforcement of environmental standards; (iv) preventing activities that are likely to cause environmental degradation; and (v) carrying out research activities. DoE's head office is in Dhaka and it also has a Dhaka Region Office, a Dhaka Metro Office and a Dhaka Laboratory. However, the DoE faces many challenges including insufficient budget to address its increasing responsibilities and need for manpower and information systems to monitor and enforce compliance. Based on a 2018 report, the DoE was operating at the time with 431 staff, against an approved 735 posts with vacancies due to bureaucratic delays (World Bank, 2018). This staff headcount is well below than that of comparable-sized middle-income countries. Additionally, there is very limited interaction and coordination among the DoE and local authorities of Dhaka City as these organizations are in different ministries; which makes accountability difficult.

At the city level, there are several organizations that have control over urban planning and development of the city, and thus influence the urban environment. The Rajdhani Unnayan Kartipakkha (RAJUK, Capital Development Authority) is a government agency under the Ministry of Housing and Public Works, whose main mandates are urban planning, development and development control. RAJUK implements infrastructure projects such as roads, housing and land development, and they also have the power to evict industries from plots that are not designated for that land use. However, enforcement of planning and land use rules by RAJUK is an ongoing challenge due to lack of capacity in terms of manpower as well as technical and monitoring capabilities. On the other hand, the Dhaka North City Corporation (DNCC) and the Dhaka South City Corporation (DSCC) have the mandate of running the municipal affairs of the city, each with an elected mayor. As such, they have directive over issues related to urban development and environmental management including waste management, social welfare and slum upgrading. Additionally, both City Corporations interact with DoE to carry out environmental clearance and the environmental management plan required in the approval process for physical developmental works. As with other local government authorities, both City Corporations are facing several capacity constraints with regards to urban planning and development control.

Furthermore, there are important non-governmental actors playing an important role in pollution management. The role of civil society in advocating for environmental protection is notable, this includes non-profit organizations as well as professional organizations. The Bangladesh Poribesh Andolon (BAPA), is one of the most noteworthy civil society organizations, as it has successfully launched important efforts to fulfil its mission to create a nationwide, united, and strong civic movement to protect Bangladesh's environment. Additionally, universities are playing an important role in terms of publishing environment-related data as well as in developing the next generation of environmental scientists and engineers.

Dhaka's institutional setup and main bottlenecks and challenges for pollution management are summarized in Figure 2.9. In general, the main issues relate to capacity constraints in terms of human and financial resources at key institutions like the DoE to manage the growing responsibilities. Furthermore, legislation is often outdated and/or not enforced and national and local bodies have overlapping mandates and roles, which makes coordination complex. As such, the country, and specially Dhaka requires more effective policy and legal framework and stronger institutions at the national and city level to control pollution and thus improve the city's competitiveness and overall livability. The institutional setup and main bottlenecks and challenges are summarized in Figure 2.9.

FIGURE 2.9: INSTITUTIONAL SETUP AND MAIN CHALLENGES FOR POLLUTION MANAGEMENT IN DHAKA



Source: Author's elaboration

CONCLUSIONS

Dhaka suffers from some of the most severe air pollution of any city in the world. Air pollution is not only imposing a significant cost in terms of health outcomes but also in terms of productivity. The experiment's initial results show that air pollution is affecting the productivity of small factory workers, but that introducing air filters led to an increase in productivity, which suggests that poor air quality has a direct effect on workers' ability to do their jobs.

The institutional assessment of Dhaka shows that while important efforts have been made, there is still a long way to go in terms of environmental and pollution management. There is poor financial and human capacity and lack of coordination among stakeholders. As such, a key action area will be to focus on institutional reforms and capacity building. Moreover, strong coordination and collaboration among the government, the private sector, and civil society are required to reverse trends, shift the country toward a greener development path and scale up clean technologies.

[38] We listed 746 small-scale textile factories across two areas in the outskirts of Dhaka. We selected 316 factories from Naryangonj and 430 factories from Kamrangichor. Addition to obtaining factory demographics, the listing survey also helped us to collect information about the perceptions about air pollution of workers, perceived levels of air quality in and around factories. To choose the final 40 factories for the baseline and intervention, we randomly selected 80 factories from the listing survey in Kamrangichor, with replacements. Later on, additional 30 factories were randomized into the intervention due to a higher than expected rejection rate. There was no pattern in the reasons for refusal to participate in the research from the firms. A cross-sectional factory survey was conducted in all 40 factories.

[39] The Baseline survey was conducted with at least 8-10 workers in 40 factories in Kamrangichor. The survey was conducted during from January 25 to January 31, 2020. The target population included owners, managers, and workers.

[40] Intervention for the study started mid-January 2020. The initial plan was to measure productivity of the workers for 6 months but due to the COVID-19 pandemic, the collection of data for the study we had to temporarily stopped. The factories have been closed down due to the lockdown. All the devices were removed from the factories on March 24, 2020 and collection of productivity data halted on March 19, 2020. Depending on guidance from national authorities work will resume when the pandemic situation allows.

[41] Although hours worked per day and output are slightly higher in the control group, the difference is not significant, suggesting productivity is comparable in both sets before the intervention. The control group works 10.55 hours per day and produces 3.5 pieces per hour while the treatment group works 9.9 hours per day and produces 3 pieces per hour.

[42] Initial results suggest this difference, while large is not statistically significant when clustered at the firm level. However, results are based only on the initial two months of data and the power calculations indicate that meaningful differences should be detected once the study resumes after the COVID-19 shutdown.

[43] Draft from 2019.

[44] These are required for specific types of industries and development projects as scheduled in ECR 1997. Some activities also require Initial Environmental Examinations (IEE) under ECR 1997.

Dhaka City Landscape Taken from 19th Floor - Photo by Abdul Awal Uzzal - Adobe Stock

ZANZIBAR:

THE LIMITING EFFECT OF POLLUTION ON THE TOURISM POTENTIAL OF THE ISLAND

POLLUTION MANAGEMENT

ZANZIBAR, AN UP-AND-COMING TOURIST DESTINATION

Zanzibar, a semi-autonomous region of the United Republic of Tanzania, has experienced fast economic growth in the past decade. Its annual GDP growth rate has averaged 6.6 percent between 2013 and 2018 and in this last year its GDP per capita surpassed $1,000 for the first time in history. However, Zanzibar is still performing slightly below mainland Tanzania, not only in terms of GDP but also in terms of employment. Zanzibar has seen an increase in the unemployment rate, reaching 23.3 percent in 2018 in urban areas, compared to 13.3 percent in urban areas in Tanzania.

The economic growth that Zanzibar is experiencing is mostly driven by the tourism industry, which represents approximately 27 percent of the Zanzibari GDP and contributes to 80 percent of its foreign exchange earnings. With a population of 1.3 million (according to 2012 census), Zanzibar is developing fast to accommodate a growing influx of tourists estimated at approximately half million people annually. Furthermore, the entire economy has benefitted from infrastructure investments driven by the tourism industry . Because the tourism sector directly generates between 20,000 and 40,000 jobs, and benefits between 60,000 to 100,000 additional people through indirect employment (such as food supply and traders), fostering these activities can help Zanzibar become more competitive.

However, many challenges associated with this activity can jeopardize Zanzibar's development and competitiveness. Tourists bring many benefits but can also strain the infrastructure and service provision in a region that is still at a developing stage. The large influx of tourists can also impact the environment and increase levels of pollution that, in turn, can have a negative effect on the ability of the island to exploit its tourism potential. Unplanned development and coastal construction are often accompanied by land, coastal, and ocean degradation. Rising levels of air and water pollution can also affect land and marine life, endanger costal reefs, and eventually destroy the natural attractiveness that has driven the tourism industry in the first place. To properly address these challenges, it is crucial to understand the effect of tourist activity on pollution and the environment and how this is perceived by tourists and residents alike.

To shed some light on this topic, a survey was administered to collect primary data to better understand the attitudes that tourists, residents, and the private sector have towards pollution. Focusing on these three groups (tourists, residents, and businesses) allows a full picture of the key stakeholders, their perspectives on the matter, and the challenges they face. Residents and the private sector can provide a complete view of what aspects are not functioning properly, while tourists can help benchmark Zanzibar's standards with other comparable beaches and tourists' destinations. The following sections describe the main findings from this data collection effort, and discuss the role of institutions in managing pollution, and the challenges they face in doing so.

THE PRESSING ISSUE OF WATER AND OCEAN POLLUTION

Water pollution due to inadequate treatment of municipal waste is a real concern in Zanzibar. The approximately 8.5 million cubic meters of liquid waste generated by the Zanzibar municipality every year are dumped untreated into coastal waters. Moreover, of the 120 tons per day of solid waste generated, only 40 percent is collected. The rest contributes to water pollution via surface water run-off and leaching, since it does not allow rainwater to properly infiltrate in the soil. As a consequence, greater amounts of rainwater run to the ocean, carrying uncollected solid waste on the way and increasing ocean pollution.

The negative effects of water pollution are observed both in the natural environment and in human health. High levels of nutrients and coli forms have been reported in coastal waters near Zanzibar Municipality. These elevated levels have had a negative impact on reefs and have resulted in a decline in coralline algal cover. Zanzibar hospitals frequently received cases showing symptoms of water borne-diseases, such as gastroenteritis and cholera. According to the Zanzibar Ministry of Health, these cases account for more than 70 percent of the total number of cases reported in health care units.

In the long term, the negative effects of these pollution vectors on the natural environment pose a danger to one of the main attractions of the island: a degraded environment can weaken Zanzibar's capacity to attract tourists. If pollution continues to grow, tourists will be less likely to visit or return, affecting Zanzibar's capacity to sustain a flourishing tourism industry and hindering the island's competitiveness.

The main goal of the survey conducted for this study was to better understand the perception among tourists and residents regarding Zanzibar's cleanliness, and the effect that perception has on tourist activity. Consequently, the study examined how likely tourists are to return to Zanzibar and how much they will be willing to pay per night to support better care for the environment. The study also examined the main effects the tourist industry brings to the island in terms of both, environmental and economic benefits and challenges.

THE EFFECTS OF POLLUTION ON TOURISM PERCEPTION

The survey collected data in four different locations in Unguja island: Stone Town, Jambiani, Kiwengwa, and Nungwi. These four locations offer different experiences for tourists and cover different geographic areas and tourist destinations. These section presents the combined responses from the four locations.

Perception of overall cleanliness in Zanzibar is below average for most of the tourists, residents and business providers. This includes cleanliness in beaches, streets, hotels, as well as the perception of the quality of ocean water and air. Only one third of tourists think that overall cleanliness in the island is good (with similar percentages for the other two groups). Furthermore, half of residents and business providers believe that overall cleanliness has not changed or gotten worse (or much worse) in the past ten years. These negative scores are mostly driven by the perception on street cleanliness, which scores worst among the different categories (with 90 percent of tourists considering street cleanliness below average).

A deeper examination of these results reveals that tourists with higher income and for whom the main attractions are water activities and the beach, tend to give a higher score to overall cleanliness. This may be driven by the fact that these tourists usually stay in gated all-inclusive resorts, with less exposure to the city and hence to dirty streets. Visitors who stay longer or who are returning visitors tend to give lower overall cleanliness scores, reinforcing the message conveyed by providers and residents: that the state of overall cleanliness is not getting better in Zanzibar.

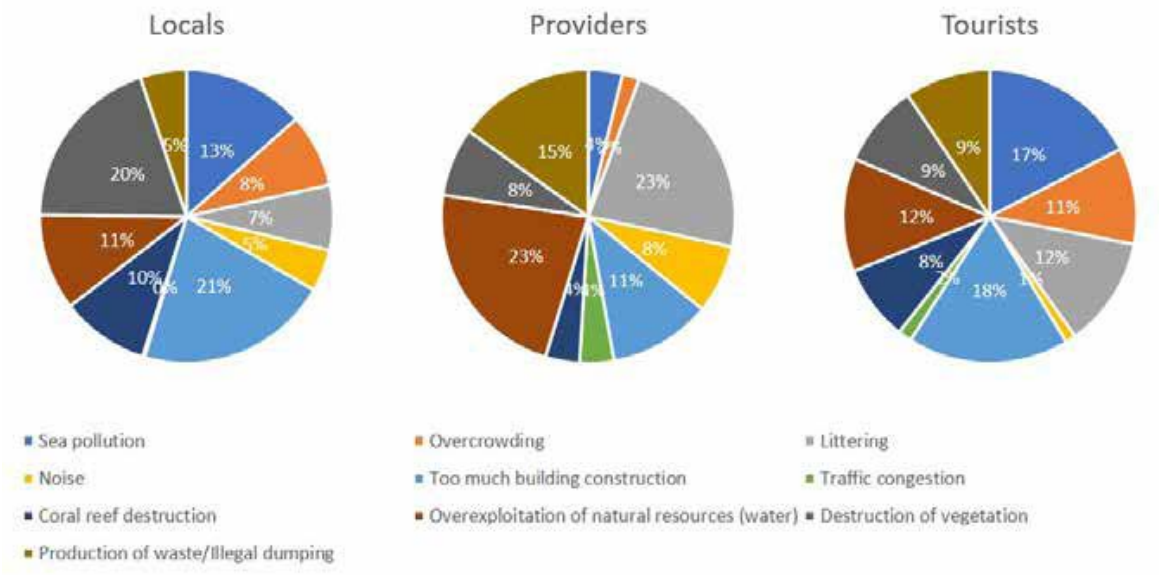
Overall cleanliness and street cleanliness perception are also clear factors affecting tourists' willingness to return to Zanzibar, as well as willingness to recommend it to friends and family. The probability of returning to Zanzibar is higher for those tourists who have given rated Zanzibar's cleanliness more highly. These tourists are also more willing to recommend visiting the island. What is more interesting is that a negative cleanliness perception motivates tourists to pay an additional fee per night to support environmental protection and cleanliness: the worst their impression, the more they are willing to pay to improve it.

Other factors also have a significant effect on tourists' willingness to return to Zanzibar or recommend it as a destination. Younger visitors are more likely to return, as well as visitors in the higher end of the income distribution. In contrast, visitors whose main purpose is business, are less willing to return for a second visit. Additionally, longer stays and nature-based activities increase the probability of a tourist to recommend Zanzibar to friends and family. Tourists who spend more time in the island, as well as those who consider beach and water activities as the main attractions, are more likely to recommend it.

The survey also highlights two positive outcomes of tourism. 40 percent of the residents and business providers believe that the tourism industry brings benefits to Zanzibar's natural environment. Among these positive benefits, they recognize higher levels of awareness about the importance of environment conservation among both the community and the government due to tourism activity. This is important because higher levels of awareness can help city leaders identify the more pressing issues in terms of both, how to manage pollution and how to benefit the tourism industry, and implement the necessary policies. Moreover, approximately 75 percent of residents think that tourists also bring more benefits than troubles to Zanzibar's economy, such as employment and business opportunities and that the tourism industry also gives economic benefits to local people.

However, there is also evidence of some negative effects that arise as a consequence of the boom in the tourism sector. While a small percentage of residents and business providers think that the tourism industry has helped improve water quality and strengthened nature protection, of those that identify some negative effects, the great majority points at such effects being related to pollution. Figure 2.10 shows the distribution of the negative effects identified these negative effects for each of the three groups (restricting the sample to those who responded that tourism bring negative effects to Zanzibar's environment). Among residents, the two most negative effects are too much construction on the island (21 percent, in light blue) and the destruction of vegetation (20 percent, in dark grey). For the business providers group, the two biggest effect are the overexploitation of natural resources, such as water (23 percent, in brown) and the littering associated with tourists (23 percent, in light grey). Among tourists, the two most negative effects they believe they bring are also too much construction (18 percent, in light blue) and sea pollution (17 percent, in blue).

FIGURE 2.10: NEGATIVE EFFECTS OF TOURISM INDUSTRY ON ZANZIBAR'S ENVIRONMENT

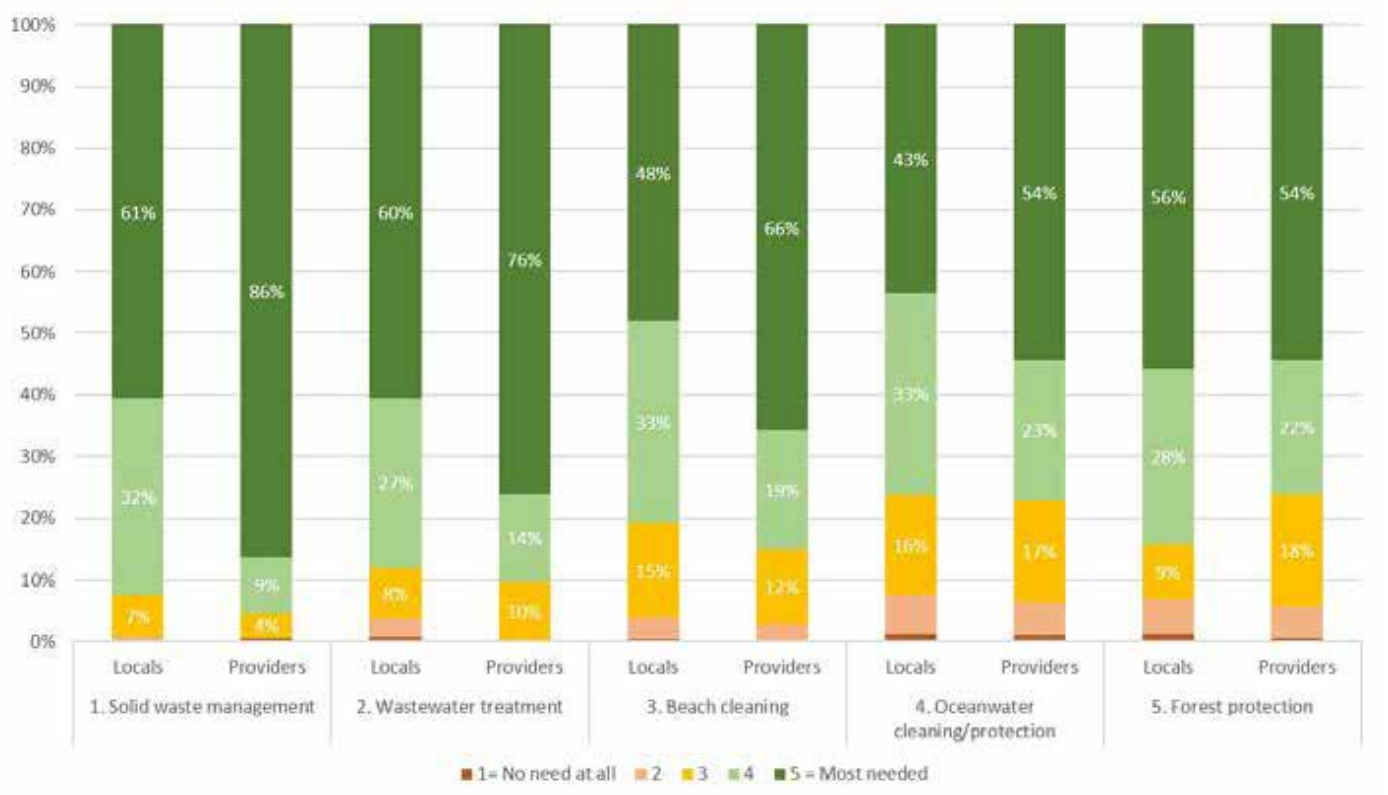


Source: Authors' elaboration based on survey data collected as part of this project. The survey interviewed 1063 tourists, 1430 residents, and 175 private sector providers.

Note: Each pie chart represents responses from locals, providers and tourists, respectively (from left to right). Responses are grouped in 10 types of negative effects: sea pollution (blue), noise (yellow), coral reef destruction (dark blue), production of waste/illegal dumping (olive), overcrowding (orange), too much building construction (light blue), overexploitation of natural resources (brown), littering (grey), traffic congestion(green), and destruction of vegetation (dark grey). Percentages are shown on each slices of the pie.

There are certain areas where the government can make a difference and help minimize some of the negative consequences associated with tourism. Figure 2.11 shows the assessment that residents and business providers' assessments of five environmental services. Waste management arises as the service that needs to be improved the most, followed by wastewater management and beach cleaning. Interestingly, a considerably lower percentage of residents and business providers believe that ocean cleaning needs improvement. Although this is surprising (given that water pollution is a real concern in Zanzibar), it may be due to the fact that it is often easier to see waste and pollution on the beach and streets than in the ocean, where waste can be more spread out or thrown further from the coastline.

FIGURE 2.11: NEED FOR IMPROVEMENT IN ENVIRONMENTAL SERVICES – RESIDENTS AND PROVIDERS



Source: Authors' elaboration based on survey data collected as part of this project. The survey interviewed 1063 tourists, 1430 residents, and 175 private sector providers.

Note: This graph is structured in five groups of different services provided by the government (from left to right, solid waste management, wastewater treatment, beach cleaning, oceanwater cleaning/protection, and forest protection). For each service, the first column shows responses from locals, and the second column responses for providers. Each column shows the percentage of locals/providers who believe each particular service does not need improvement at all (1-brown) to most needed of improvement (5-dark green).

THE ROLE OF INSTITUTIONS

As a semi-autonomous region, Zanzibar has a central governing body, the Revolutionary Government of Zanzibar (RGoZ), which is mandated to perform all functions that are "non-union matters". This remit includes environmental protection and municipal services. In terms of legislation, the RGoZ approved two policy documents regarding environmental protection and management: the National Environmental Policy of 1992 (NEP-92) and the 1996 Environmental Management for Sustainable Development Act of Zanzibar (EMSDA-96). The NEP-92 laid the groundwork for the establishment of the institutional and legal structures necessary for environmental management and nature preservation. It also addressed topics such as support of sustainable livelihoods, land use planning, and rational exploitation of natural resources. The EMSDA-96 complemented this act by providing regulatory measures and established that these should be enforced by Zanzibari institutions responsible for the environment.

Although these two acts were a step in the right direction, their implementation and enforcement yielded mixed results. The effort was not enough to address the greater and severer challenges that came as a consequence of the rapid population and economic growth brought by Zanzibar's thriving tourism sector. This resulted in the need to review and update these two main policies and two new acts were enacted: the new Zanzibar Environmental Policy of 2013 (ZEP-2013) and the new Zanzibar Environmental Management Act of 2015 (EMA-2015). These two documents are now the overarching policy and legislation that direct all practices in Zanzibar with regard to environmental management, natural habitat protection, pollution control, and waste management.

These two acts have distinct objectives and goals. The ZEP-13 general objective is "to prevent and control pollution and degradation of terrestrial, air, marine and other aquatic environment." The policy specifically refers to waste management as one of the ways to control pollution, but here, there are two key concerns: first, the inadequate national capacity to properly manage solid waste and wastewater generated in the communities; and second, the lack of clear guidelines and measures regarding the proper management and disposal of hazardous substances. The EMA-15 is the umbrella law on environmental governance in Zanzibar, where specific issues are discussed, mostly related to the obligations to protect the environment (including the peoples' right to a clean, safe, and healthy environment) and environmental management. For example, one of the key points of this act is to establish that Local Government Authorities and local institutions are responsible for solid waste management and the proper handling of any type of medical waste.

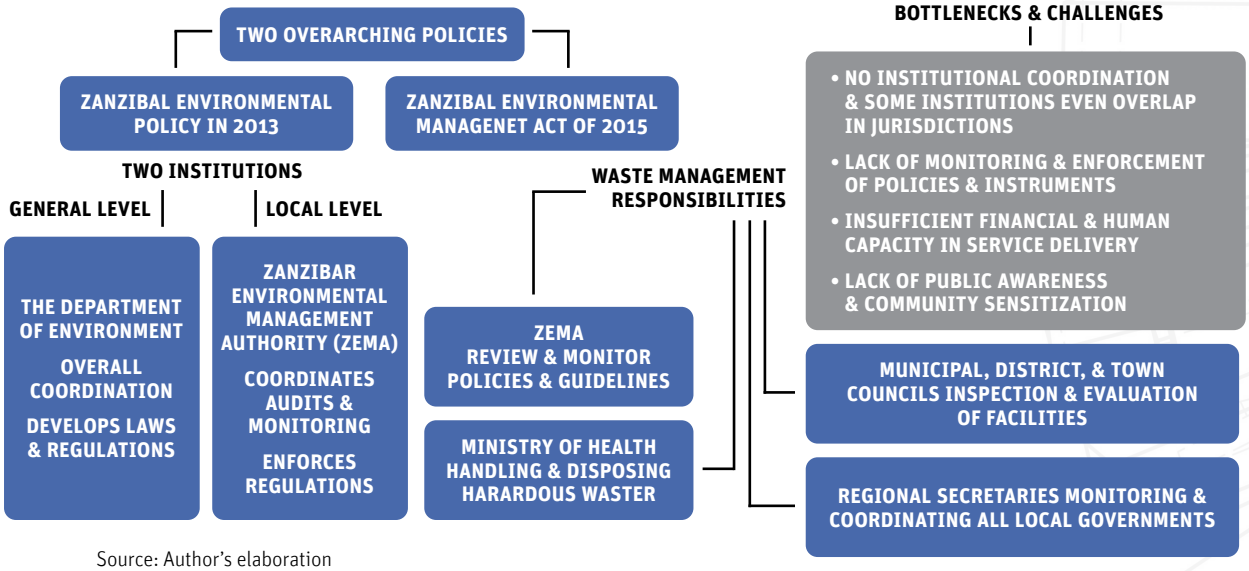
Aside from these overarching policies, there are two institutions in charge of managing environmental issues. At a general level, The Department of Environment (under the Office of the 2nd Vice President of Zanzibar) retains the overall responsibilities of coordinating of environmental management, assuming national responsibility for the development of environmental laws and regulations, as well as monitoring the implementation of these regulations. It is also charged with monitoring the environmental conditions, collecting data, disseminating information related to the environment, organizing relevant research, and promoting awareness of environmental issues among the public. At a local level, day-to-day environmental management duties are performed by Zanzibar Environmental Management Authority (ZEMA), which was established under the EMA-15. Some of ZEMA's core functions include coordinating of environmental audits/monitoring, issuing of environmental certificates, permits or approvals, enforcing of regulations and compliance, and promoting environmental education and awareness, to name a few.

Waste management (solid waste and wastewater treatment) responsibilities are, in theory, also divided between the central government and local governments. At the central government level, two institutions are accountable for these tasks. ZEMA is responsible for reviewing and monitoring the waste management policies, guidelines, and capacity of related institutions. The Ministry of Health is in charge of handling and disposing of hazardous medical waste, as well as assessing its impacts on the environment. At the local government level, regional councils are responsible for the inspection and evaluation of solid waste management facilities, including allotting land for facilities such as composting centers, transfer stations, and landfill sites. Under this arrangement, municipal, district and town councils are responsible for the collection, transfer, and disposal of municipal waste, including the planning, investment, and operation and management of solid waste management facilities.

To complement this structure, Regional Commissioners (especially the Regional Secretaries) are responsible for monitoring and coordinating all local governments (municipalities, towns, and district councils). However, in practice, their role is minimal. Municipal, district and town councils often manage the solid waste generated within their jurisdiction in a self-contained manner without much real planning or coordination. Waste generated in their respective area is generally collected in cooperation with the Shehias (equivalent of villages and the smallest administrative unit in Zanzibar), and taken to a waste dump site in the area.

Despite these efforts and policies, several challenges and bottlenecks still need to be addressed. The institutional setup and main bottlenecks and challenges are summarized in Figure 2.12. First, there is no institutional coordination and some institutions even overlap in jurisdictions, resulting in poor performance and services in many aspects. Given the small size of Zanzibar, having multiple layers of government proves to be a coordination challenge and may not be the most efficient way of delivering services such as pollution control and waste management. Second, there is lack of monitoring and enforcement of policies and instruments. Although an established institutional and legal framework for environmental and waste management has been in place for at least two decades, Zanzibar's power to enforce that framework has been largely undermined by many factors, such as political sensitivity, conflicting interests in economic benefits, and environmental outcomes. Moreover, in cases where multiple policies and regulations touch upon the same topic, there is lack of clarity on which policies and/or regulations are overarching and who has the authority to monitor and control their proper implementation. Third, there is insufficient financial and human capacity in service delivery. Only 23 percent of households received regular solid waste collection, and even from these, hardly any revenues are collected, leaving the local governments to operate their services almost solely on their own limited budget. Forth, there is lack of public awareness and community sensitization. A recent study conducted by the Department of Environment showed that 60 percent of the local residents considered natural resources as a public good which they could harvest or utilize without restrictions, adding an extra burden on the ability of the government to protect the environment and manage pollution. The institutional setup and main bottlenecks and challenges are summarized in Figure 2.12

FIGURE 2.12: INSTITUTIONAL SETUP AND MAIN CHALLENGES FOR POLLUTION MANAGEMENT IN ZANZIBAR



Source: Author's elaboration

CONCLUSIONS

Zanzibar's location advantage and its natural environment make tourism the most important economic activity of the island and the main driver of its economy. It represents almost one third of Zanzibar's GDP, contributes to 80 percent of its foreign exchange earnings, and generates up to 40,000 jobs. To date, however, Zanzibar's reliance on tourism has involved serious trade-offs. On the one hand, there is still untapped potential for this industry and Zanzibar can benefit from attracting more tourists to the region. On the other hand, increasing tourism can put an excessive burden on infrastructure, services and the environment if not properly managed. Grappling with these trade-offs carefully is crucial if Zanzibar is to become more competitive.

To help boost the tourism industry, many factors can be addressed. First, the cleanliness of streets and beaches is important for attracting tourists. Their overall perception of cleanliness affects their willingness to return to the island, and their sense of street cleanliness affects their willingness to recommend the island to friends and family. Given that more than half of both locals and providers agree that the level of cleanliness in Zanzibar has not changed or gotten worse in the last ten years, increasing efforts to clean up Zanzibar could prove beneficial for the island. Second, tourists who mainly engage in nature-related activities are more likely to recommend Zanzibar as a destination. Thus, protecting the environment and boosting such activities can help support the industry. Third, the government can help upgrade services in certain areas to help the tourism industry reach its full potential. Infrastructure, waste management, and public services appear to be the areas where most improvements are needed.

A growing tourism sector can bring not only economic benefits but also bolster Zanzibar's efforts to defend the environment. Aside from generating jobs and creating more opportunities for businesses, the tourism industry can also help increase environmental awareness. Approximately half of both locals and providers believe that communities and the government have become more conscious of the importance of the environment due to some of the tourist activities. Although part of this awareness may have been driven by the negative effects brought by the industry, such as increasing levels of construction and pollution or the destruction of vegetation, the fact that most of touristic activities focus on water attractions and the natural environment highlights the necessity of safeguarding these resources. As levels of awareness keep rising, this could translate into more investments and better management of water and nature protection.

Strengthening this industry while simultaneously confronting the challenges it brings, particularly in terms of the institutions and regulations responsible for managing pollution, will support Zanzibar in two ways. First, it will help the island stay competitive. Second, it will help make Zanzibar's growth sustainable by increasing awareness of the dangers of pollution, which can lead to more effective efforts to preserve the natural environment.

[45] Zanzibar Office of the Chief Government Statistician (OCGS). 2019. Zanzibar Statistical Abstract 2018.

[46] RGoZ President's Office of Finance, Economy and Development Planning. 2015. ZanPlan.

[47] According to Mohammed (1993), the liquid waste generated by Zanzibar municipality contributes to approximately 3100 tons of biochemical oxygen demand (BOD), and a similar amount of suspended solids, and 520 and 16 tons/yr of nitrogen (N) and phosphorus (P) , respectively.

[48] Zanzibar Sustainable Programme. Working Group Report: water supply, waste water, flooding and drainage, Zanzibar Municipality, 2000b. 21pp.

[49] Mohammed SM (2002) Pollution management in Zanzibar: the need for a new approach. Ocean Coast Manage 45(4–5):301–311

[50] Mohammed SM (2002) Pollution management in Zanzibar: the need for a new approach. Ocean Coast Manage 45(4–5):301–311

[51] While those who rate cleanliness higher are more willing to return, among those who actually return to the island, the rate of cleanliness seems to be lower (they see Zanzibar as dirtier compared to those visiting for the first time). This may be a consequence of higher awareness of dirtiness, pointing at increased knowledge and better information with repeated visits.

[52] Other responses considered that the effects of tourism on Zanzibar's natural environment is either neutral or negative, with a small percentage who did not know what to respond.

[53] To first assess the overall effect of tourism on Zanzibar's environment, the survey asked: "How would you characterize the impact of tourism on Zanzibar environment". Responses were as follows: From Tourists: 28 percent positive, 43 percent neutral, 14 percent negative, 15 percent don't know; from Locals: 39 percent positive, 37 percent neutral, 16 percent negative, 8 percent don't know, from providers: 37 percent positive, 42 percent neutral, 16 percent negative, 5 percent don't know.

[54] RGoZ. 2013. Zanzibar Environmental Policy 2013.

[55] HydroPlan. 2018. Consultancy for the development of a solid waste management strategy for the Zanzibar Archipelago-Inception Report.

[56] Zanzibar does not have any sanitary landfill yet. Its first sanitary landfill is currently under construction as part of the World Bank-financed Zanzibar Urban Services Project, due to be completed and in operation by end of Year 2020.

[57] RGoZ. 2013. Zanzibar Environmental Policy 2013.

Aerial. Stone town, Zanzibar, Tanzania - Photo by Mariusltu - Adobe Stock

MONROVIA:

THE EFFECTS OF POLLUTION VECTORS ON MARKET COMPETITIVENESS

POLLUTION MANAGEMENT

MONROVIA, THE CENTER OF LIBERIA'S ECONOMIC ACTIVITY

Today half of the 4.6 million Liberians live in an urban settlement and about a quarter (or 1.3 million) of them reside in Monrovia . Historical influences have made Monrovia the center of Liberia's economy and the disparities between the city and the rest of the country (in terms of wealth, infrastructure and population) are quite considerable. Monrovia's population was 330,000 before the war (1980), 15 times larger than the next largest town, Buchanan. Today, the population of Greater Monrovia is almost 24 times larger than that of Buchanan, which has a population of about 60 thousand people. Greater Monrovia's population has increased 13-fold and built-up area almost doubled over the last four decades from 100 sq km in 1975 to 176 sq km in 2013.

The metropolitan region is a key contributor to the economy and has a significant role to play in economic recovery and transformation - but most jobs are in the informal sector, and poverty levels and food insecurity are high. The Monrovia metropolitan region is home to 80 percent of the more than 41,000 officially registered firms in Liberia and the largest markets in the country. The majority of the population, however, makes a subsistence living, with female-owned firms making up a large share of the informal sector. The informal sector is also significantly linked to the agricultural sector, including informal vendors and small vegetable growers which reflects vegetable farming's importance as a profitable horticultural activity. But 20 percent of the city's residents are moderately or severely food insecure, 40 percent suffer from food poverty, and 30 to 60 percent of food production is unmarketable at the retail level. This is partially due to an absence of a modern functioning wholesale market essential to efficiently linking production and consumption. Instead, Monrovia's residents are served by a congested and unhygienic market infrastructure that cannot segregate wholesale and retail functions, resulting in a substantial post-harvest loss for perishable produce that exacerbates solid waste management (SWM) challenges in the city and raises food prices for consumers. It also weakens the significant potential to increase domestic agricultural production and forge links with the service sector.

The management of the vectors of pollution in Monrovia is fraught with financing and institutional concerns. This is especially so for the management of sanitation – including solid waste. Based on recent tonnage data, the waste collection rate in Monrovia around is only at 45 percent of the total waste generated in the city. (World Bank, 2019). The sanitation concerns – especially solid waste disposal - is especially evident around the two main food markets (Duala market and Red Light market), where increasing amounts of waste are dumped daily, posing risks to human health and the environment.

To better understand the issues related to pollution and productivity in Monrovia's markets, a series of geospatial, qualitative, and quantitative data collection activities were conducted in the Duala Market as part of the Open Mapping for Productivity and Pollution Impacts in Duala Market Project (Humanitarian OpenstreetMap, 2020). Based on the data collected, this note focuses on: (i) exploring the management of pollution vectors, in particular related to waste, infrastructure facilities and food loss, (ii) their relationship with market productivity; and (iii) describing the institutional bottlenecks inhibiting the proper functioning of the market.

THE DUALA MARKET: CENTER FOR ECONOMIC ACTIVITY AND POLLUTION

Wholesale markets represent a key pillar of the Liberian economy as they are an important source of spending and income. Households rely heavily on markets for their basic needs; it is estimated that 94 percent of urban households and 74 percent of rural households purchase their food in local markets. Moreover, food represents an important spending category as a recent post-Ebola survey found that a quarter of households spend over 65 percent of their income on food (World Food Program, 2015). Agricultural producers also rely on markets to sell their produce and purchase food and essential items. They also constitute an essential source of employment for many other urban residents: 70 percent of employment in the country is informal, with most people in urban areas deriving their income from petty trade.

Duala Market is one of the most important economic zones of the Greater Monrovia Metropolitan Area, serving as a critical food market connecting agricultural activities in outer counties, such as Bomi and Nimba, to Monrovia's urban food system. It is the second largest market in the city, after the Red Light market. Duala Market is located on the north end of Bushrod Island within the city. The market is long and narrow, with commercial activity stretching approximately 1.5 km along the United Nations (UN) Drive. While the market has official boundaries managed by the Liberia Marketing Association (LMA) , these boundaries are not easily observable as significant expansion of market activity has blurred the lines between formal and informal market. The majority of businesses and market activity parallels the road, though sometimes it spills back away from the road into residential areas. Most market vendors sell basic goods, such as food, oil, hygiene items, meat/fish, agricultural inputs, clothing, etc.

The official Duala Market consists of three annexes (the main building for the sales of general produce and foodstuffs, the bitter-ball kitchen and the right annex building). There are approximately 433 vendors operating within the official market boundaries. Three sub-markets have developed within the expanded, unofficial boundaries of the Duala Market: the Kuwait Market , managed by LMA under a separate market superintendent; the Saturday Market (also known as Afrindo Shopping Center Market, operated by a private entity; and the Karngar Building, operated by the Governor of the Borough of New Kru Town. It is estimated that between 1,120 to 3,360 vendors operate in these informal areas. The market has grown from an area of 0.017 square kilometers to 0.201 square kilometers – representing 11.8 times increase. This is about the same number of vendors, with almost ten times the space of the Gran Bazaar in Istanbul. Figure 2.13 shows the expanded market layout. This expansion has occurred rapidly, often blurring the lines between market boundaries and management responsibilities.

To operate within the official boundaries, marketeers are charged a daily ticket fee of LDR$20 (US$0.10) issued by the LMA. Daily revenue from ticket fees is estimated at LRD$8,660 (US$44). Outside the market official boundaries, expansion has occurred in private land, thus informal vendors usually pay fees to submarket managers, private property owners, or others. It is estimated that regulating and consolidating unofficial vendors could generate an additional income from ticket sales of to up to LDR$67,200 (US$338) daily.

Despite the economic importance of wholesale markets, some of their main negative externalities relate to impacts on human health and the environment due to unsanitary conditions and inadequate waste management. For example, a study of wholesale and retail food markets in Dhaka found that ruminant and general fecal contamination of produce in markets is common and suggest that unhygienic conditions in markets are a key cause of post-harvest fecal contamination of produce (Harris et al., 2017). Similarly, a study in Nigeria found contamination of tomatoes with coliforms and Escherichia coli in markets, and urged the adoption of food safety practices on farms, during transport, and in markets (Shenge, 2015). In Hanoi, the pollution caused by rotten products and wastewater has become alarming at the surroundings of Long Bien Market, the biggest wholesale market in the city, has become alarming.

The Duala Market faces significant challenges that contribute to increasing pollution and threats to human health, including rising levels of waste, lack of infrastructure and sanitary facilities, food waste and congestion. To better understand the links between these issues and their effects on the performance of the market, and through that on the competitiveness of the city, the Humanitarian OpenStreetMap Team (HOT) and iLab Liberia, in collaboration with the World Bank led the Open Mapping for Productivity and Pollution Impacts in Duala Market Project. From October 2019 through February 2020, a series of data collection activities were conducted, focusing on four topics of interest on the Duala Market: geographic layout and infrastructure, economic activity, solid waste, and traffic. Box 2.2 summarizes the methodology for data collection.

FIGURE 2.13: DUALA MARKET LAYOUT

Source: Humanitarian OpenstreetMap, 2020

BOX 2.2:
METHODOLOGY FOR DATA COLLECTION

This study is based on primary geospatial, qualitative, and quantitative data collection conducted over a five-month timeframe in Monrovia, Liberia. Data collection activities included:

- Participatory Mapping/Ground Truthing: to capture the official and unofficial boundaries of the market with key officials and stakeholders.
- Focus Group Discussions (FGDs): A series of four FGDs were held with multiple stakeholder groups to gather qualitative information on the structure and interactions between market actors, vendors, and understanding of market conditions as well as potential improvements.
- Infrastructure & Services Mapping: A geospatial survey was conducted using OpenMapKit (OMK) to capture the market infrastructure, activity distribution, and features such as businesses, solid waste sites, and drainage, based on the area determined through participatory mapping. This data was uploaded to OpenStreetMap following data capture and cleaning.
- Vendor & Market Products Survey: Using OpenDataKit (ODK), information was collected from market vendors on products sold including average pricing, customer demographics, estimated food loss, and productivity loss due to illness.
- Flow Observations: A series of four survey activities were conducted using ODK to gather a baseline understanding of how people, goods, and waste move through the market ecosystem. These surveys included product delivery, traffic monitoring, parking, and waste movement.

Triangulation of data collection tools, approaches, and analysis facilitated a deeper understanding of the dynamics within Duala Market and those impacting it.

Source: Humanitarian OpenStreetMap, 2020.

MANAGEMENT OF POLLUTION VECTORS IN THE DUALA MARKET

Four main pollution vectors have been identified that limit the productivity and competitiveness of the Duala Market, while posing significant health risks. The pollution vectors are: (i) the poor management of solid waste, (ii) unsuitable water and sanitation infrastructure, (iii) food waste – also linked to poor SWM – and (iv) traffic and congestion. These are explained in the following section.

Solid waste management

SWM is one of the biggest issues in the market. Perishable products, charcoal and plastic generated from the dry goods are major contributors to the large amounts of solid waste generated at the Duala Market. There is only one designated waste site within the original boundaries of the market, which means that waste is disposed consistently along the roadsides, namely along the UN Drive. The intention of this site is to collect the market waste into one location; however, the size of the site and infrequency of removal is inadequate given the waste generated. The Monrovia City Corporation (MCC) and Community-Based Enterprises (CBEs) teams are meant to work together to collect the market's waste, but due to organizational conflicts and lack of clear responsibilities, MCC is often the only daily waste collection presence. Outside the official market area there are 6 waste sites. All of these sites exist where built up zones meet swampland area, creating potential for pollution and health issues.

Water and sanitation infrastructure

The water, sanitation, and hygiene infrastructure in the Duala Market is extremely precarious, causing contamination and health issues, while limiting the economic activity of the market. In terms of water points, there are two operational private points within the official market grounds. Both boreholes are identified as being not safe for drinking. These water points are within close proximity of toilets and the solid waste dumping site. One water point is located where swampland area meets the market, increasing likelihood of contamination. Outside the official market boundaries, there are 17 water points. All but one is operational, and they are all managed by different entities including religious institutions, government, and private owners. Lastly, there are three toilet facilities within the official market which are all 'pay-per-use.' Toilet quality and access was specifically identified as one of the key challenges to the market operations. Outside the official market boundaries there are 12 toilet facilities, of which only three are public and free to use, while the rest are privately operated. Many of these toilets are located within close proximity to nearby swamps. As there is no proper sewer system, these toilets create significant issues with respect to pollution despite efforts to keep them clean. Additionally, due to their proximity to the swamps, many of these toilets are not easily accessible during the rainy season.

The drainage network within the expanded market area is completely fragmented and ineffective. The largest contiguous segment of drainage, running along the east side of UN Drive, is 300 meters in length. An additional 88 meters of drainage exist underneath the eastern edge of the main Duala Market building. Drainage structure is inconsistent in material, size, design, and maintenance, with most segments disjointed from outflows. Nearly all channels have no existing outflow or are too blocked by debris to drain. Focus groups identified the drainage network as one of the most significant infrastructure challenges the market faces. Vendors and other stakeholders expressed concerns that the state of the drainage network leaves the entire market area muddy, especially during the rainy season, largely from pools of waste. Hence, customers are now going to nearby markets in Brewerville and Caldwell to avoid the smell and pollution of Duala. Furthermore, children who accompany their parents to sell are known to frequently get ill from malaria, dysentery, and diarrhea from year-round pollution.

Food waste

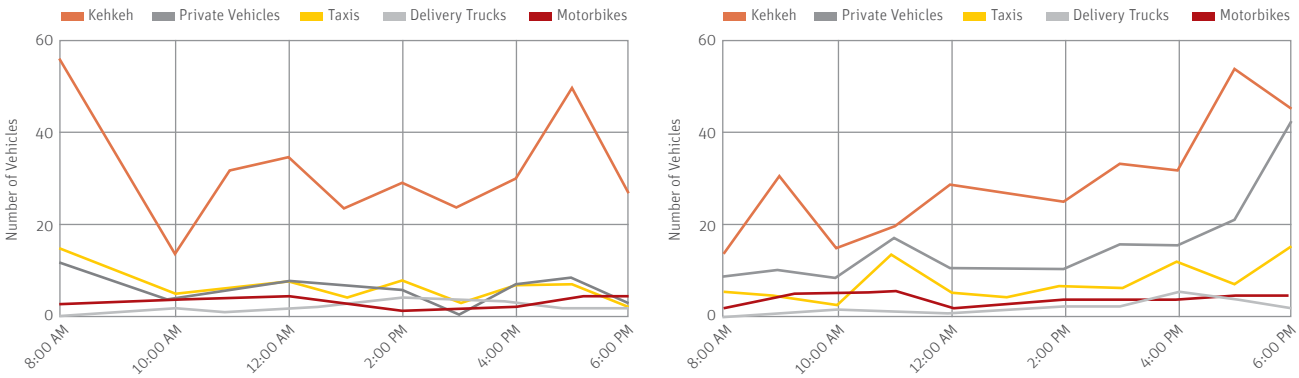
There is a significant food loss and therefore profit losses and increasing waste due to lack of proper storage facilities. Also, limited warehouses reduce the scalability and growth of market activities. For the formal Duala Market, most storage facilities are made of metal while a few are of concrete. These facilities only store "dry goods" such as textiles, electronics and non-perishable goods because they lack of cooling systems, electricity, and the equipment necessary to handle frozen or perishable goods. Of the three informal markets currently forming the expanded Duala Market, there is not a single cold storage warehouse facility. What is available are a few ice boxes operated by individuals for the storing of perishable goods or fresh produce and these facilities are found only around the original Duala Market building. Therefore, vendors from the other expanded market areas take their perishable or fresh produce to these facilities (ice boxes) which are not secure or large enough. Given the limited number of ice boxes available and stable power, many goods are prone to get damaged daily.

Based on surveys of products sales, waste and storage rations, 51 percent of fruit and vegetable products are sold by close of business on an average day. For the unsold product, 43 percent is stored or saved, and 6 percent of product is wasted in some form. The next day, approximately 9 percent of the stored category is wasted. On average, $291 LRD are lost per vendor from stored food, accounting for 8.8 percent of potential gross profit. For meat products, vendors indicated that the majority (65 percent) is sold by close of the business day. 2 percent of product was reported as being wasted in some form over the course of the business day, and the remaining 33 percent of unsold product being stored or saved. As with the fruits and vegetables, the next day, approximately 9 percent of the stored category is wasted. The average meat vendor loses $176 LRD per day due to storage product loss, accounting for 9.1 percent of potential gross profit.

Traffic and congestion

Persistent traffic congestion within the perimeter of the market, as well as high traffic and road network issues in the surrounding area, impact the potential for sales and the ability to move product, therefore inhibiting the productivity of the market. Through traffic surveys, two stretches of the road network surrounding Duala Market were identified as having the heaviest vehicular congestion causing regular traffic jams. These sections are south-bound from north of Saturday Market to Kuwait Market, and northbound from south of Caldwell Road to the original market boundaries at the main Duala Market Building. Overall, the busiest times of day with the highest total vehicle counts were around 8 am and 6 pm (see Figure 2.14). While kehkehs or three-wheel motor vehicles had the most significant presence, their small size allows for a higher number to share the road at a single time. Rather it is the presence of taxis and private vehicles appear to contribute to more significant traffic jams.

FIGURE 2.14: HOURLY VEHICLE COUNT



Source: Humanitarian OpenstreetMap, 2020

BOX 2.3:
MAIN STAKEHOLDER AND THEIR RESPONSIBILITIES

- The Liberia Marketing Association's (LMA) role is to coordinate the activities of all markets within Liberia in a structural and orderly manner. LMA operates all facilities within the original market boundaries. LMA collaborates with MCC in the implementation of waste collection and disposal.
- Monrovia City Corporation (MCC) is responsible for environmental management including sanitation primarily in the form of beautification, street cleaning, and solid waste collection and disposal. Within the market, it is responsible for structuring the implementation of solid waste management.
- The Borough of New KRU Town has jurisdiction over the area within the expanded market boundaries and authority over one of the buildings within Duala Market. It works in collaboration with the MCC, the LMA, and other actors responsible for collection of garbage from designated sites.
- Duala Brothers Association (DBA) consists of several businesses operating warehouses in Duala Market and its expanded areas.
- The Federation of Petty Traders (FEPTIWUL) is responsible for regulating the activities of the Petty Traders and coordinating with other partners in adhering to the activities of Petty Traders.
- Afrindo Shopping Center/Saturday Market is a private market within the expanded boundaries popular for its sales of vegetables and fruits as well as offloading of the trucks that usually bring in produce.
- Community Based Enterprises (CBEs) have licenses for the collection of waste at the community level and carry waste to MCC scape-buckets or other designated sites.
- Small Medium Enterprises (SMEs) and the National Association of Community Based Enterprise (NACOBE) manage cars/mini-trucks collecting waste from businesses or other entities for disposal at Wein Town landfill and other large disposal sites.
- Liberian National Police (LNP) is the recognized institution responsible for regulating traffic in and around the Duala Market.
- The Federation of Road Transport Union provides support to LNP in managing traffic due to understaffing.

Source: Humanitarian OpenStreetMap, 2020

Most of the merchandise is transported by taxies or delivery trucks. There are no designated spots for unloading, so vehicles stop haphazardly in the road to unload generating substantial traffic. On average, a taxi spends 18 minutes unloading on UN Drive. Most taxis come from Bomi County and spend on average 2 hours travelling to the market. On the other hand, delivery trucks spend approximately 69 minutes unloading on UN Drive. The majority of trucks travel for one hour, originating from mostly Central Monrovia (35 percent), Clara Town (31 percent), or Logan Town (15 percent).

With a lack of sidewalks and vendors selling into the roadway, pedestrian traffic congests not only congestion within the market itself, but the roadway as well. Pedestrians were observed in highest concentrations between 12 and 1 pm at both the Duala Market and the Sunday Market.

THE ROLE OF INSTITUTIONS

The issues faced by the Duala Market are reflection of the institutional challenges present at the national and city level in terms of managing pollution and environmental protection. While a set of laws and regulations exist, lack of enforcement, overlapping mandates and limited resources undermine their effectiveness. Liberia's environmental laws are based on article 71 of the 1986 Constitution which advocates for the participation of all Liberians in the protection and management of the environment and natural resources. The main legislation is the National Environmental Policy (2003), which seeks to ensure the improvements of Liberia's physical environment, quality of life, and coordination between economic development and sustainable growth. Additionally, the Environmental Protection Agency Act and the Environmental Protection and Management Law (also approved in 2003), created the Environmental Protection Agency (EPA), the main national level agency responsible for environmental management. Setting up national guidelines for solid waste management, establishing environmental quality standards and ensuring compliance with pollution control are among its main responsibilities.

At the national level, there are several agencies with mandates relating SWM, water and sanitation

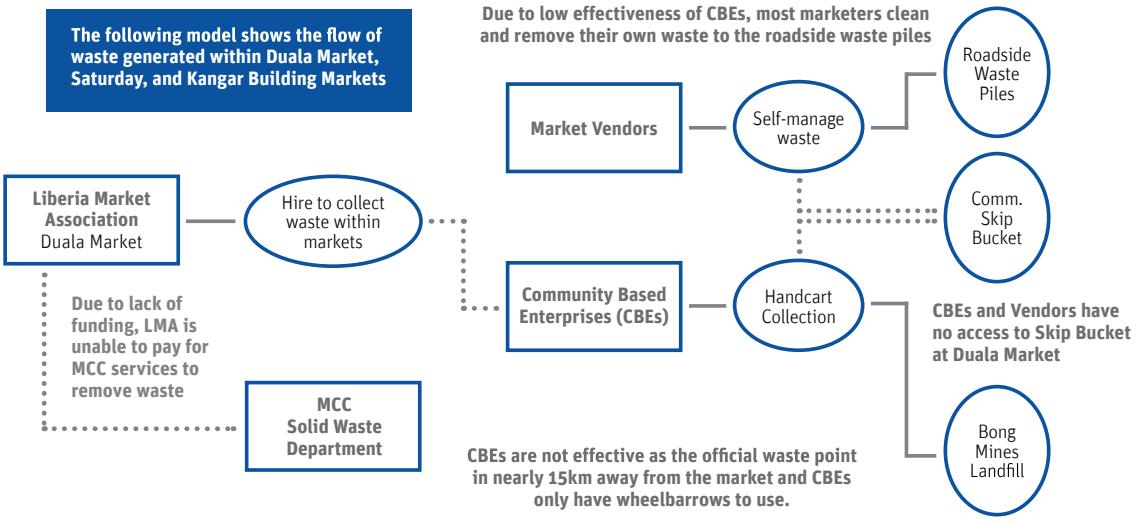
and traffic management. The Ministry of Public Works (MPW) is responsible for infrastructure development. It has a role in in traffic management and the construction of roads and drains as it is responsible for road network development and maintenance. The Liberia Water and Sewer Corporation (LWSC) is responsible for water supply and sanitation services. The Liberia National Police (LNA) is responsible for regulating road traffic. Most of these institutions struggle to fulfil their mandates and provide services more efficiently, due to lack of resources and clear targets. The 2014 Ebola crisis further affected revenues of these organizations as many businesses were closed. Many of these institutions are working with domestic and donor funding to improve their capacity and reach.

For example, in spite of institutional reforms, funding for water and sanitation has remained inadequate. While annual needs were estimated at US$110 million in 2014, funding for the sector is currently around US$25 million (GoL 2013). Hence, the total network length is only 231 km, spreads to less than 50 percent of the Greater Monrovia area, and reaches only approximately 6,400 households. This represents barely three percent of the population of Monrovia, with only five percent more accessing piped water through public standpipes.

At the local level, the MCC is the governing body of the Greater Monrovia District, overseeing the execution of municipal functions. The issues are similar to the national level as there is lack of clear responsibilities among key stakeholders and limited resources to fulfil them. For example, in terms of SWM, the MCC has the mandate to collect the trash in the city, however within perimeter of Duala Market, responsibilities get blurred. The LMA is required to collaborate with MCC in implementation of solid waste collection and disposal. For waste generated within the market, LMA contracts CBEs to collect waste from within the market. These CBE workers use handcarts to collect and transport waste from Duala Market to the Bong Mines landfill, nearly 1.5 km from Duala Market. But given these distance, time, and volume restrictions, it is extremely difficult for CBEs to make a profit. As a result, most marketers clean their own spots, tables, or shops - bringing waste to the roadside. Once at this point, the waste falls within the perimeter that MCC is responsible for cleaning. Box 2.3 provides a list of the public and private stakeholders involved in the market management, including SWM.

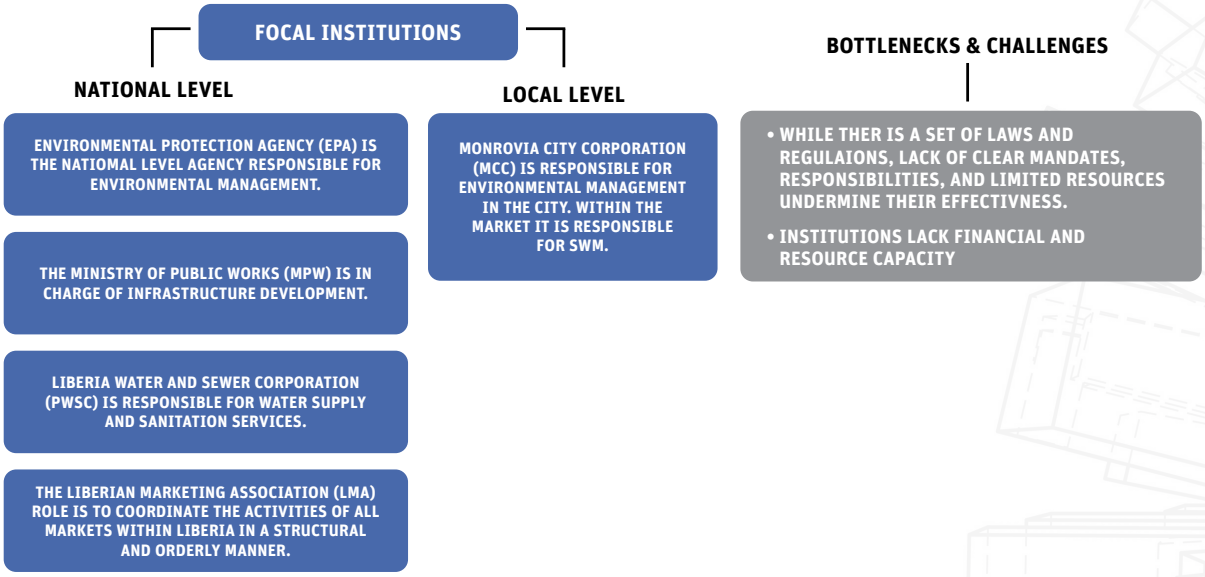
Managing and collecting waste piles along UN Drive (from Caldwell Junction to Club Breweries) are the responsibility of the MCC Solid Waste Department, which provides licenses to various CBEs to collect roadside waste using handcarts. But similar to the challenges faced by CBEs hired by LMA, roadside collection CBEs are also not allowed to use the dumpsters and must transport all waste by foot to the Bong Mines Landfill, which is 1.5 km away. In order to fill the gap in waste collection, the private sector has stepped in and round market have directly hired SMEs, CBEs, NACOMBE and other private entities to manage their waste. Waste is collected using cars and mini trucks to be transported to the Wein Town Landfill, and these private entities pay license fees and registration to MCC on an annual basis for operation. Figure 2.15 provides a graphic representation of the Duala Market waste collection process.

FIGURE 2.15: DUALA MARKET WASTE COLLECTION PROCESS



Due to its history of instability and conflict, Liberia's institutions are one of the weakest in the world. In terms of pollution management and environmental protection, there are laws and regulations in place, however enforcement and implementation are very weak. The institutional setup and main bottlenecks and challenges are summarized in Figure 2.16. The main institutional challenges center around lack of technical capacity and financial resources from the various organizations to fulfil their mandates. Furthermore, there is an overlap and imprecise division of responsibilities between the various public authorities. For example, on one hand the EPA and the municipalities have a monitoring role with regards to solid waste, and on the other hand the MLME and the MPW have their respective responsibilities for preparing engineered landfill sites, although in practice, these are actually being constructed and managed by the MCC.

FIGURE 2.16: INSTITUTIONAL SETUP AND MAIN CHALLENGES FOR POLLUTION MANAGEMENT IN MONROVIA



Source: Humanitarian OpenstreetMap, 2020

CONCLUSIONS

Monrovia has experienced a high population growth in the last decades as more and more people have migrated from rural to urban centers. While it concentrates most of the country's economic activity and employment, they city faces many challenges, including high levels of pollution that inhibit its productivity and livability. Further, the institutions at the national and local level have limited financial and human capacity to respond to the growing needs of the population, thus undermining its competitiveness.

The Duala Market, one of the city's key economic zones, is a reflection of the pollution and waste problems in the city. The results of the mapping and data collection analysis identify four main vectors of pollution: (i) the poor management of solid waste, (ii) unsuitable water and sanitation infrastructure, (iii) food waste, and (iv) traffic and congestion. The challenges faced by the market and the vendors rapidly increasing as the market continues to expand beyond its official borders and there is weak institutional capacities and infrastructures to address the issues.

As such, clarity over organization, management, and jurisdiction of responsibilities between market actors is absolutely critical moving ahead and should be prioritized in efficient functioning of market and for reduced pollution. Administrative coordination amongst varied management actors is needed to better arrange commodities and to increase facilities for a more structured market. There is a need to divide up these formal and informal markets by product to reduce conflict between vendors, regulate pricing, improve efficiency of customer traffic, and to improve waste management. This will reduce congestion and help with the handling of waste.

[58] Liberia currently classifies of settlements of 2000 people as urban, without requiring any additional validation that would confirm urban characteristics like physical or economic infrastructure, or density. Under the draft Local Government Act, a new classification is being proposed that would define settlements of more than 25,000 as cities, and settlements of 10,000 people as townships.

[59] One note of caution here is that these estimates are based on the WDI and the recent SCD (2017). They were identified as a likely overestimate of the total population of Liberia (see Technical Note on the HIES 2016) and will be corrected during the implementation of this ASA.

[60] During the First Liberian Civil War, between 1989 and 1997, Monrovia's safety conditions attracted a huge migration.

[61] Case Study: Urban growth in Liberia's only metropolis: Monrovia. West Africa: Land use and Land Cover dynamics. https://eros.usgs.gov/westafrica/case-study/urban-growth-liberias-only-metropolis-monrovia. Accessed on May 22, 2019

[62] Liberia: Spatial Analysis of Transport Connectivity and Growth Potential, 2017

[63] An estimated 69 percent of Liberian women are self-employed, compared to 56 percent of men. Roughly 34 percent of formal SMEs are owned by women, but most female entrepreneurs work informally and in low-productivity sectors such as retail and trade. In 2010, about 75 percent of female workforce was employed informally versus 61 percent of the male workforce. Wholesale and retail trade, the country's second-largest contributor to total employment after agriculture, employs 35 percent of the female workforce, compared to just 15 percent of the male workforce (International Finance Corporation. 2013 "Striving for Business Success: Voices of Liberian Women Entrepreneurs").

[64] WFP, October 2010, Comprehensive Food Security and Nutrition Survey 2010.

[65] Liberia's 2010 Labor Force Survey.

[66] World Bank, 2012, Poverty and the Policy Response to the Economic Crisis in Liberia.

[67] Established with the purpose of providing better marketing facilities and lending practices, the LMA is a nationwide organization with branches in each of the country's 15 counties.

[68] The Kuwait Market which previously had a market building a few years ago was demolished for safety reasons due to the old structure back in 2017. All vendors of the Kuwait market sell outdoor and along the streets.

[69] Liberia's GDP per capita (current US$) is $677,3 (2018).

[70] LMA also charges a one-time fee to traders to register them as part of the association.

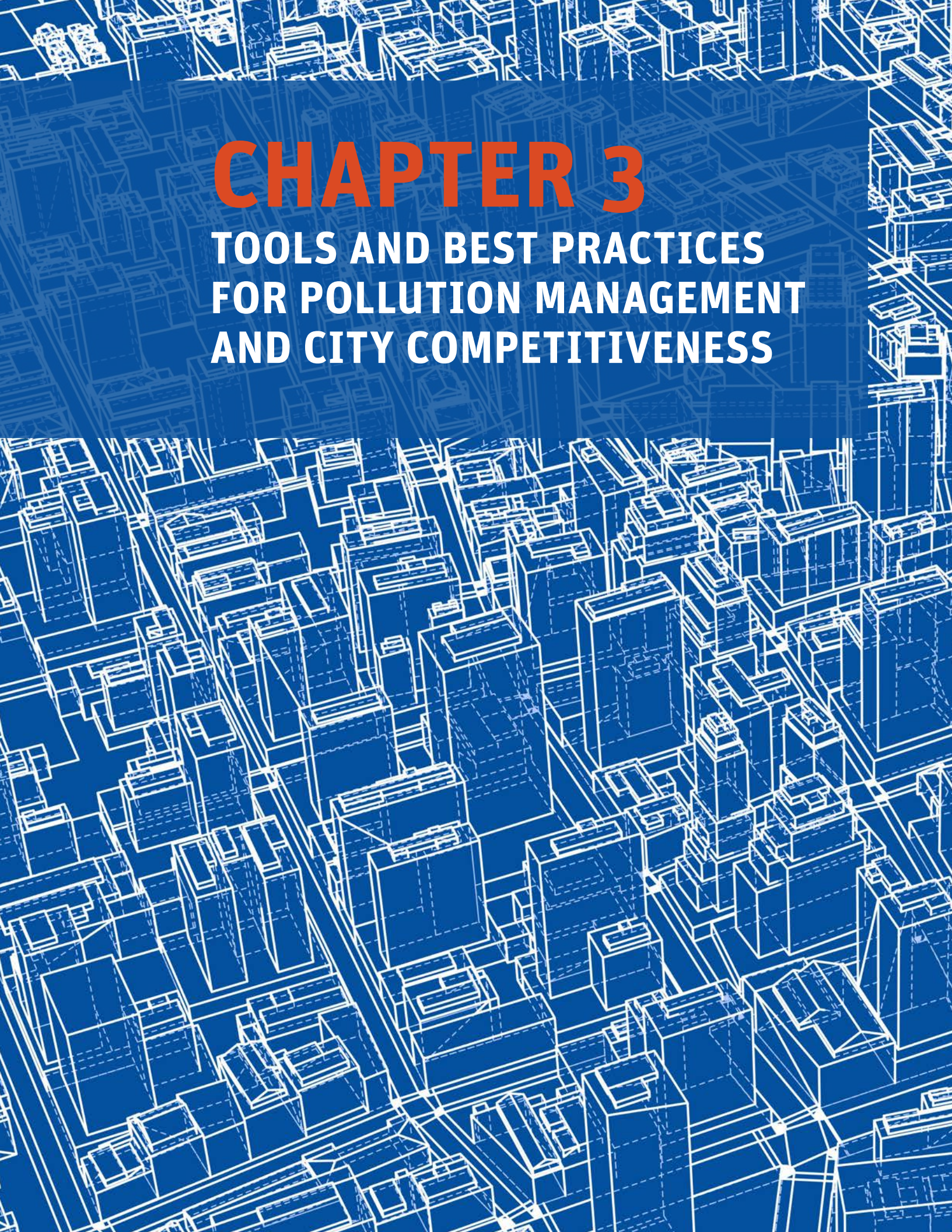
[71] https://tuoitrenews.vn/news/society/20191112/hanois-air-pollution-reaches-worst-level-since-yearstart/51849.html

[72] 287 vendors were surveyed for product sales, waste, and storage ratios, providing product information for 440 items across 42 fruit and vegetable types. 116 of those vendors reported selling meat products, providing information for 7 product types.

[73] The only community skip bucket present in both the original and expanded market boundaries is located within the original market boundaries behind the Duala Market building. This skip bucket is not available for market vendor or customer use - anyone found dumping waste from the market in the community skip bucket is fined $50 USD.

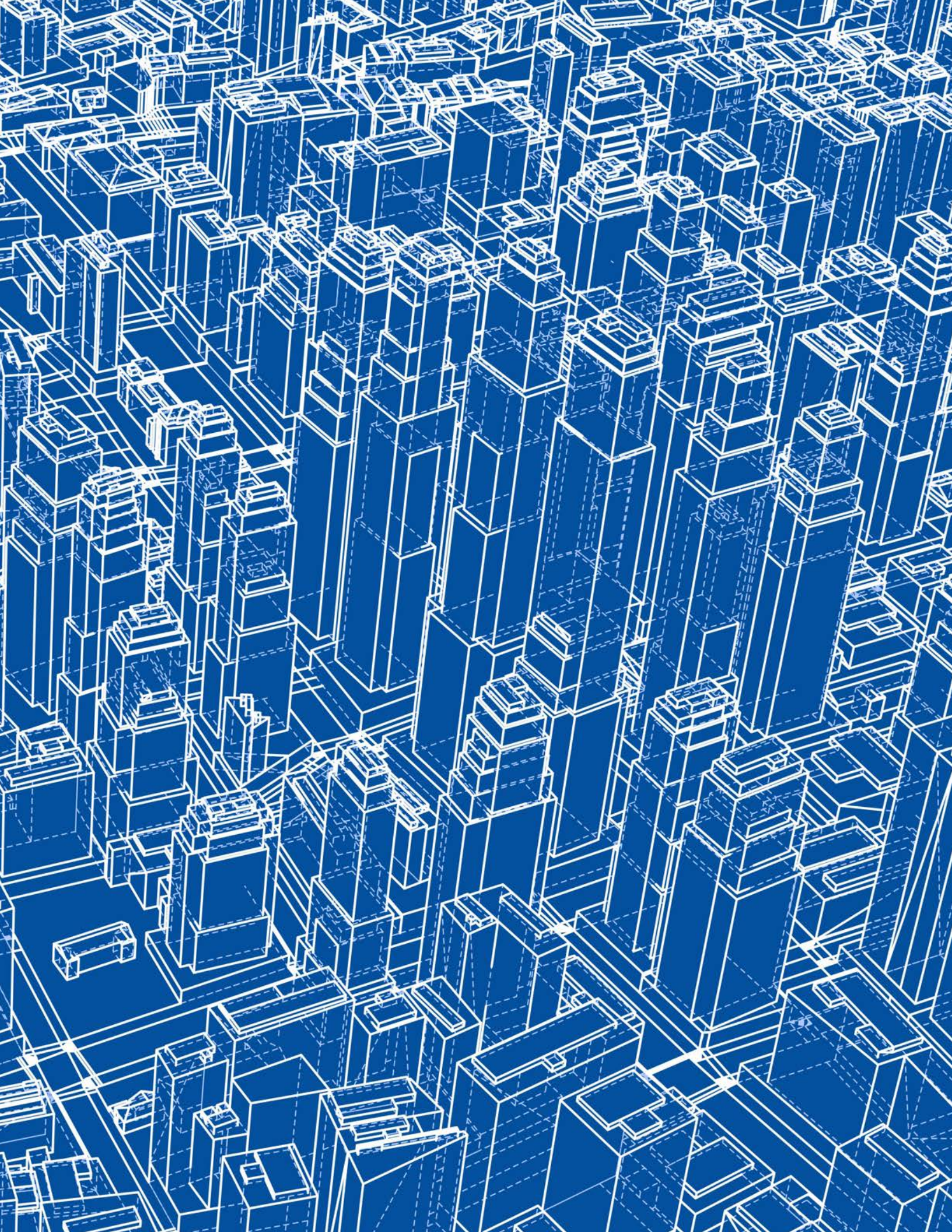
Liberia City Scape: Broad Street - Photo by Besspher - Adobe Stock


Visuals
BECHE KOKO VISUALS



CHAPTER 3

TOOLS AND BEST PRACTICES FOR POLLUTION MANAGEMENT AND CITY COMPETITIVENESS



As evidenced in the empirical analysis and the city case studies, pollution in all its different forms can greatly harm cities' competitiveness. Results from Kampala and Dhaka show how air pollution can impede the productivity of firms and workers alike. In Zanzibar, water and ocean pollution are affecting the tourism industry, an important pillar of the economy, and lastly in Monrovia, poor management of waste in the Duala Market, one the key economic zones in the city, is undermining the market's performance. As such, managing pollution is crucial for cities. It is important for policy makers to understand where its dangers lie and how to take action to prevent, manage, and reverse it when possible. Developing a successful and comprehensive pollution management strategy can improve city competitiveness, and through that lead to economic benefits by increasing job creation, attracting investments, reducing travel times and costs, and increasing economic activities such as tourism.

The objective of this chapter is to provide city officials with tools and best practices for pollution management and city competitiveness. It does so through a two phased approach. First, it provides a reflection on the main institutional gaps identified in the four case study cities. The analysis uses Kampala, Dhaka, Zanzibar, and Monrovia, as the issues seen in these cities are experienced by many other fast-developing cities. The gaps are grouped in three categories: (i) regulatory framework gaps, (ii) human and financial capacity gaps, and (iii) coordination gaps. The focus on these three areas stems from the City Competitiveness Framework (World Bank, 2016), as these are identified as key principles that need to be addressed to make cities more competitive. Second, a series of selected international best practices is put forward using the Competitive Cities Framework. The best practices feature three types of cases: cities that have enhanced their competitiveness through the implementation of environmental programs as part of a wider green economy strategy; cities where environmental programs began as sectoral approaches but have been the catalyzers of ambitious green economy strategies; and cities that have implemented smaller sectoral programs but that have nonetheless been effective in enhancing competitiveness. These best practices can help policy makers design better strategies in their own cities. The selection of these best practices cities tries to go beyond the usual benchmarked examples of successful cities, such as London and Paris, and focuses on "less known" examples of cities that successfully managed pollution while building their competitiveness. Examining these examples can contribute more effectively to filling the knowledge gap and give a new perspective on how cities can tackle pollution challenges and thrive.

INSTITUTIONAL ASSESSMENT GAP ANALYSIS

The institutional assessments of the city case studies evaluate the legislative framework and institutional setup of the cities to manage pollution, specifically as it relates to which ever pollution vector impacts the productivity of the sector analyzed the most. While all four cities have shown progress in implementing regulations and managing pollution, much more needs to be done to arrest the stark effects of pollution and environmental degradation on competitiveness and overall livability. The gaps observed in Kampala, Dhaka, Zanzibar, and Monrovia are analyzed in three categories: regulations, capacities, and coordination.

Analysis of the regulatory framework gap captures the adequacy of key environmental policies, regulations, and standards that govern the institutional setup in charge of managing the identified vector of pollution, while also assessing its enforcement capacity, accountability, and transparency. The human and financial capacity gaps gauge the availability of skilled, effective staff, their scientific and technical knowledge and capacity, the availability of modern and appropriate technologies, and access to financial resources with equitable allocation. Lastly, the coordination gap evaluates how well-defined roles and responsibilities are among national and local players for environmental and pollution management. This includes clear mandates among national institutions, government authorities, and urban development and planning authorities; it also entails coordination with civil society. Table 3.1 summarizes the pressing points highlighted by the gap analysis for each one of the case study cities.

TABLE 3.1: GAP ANALYSIS

	KAMPALA (air pollution)	DHAKA (air pollution)	ZANZIBAR (water and ocean pollution)	MONROVIA (waste pollution)
REGULATORY FRAMEWORK	• There is lack of a specific legislation focusing on controlling air pollution and promoting clean air programs. • Legal framework for managing urban air quality is fragmented and relies on a patchwork of different laws, making enforcement very difficult.	• Key legislation takes time to be approved or modified (e.g. the Bangladesh Clean Air Act). • The environmental clearance process lacks transparency as there is no requirement for local consultation or disclosure of information.	• While there is an established institutional and legal framework for environmental and waste management, there is lack of enforcement.	• Laws and regulations have been formulated to address environmental issues, however there is lack of enforcement. • There is an absence of comprehensive waste recycling and reuse programs.
CAPACITY GAP	• There are few stations for air quality monitoring at the national level, which in turn results in lack of air pollution data and emissions inventory. • There is limited local research and training capacity on air pollution.	• The Department of Environment (DoE) lacks staffing to perform its core functions and growing responsibilities. Staffing needs are particularly acute at the divisional and district levels. • The DoE lacks a comprehensive management system and database to enforce environmental legislation. • There is no system to consistently collect pollution fines.	• At the local level there is insufficient financial and human capacity for service delivery.	• The Monrovia City Corporation (MCC) has extremely limited resources to effectively fulfil its mandate. It faces shortages in human and financial resources to operate a viable SWM system. In the Duala Market, the unclear regulatory framework means that the MCC does not get remunerated by the LMA, which is supposed to manage the market on its behalf and pay MCC a fee. • Technical expertise at various ministries, including the Environmental Protection Agency (EPA) is relatively low. The same situation is observed at the local level with municipalities. • There is lack of equipment for waste collection (e.g. tipper trucks).
COORDINATION GAP	• There is inadequate guidance on air quality management at national and local level. The KCCA receives no national level direction on monitoring and management of air quality. • There is lack of integration and mainstreaming of air quality issues in national development plans. Land use and transport planning programs barely consider the issue of air pollution.	• The DoE does not publicly disclose environmental monitoring information from industries or development projects, or compliance records, including fines or compensation levied for violations and damages. • Public awareness of environmental issues is limited, which makes it difficult to hold the system accountable.	• There is overlapping in jurisdictions and lack of institutional coordination as the responsibilities of environmental governance and waste management cut across different level of governments and different sectoral institutions. • A disconnect between supply and demand of basic services and infrastructure investment prevents the government from addressing the development control and environmental management challenges effectively. • There is lack of public awareness and community sensitization.	• There is overlap and vague division of responsibilities between the various public authorities for waste collection, which is especially evident around the market area. • There is partial coordination among government agencies, donors, non-governmental organizations (NGOs), and the private sector in the implementation of programs and initiatives.

As seen in the table above, despite the very different country contexts and the varied pollution challenges, some common issues in terms of city level pollution and environmental management emerge. In all cases, sectoral policies are limited, and enforcement of existing policies and regulations is deficient. Many of the key institutions also face very serious capacity limitations due to inability to recruit the right personnel with the necessary skills, as well as inadequate funding. Additionally, there is lack of coordination among stakeholders at the local and national levels; the same is true of other key sectors like urban and land use planning, and key stakeholders like civil society. Beyond these three gaps, financing for pollution management is often a key bottleneck for policymakers.

Finding solutions to these challenges is not always straightforward. But around the world, examples can be found of cities that have been able to strengthen competitiveness while managing pollution and minimizing its negative effect on quality of life and productivity. The following section presents a review of the experiences of several cities, and extracts lessons that cities in the developing world could consider as they build their strategies to strengthen competitiveness while managing pollution.

BEST PRACTICES USING THE COMPETITIVE CITIES FRAMEWORK

There are different ways in which cities implement pollution control and environmental protection programs. This section presents best practices of cities that have developed different programs with the same goal: to improve pollution while enhancing competitiveness. They all have positive effects on the economy, not only due to the estimated health benefits they bring, but also because they can provide new job opportunities, attract companies, foster innovation and enhance industry efficiency.

In all successful cases, cities have strengthened regulations and enforcement, built strong institutions and local capacity for implementation of regulations and management of pollution, and fostered coordination across sectors to ensure that complementary policies to pollution management are in place. First, cities that have managed to manage pollution while strengthening competitiveness have further developed and reinforced a range of complementary policies along three lines: pollution management, environmental protection and urban development, as well enabled a system for effective enforcement. Second, they have invested in much-needed human capital and found ways to crowd in resources for the protection of the environment, coordinating actions between national and local governments. Third, successful cities have clarified roles and responsibilities and improved coordination with different stakeholders including civil society and the private sector. To bring in different stakeholders and leverage their strength, cities have invested in transparent information systems that raise awareness of environmental issues and engage citizens in preventive and protective actions.

The selection of cases was done with the aim of having a broad coverage of pollution challenges and regions to initiate a discussion of effective strategies for the two-prong challenge discussed in this report. Each city is different in its economic landscape, pollution concerns, and institutional arrangements. However, the cases here presented demonstrate how political will, joint efforts between public and private actors, transparent dialogue with citizens, and constant interaction with other tiers of government are indispensable to the implementation of successful processes.

The cases also incorporate cities with different income levels and across various regions. As such, 7 cities were selected:

1. Copenhagen, Denmark, for transport and air pollution management
2. Vancouver, Canada, for transport and air pollution management
3. Kawasaki, Japan, for industrial air pollution
4. Muangklang, Thailand, for waste management
5. Baku, Azerbaijan, for waste management and hazardous waste management
6. Kitakyushu, Japan, as a Sustainable City
7. Sao Paulo, Brazil, as an interesting case of a megacity that still struggles with severe air pollution

TABLE 3.2 BELOW SUMMARIZES THE MAIN LESSONS FROM THE BEST PRACTICE CASES. ADDITIONAL DETAILS ARE PROVIDING IN THE COMING SECTIONS.

CITY	POLLUTION CHALLENGE	LEVERAGING ITS WEDGE	INSTITUTIONS & REGULATIONS	INFRASTRUCTURE & LAND	SKILLS & INNOVATION	ENTERPRISE SUPPORT & FINANCE
Copenhagen, Denmark	Air pollution from fuel combustion of vehicles (high NO_2 levels)	City wedge: large and effective public sector. The city has worked in the design and implementation of regulations, economic incentives and agreements with the private industry, in collaboration with local governments. Stakeholders' engagement wedge: place public-private partnership at the core of its strategy Intergovernmental relations wedge: strong collaboration with the central government and other municipalities	- Low Emission Zone since 2008 - Attractive and Clean Transport System: goal to have a bus fleet composed by electric, hybrid and biogas buses by 2025 - Promotion of electric vehicles: all cars bought in the city since 2010 are electric - Parking strategy: reduction of 6 percent in traffic due to increasing parking fees for non-residents	- Construction of a bike-friendly and walkable city - Integrated transport system to optimize the use of urban space - Intelligent transport system to improve traffic flow	Climate Action Plan that puts innovation at the center by greatly investing in energy efficiency, renewable energy, and green mobility.	- Car sharing program
Vancouver, Canada	Air pollution	City wedge: active political interest since 1971, establishing a single regulatory agency for air pollution control and having clear goals. Stakeholders' engagement wedge: clear effort to engage with private stakeholders Intergovernmental relations wedge: strong coordination between private actors, municipalities and different government branches; integration of plans among different governmental levels	- Emission inspection program aimed at reducing carbon emissions from old cars at the Metropolitan Level - Aim to deliver 100 percent of its energy from renewable sources before 2050	- Installation of 111 charging stations in 2015 - Investments in safe-cycling infrastructure - Purchase of a corridor to create a greenway that allows separated walking and biking spaces		

CITY	POLLUTION CHALLENGE	LEVERAGING ITS WEDGE	INSTITUTIONS & REGULATIONS	INFRASTRUCTURE & LAND	SKILLS & INNOVATION	ENTERPRISE SUPPORT & FINANCE
Kawasaki, Japan	Air Pollution from industrial activity	City wedge: use of the administrative and legislative capacity to set a robust system (soft and strong measures) for protection of air quality and economic growth Stakeholders' engagement wedge: agreements made between the local government and industry (almost 50 companies) to establish air pollution prevention measures Intergovernmental relations wedge: regulations enacted at the national level that complemented the actions taken at the city level	- Establishing agreements on air pollution prevention with leading industries (1970) - Installation of a robust monitoring system in 1972 - Set limits for emission of pollutants for each facility		- Investment on pollution prevention and training of engineers and technicians	
Muangklang, Thailand	Solid Waste	City wedge: launch a solid waste management program with limited budget, relying on support from private partners and neighboring areas. Stakeholders' engagement wedge: public-private partnership with the market vendors of the municipal market		- Installation of an outdoor conveyor belt for manual segregation of waste (separation of recyclable and non-recyclable materials and organic waste) - Installation of a low-tech incinerator to dispose non-recyclable and non-compostable waste - Construction of a facility to collect and treat organic waste for compost production		
Baku, Azerbaijan	Solid Waste	City wedge: centralized government who established a comprehensive Environmental State Program in 2006 Stakeholders' engagement wedge: the government founded a state-funded company in 2008 to manage municipal waste disposal Intergovernmental relations wedge: Collaboration between the Central Government and Baku's Municipality remains a pressing issue		- Rehabilitation of Balakhani Landfill - Closure of approximately 80 percent of the informal dump sites - Installation of a Waste Recovery Facility - Installation of a Waste to Energy Facility	- Eco Industrial Park to help entrepreneurs and investors of the recycling industry (provision of infrastructure, support for mechanical processes, etc)	

CITY	POLLUTION CHALLENGE	LEVERAGING ITS WEDGE	INSTITUTIONS & REGULATIONS	INFRASTRUCTURE & LAND	SKILLS & INNOVATION	ENTERPRISE SUPPORT & FINANCE
Kitakyushu, Japan	Air and water pollution from industrial activity	City wedge: use legislative power to establish policies, platforms, and economic measures Stakeholders' engagement wedge: important partnerships with the private sector and cooperation with research institutions	- Installation of a warning system to issue smog alerts - Creation of a new institutional network - Set of specific regulations, platforms, policies, and economic measures - Establishment of national quality standards	- Installation of the Eco-Town Project in 1997 to achieve zero emissions and waste by using all waste and materials in other industrial processes	- The Eco-town project resulted in several innovations in the recycling industry	

AIR POLLUTION MANAGEMENT IN COPENHAGEN, DENMARK

Copenhagen is widely recognized as a green economy leader and as one of the greenest cities in the world. The city of Copenhagen sets a good example of how urban planning benefits both competitiveness and environmental quality. It also demonstrates how a clear city vision, goals, and strong cooperation between stakeholders can improve a city's the economy and air quality at the same time. The following paragraphs highlight the actions taken by the city government that have been key for the success of Copenhagen.

Like several cities in the developed world, Copenhagen's biggest struggle when it comes to air pollution are the emissions released from fuel combustion of vehicles, and although its air quality ranks among the best in Europe, the city still deals with levels of NO2 above the European norm. However, since 2002, air quality in Copenhagen has significantly improved due to a wide range of policies and actions taken by the city government in cooperation with the private sector, citizen organizations, and other municipalities. The main factors in this improvement have been urban planning and green mobility, such as an efficient transport system, promotion of cycling and foot transportation, and the adoption of electric vehicles.

MAYOR'S WEDGE

Copenhagen possess a large and effective public sector that has used all its capacity to implement sound environmental policies and incentives to develop a strong green economy.

The city has designed and implemented regulations, economic incentives, and agreements in conjunction with private industry. Along with the effectiveness of the local government in setting a clear vision and goals, this cooperation has been fundamental in making Copenhagen a competitive and sustainable city.

In 2007, the Copenhagen City Council adopted the "Eco-metropolis Vision". This vision is the foundation of several plans that make Copenhagen one of the greenest cities in the world, such as the Climate Action Plan, the Bicycle Strategy, and the Strategy for Urban Life. The ambitious goal of Copenhagen is to become a Carbon Neutral City by 2025, and every plan, program or project in Copenhagen must be designed and implemented as a contribution to that goal. One of the several ancillary benefits of this is plan is the improvement of air quality in the city (Sharing Copenhagen , 2014), for which the Clean Air Plan (CAP) of 2013 was created. The CAP sets specific actions aimed at reducing air pollution (special focus on PM10).

Part of Denmark's traditional culture is to solve urban challenges through the integration of policies and urban planning. In this regard, the challenge of improving air quality is not addressed only by the

Clean Air Plan but through several other strategies. These include the Climate Action Plan and the 2015 Municipal Plan of Copenhagen (City of Copenhagen, 2015): with an expected population growth of 17 percent between 2015 and 2027, the Municipality is planning to accommodate these new 100,000 people in a dense, smart, and sustainable city able to provide welfare and promote continuous green growth. The plan builds on the traditional Urban Plan of Copenhagen, the so-called Finger Plan (1947). The principles of the Finger Plan, which built the foundations of what Copenhagen is today, were that the distance between housing, jobs, and green areas should be as short as possible and reachable by public transport (City of Copenhagen, 2016).

PUBLIC AND PRIVATE STAKEHOLDERS' ENGAGEMENT WEDGE

One of the most notable features of Copenhagen's approach to becoming a sustainable city and being named the 2014 Green Capital of Europe is that it placed public-private partnership at the core of its strategy. A clear example of this is the formalization of the Copenhagen Solutions Lab, which focuses in creating triple-helix partnerships for smart city projects across all sectors in the city. Some concrete examples are the implementation of projects like the Intelligent Transport System (ITS) Action Plan (explained in detail below), where the administration, in collaboration with universities and private companies, has developed and tested new ITS solutions for the benefit of citizens and users. Another good example is the partnership between the Environmental Protection Agency, Movia (the Public Transport Company), and private actors to reduce old buses' emissions by means of filters and other technologies (see below).

INTERGOVERNMENTAL RELATIONS WEDGE

Copenhagen's strong collaboration with the central government and other municipalities is another crucial element of its success. For instance, on an European Union (EU) level, the City is participating in three projects aiming to promote EVs and develop a common European charging infrastructure, and one project aiming to promote hydrogen cars (City of Copenhagen (b), 2017). Another example is the inter-municipal partnership between the Capital Region of Denmark and 23 municipalities within the region to build cycle superhighways, a net of bike paths between different municipalities (City of Copenhagen, 2016).

COPENHAGEN'S BUCKETS: INSTITUTIONS & REGULATIONS, INFRASTRUCTURE & LAND, AND ENTERPRISE SUPPORT & FINANCE

When it comes to the improvement of air quality, Copenhagen has adopted an approach focused mainly on promoting Green Mobility by implementing a wide range of policies and strategies that mainly involve crafting regulations, incentives, and infrastructure in cooperation with the private sector. The synergy of these actions has driven Copenhagen's success.

INSTITUTIONS AND REGULATIONS

1. Low Emission Zone (LEZ): Since 2008, Copenhagen introduced a Low Emission Zone for heavy goods vehicles. The LEZ applies to all diesel-powered vehicles above 3½ tons. The vehicle must either meet Euro 4 standards (or newer) or be retrofitted with an effective particle filter. The LEZ has been shown to be very effective: from 2008 to 2010, emission from trucks and buses has been reduced by 60 percent. This corresponds to 16 percent of the complete particle emission from all vehicles (City of Copenhagen, 2017). In 2017, the Municipality tighten the LEZ requirements. (City of Copenhagen, 2014).
2. Attractive and Clean Public Transport system: The "Clean Air Plan" aims to reduce emissions of nitrous oxide and particulates by 60 percent. In 2013, it was expected that by 2016 approximately 50 percent of the most polluting buses should have been equipped with filters that reduce nitrous

oxide and particulate emissions by 90-95 percent. The municipality of Copenhagen is working in a development project in cooperation with the Environmental Protection Agency, Movia (the Public Transport Company), and private actors to reduce old buses' emissions by means of filters and other technologies. The goal of the city is to have a bus fleet composed of electric, hybrid, and biogas buses by 2025 (City of Copenhagen). In addition, the city of Copenhagen is continuously expanding the Metro system.

3. Promotion of Electric Vehicles: Copenhagen has aggressively promoted the use of Electric Vehicles (EVs). EVs have been exempted from taxes since 1983. Additionally, the City Council has decided to reserve 500 parking spaces for EVs to set up and operate charging stations for a period of ten years, and it is working on long-term plans to create public infrastructure for EVs. Since 2010, every car bought in Copenhagen has been an electric car, and at the moment, 225 Municipal cars are EVs. As of spring of 2017, 85 percent of the municipality's vehicles are electric, hybrid or hydrogen powered. An important aspect of the promotion of EVs is the cooperation with other municipalities and companies at the national and international level (City of Copenhagen (b), 2017).
4. Parking strategy: The City adopted a parking strategy in which parking fees have increased for non-residents and decreased for residents. The increased pay parking rates have resulted in a fall in car traffic of a 6 percent (City of Copenhagen, 2009).

INFRASTRUCTURE & LAND

1. Construction of a bike-friendly and walkable city: Copenhagen is famous for being the bike-friendliest city in the world. Today, 34 percent of all trips in Copenhagen are made by bicycle (52 percent increase since 2012) and the goal is to be the world's best city for cyclists by, increasing the percentage of commuters who cycle to work and school to 50 percent and reducing cyclists' average travel time by 15 percent. The overall goal is to achieve a traffic composition of maximum 1/3 cars, 1/3 bicycles, and 1/3 public transport (City of Copenhagen). The city has invested in infrastructure and new systems to foster an even greater number of cyclists on the streets of the city. An example is an inter-municipal partnership between the Capital Region of Denmark and 23 municipalities within the region to build cycle superhighways, a net of bike paths between different municipalities. Another example is Bycyklen Copenhagen, the world's first electric smart bike-share system where each bike has a touchscreen tablet which can be used for navigation and payments. The city also works in increasing the parking spaces for bicycles, and path networks (City of Copenhagen, 2016).
2. Integrated Transport System: Interconnected public transportation optimizes the use of urban space in a very effective way. Copenhagen has focused on intermobility to enable a transport system where people and freights can move effectively. People in the city choose between different transport modes and they are no longer viewed individually as a single type of commuter – be it cyclists, pedestrians, drivers, or users of public transportation. An integrated transport system requires sound planning and infrastructure. Copenhagen has invested in building rail stations with great accessibility and easy transfer for both bikes and cars with parking facilities that provide different options of transport for commuters arriving or leaving the station (City of Copenhagen, 2016).
3. ITS: Copenhagen is working on the implementation of a digital system aimed to improve traffic flow. For instance, the intersection controllers of traffic signals on all major roads for bicycles, buses, and cars are being optimized for better traffic management, which decreases emissions of pollutants to the air. Specific bus lines can use GPS to notify the traffic signal of their position so that the signal can prioritize them. A similar system is being established for green waves for cyclists and private vehicles (City of Copenhagen, 2014).

SKILLS AND INNOVATION

Innovation lies at the heart of the Climate Action Plan, which, as mentioned, greatly invests in energy efficiency, renewable energy, and green mobility, all policies directly related to the improvement of air quality. For instance, the Green Mobility Plan of Copenhagen establishes the city as a place where green mobility solutions will be tested in real life, and marks the city as a leader in innovation by supporting the development of electric hydrogen technology through specifications for the procurement of municipal vehicles, by developing traffic signals with green waves of cyclists, and by laying LED lighting in bike paths to warn truck drivers of cyclists (City of Copenhagen (b), 2016).

ENTERPRISE SUPPORT AND FINANCE

1. Car sharing programs: Electric car sharing programs provide a solution for decreasing the city's vehicle fleet. Copenhagen promotes car sharing systems through programs like DriveNow, which is the first electric free-floating car sharing system in the world (City of Copenhagen, 2016). DriveNow is a joint venture between BMW and Sixt AG, and it is a franchise model and operated by Arriva. Arriva received funding together with the Energy Supply Company E.ON from the Capital Region, and the cities of Copenhagen, Frederiksberg, and Tårnby supported the operation by earmarking parking for the service and offering reduced parking fees (City of Copenhagen (b), 2015).

EFFECTS ON COPENHAGEN COMPETITIVENESS

The actions above are some of the most effective that Copenhagen has taken to reduce air pollution. However, they are only a fraction of a broader set of activities aimed to make Copenhagen Carbon Neutral in 2025, and none of them have hindered the city's competitiveness. On the contrary, the city remains one of the most productive cities in Europe, with gross value added exceeding US $83,000 per worker in 2010 (LSECities, 2014).

The green economic success of Copenhagen is attributed to drivers like its urban form, innovation, skills and employment, low carbon, and environmental quality (LSECities, 2014). Copenhagen also leads the world's green-tech market. The 2013 European Cluster Excellence Scoreboard ranked Copenhagen's cleantech industry first in growth in annual revenues, and second in growth in output and profit between 2010 and 2013. On top of that, the Green Growth Council estimated that the number of green growth jobs in the City of Copenhagen Capital Region was approximately 11,000. The Green Growth Council also demonstrated that the green growth sector showed higher productivity rates than the manufacturing and welfare technology sectors between 2003 and 2009 and that exports in the green tech sector grew by 17.6 percent in 2013 (LSECities, 2014).

Some particular economic benefits derived from the actions aimed to improve air quality are related, for instance, to the travel time gains associated with a smart urban planning and integrated transport systems. These travel time gains produce significant cost savings, with journey-to-work time costs in Copenhagen estimated at 3.4 percent of GDP, compared to 5.8 percent of GDP in Stockholm and 8.4 percent of GDP in London (LSECities, 2014). The hours lost due to traffic congestion currently constitute € 0,76 billion per year for the Capital Region (City of Copenhagen, 2014).

The City of Copenhagen estimates that for every kilometer commuted by bike instead of by car, society saves around 1 EUR. It is also estimated that healthier citizens reduce health care costs at an estimated rate of 0.77 EUR per km cycled (City of Copenhagen, 2014).

Green mobility also creates new jobs. It is estimated that up to 435,000 additional jobs might be created if 56 major European cities had the same modal share of cycling as Copenhagen (Carmichael et al., 2017).

AIR POLLUTION MANAGEMENT IN VANCOUVER, CANADA

Vancouver is a great example of a city successfully managing air pollution while growing in competitiveness in the context of a metropolitan area. The city has been ranked second in the U.S. and Canada in the Green City Index, commissioned by Siemens. Within this index, the city ranks first in Air Quality due to its excellent performance in meeting all the quality standards for all pollutants excepting O3, levels of which are greatly influenced by the use of fossil fuels at the global level (metrovancouver, 2014).

Vancouver aims to be the world's greenest city in 2020 and to have the purest air. One of the most outstanding measures the city has taken towards its goal is the promotion of green mobility, where Electric Vehicles and the installation of charging stations and rebates for their purchase have greatly contributed to air quality improvement. This measure and others implemented by the city are explained in greater detail below.

Vancouver's ambitious environmental goals haven't prevented it from becoming a competitive city. According to the Vancouver's Economic Commission, Vancouver is the 3rd most livable city in the world, the 3rd greenest city in the world, and the top startup ecosystem in Canada.

MAYOR'S WEDGE

Vancouver has demonstrated concern and active political interest in preserving good air quality since 1971, when the Greater Vancouver Regional District (GVRS), the single regulatory agency for air pollution control, was established.

Several actions have been taken since the GVRS was created. The most recent and ambitious plan was launched in 2011, when Metro Vancouver explicitly recognized the inextricable link between air quality, climate change, and energy issues, and made the decision of adapting its 2005 Air Quality plan to transform it into the Integrated Air Quality and Greenhouse Gas Management Plan (IAQGGMP) (metrovancouver, 2011). The foundations of the IAQGGMP lie in the Sustainability Framework Initiative (SRI), which formally adopted sustainability as the center of its operating and planning philosophy (metrovancouver, 2011). The IAQGGMP is composed of three goals and 13 strategies.

At the City level, the local government set the goal of becoming the greenest city of the world by 2020. The steps to achieve this goal are documented in The Greenest City Action Plan (GCAP). The design and implementation of this plan sets the guidelines for achieving the Zero Carbon, Zero Waste, and Healthy Ecosystems targets while boosting a strong green economy. The ten goal areas of work within these three focus areas are:

1. Climate and Renewables
2. Green Buildings
3. Green Transportation
4. Zero Waste
5. Access to Nature
6. Clean Water
7. Local Food
8. Clean Air
9. Green Economy
10. Lighter Footprint

The Clean Air target is closely related to the Metro Vancouver work on the IAQGGMP. The target is to "beat the most stringent air quality guidelines from Metro Vancouver, British Columbia, Canada, and the World Health Organization," and the efforts are concentrated in monitoring and in promoting electric vehicles (City of Vancouver (b), 2017). Other goals that are directly related to air quality are the Climate and Renewables and Green Transportation Targets. Both targets address air quality through the promotion of green mobility, clearly reflected in their respective action plans, the "Renewable City Action Plan" (City of Vancouver (f), 2017), and "Transportation 2040" plan (City of Vancouver, 2012).

PUBLIC AND PRIVATE STAKEHOLDERS' ENGAGEMENT WEDGE

Engagement with private stakeholders is an important component of the GCAP, which is particularly focused on promoting green mobility options. Examples are the collaborations between the city government and car sharing companies, which play an important role in reducing emissions through reducing private car use. The city of Vancouver teamed up with private companies such as Modo and Car2Go by assisting them in the promotion of their products and by creating special zones for this kind of green mobility option (City of Vancouver, 2012).

The city also launched the "Sustainable Commuting Program" to incentivize city employees to use sustainable transport options. Under this program, the city partnered with Modo to provide better access of car sharing options to employees in need of a vehicle during work hours (City of Vancouver (e), 2017).

INTERGOVERNMENTAL RELATIONS WEDGE

The design and implementation of the above-mentioned plans require strong coordination between private actors, municipalities, different government branches, and citizens. Coordination with other policies and stakeholders, and the synergies generated among them, is key for the success of the plan's implementation; accordingly, the IAQGGMP explicitly lays out how the plan is interconnected with several other policies at the national, province, metropolitan, and local level.

The integration of plans among different government levels is also key in the process of improving air quality. The City of Vancouver actively works on integrating the CGAP and the IAQGGMP. For instance, one of the priorities of the CGAP is to work with Metro Vancouver to ensure the installation of monitoring stations within city limits so that quality data and information are available for sources and locations across the city.

THE TWO MAIN BUCKETS OF VANCOUVER: INSTITUTIONS & REGULATIONS AND LAND & INFRASTRUCTURE

When it comes to clean air, Vancouver has used the city wedge through the implementation of regulations, plans, and infrastructure, which are mainly focused on promoting the use of electric vehicles and promoting green mobility. These measures, along with other interesting approaches, are described below.

INSTITUTIONS AND REGULATIONS

Metropolitan Level: One of the most effective plans carried out in the 1990s at the metropolitan level was AirCare, an emissions inspection program aimed at reducing carbon emissions from old cars. Every car was required to pass an inspection in order to be able to circulate. It is estimated that AirCare helped reduce 85-tonnes of PM10 emissions from heavy-duty diesel vehicles every year (G.W. Taylor Consulting, 2002). The AirCare program was canceled in 2014.

Additionally, in 2015 the Metro Vancouver area became the 14th jurisdiction to sign on to the International Zero-Emission Vehicle (ZEV) Alliance. Members of the alliance have committed to making all new passenger vehicles purchased in their jurisdictions ZEVs by 2050. Accordingly, in April 2015 the Government of BC renewed its incentive for clean-energy vehicles (electric vehicles, plug-in hybrid electric vehicles, and hydrogen fuel cell vehicles), which consists of a rebate of $6,000. In addition, prospective vehicle buyers can also receive up to $3,000 in the provincial Scrap-It program for trading in older vehicles. The provincial government is also providing up to $4,500, or 75 percent of installation costs, for electric vehicle charging stations in apartment and condo buildings (City of Vancouver, 2016).

City Level: As part of the GCAP, Vancouver committed to deriving 100 percent of its energy from renewable sources before 2050. In November 2016 Vancouver adopted the Electric Vehicle Ecosystem Strategy, which aims to create flexible options for charging vehicles.

Another plan aligned with the Clean Air goal is the Green Transportation Goal. The 2020 goal of the city of Vancouver is that 2/3 of trips be made by foot, bicycle, or public transit, and to reduce the average distance driven per resident by 20 percent from 2007 levels (City of Vancouver (c), 2017). In 2016, for the second year in a row, Vancouver residents made half of their trips by walking, cycling, or transit (City of Vancouver (b), 2016). In addition, 2016 saw a decrease of 32 percent in distance driven per person since 2007, and as of 2017 23 percent of the residents walk to work (City of Vancouver (d), 2017).

INFRASTRUCTURE AND LAND

As part of the GCAP, the city of Vancouver has completed the installation of 111 charging stations in 2015 (City of Vancouver, 2017).

As part of the Green Transportation goal, the city of Vancouver has invested in:

- Introduction of a bike-sharing program
- Investment in safe-cycling infrastructure
- In March 2016, the city purchased an important corridor that will allow the creation of a greenway with separated spaces for walking and cycling (City of Vancouver (c), 2017).

EFFECTS ON VANCOUVER'S COMPETITIVENESS

The Greenest City 2020 Action Plan establishes the goal of doubling the number of green and local food jobs. Since it was implemented:

- Green jobs have increased 19 percent since 2010
- Local food jobs have increased 21 percent since 2010
- 25 percent of Canada's clean-tech companies are in Vancouver
- Vancouver's GDP is the fastest growing in Canada (Vancouver Economic Commission , s.f.)

Beyond of the Green Economy sector, Vancouver positions itself as a very competitive city. During 2016, Vancouver and Toronto led the country with 4 percent GDP growth. About half of this growth is attributable to the finance, insurance, and real estate sectors, although the high-tech, tourism, manufacturing, and film sectors also contributed to a large percentage (Bennett, 2017).

The green mobility plan has brought great benefits to Vancouver residents, who are spending $9 million less on energy for transportation (City of Vancouver (f), 2017).

Although the market for electric vehicles in British Columbia is very recent, there is great potential for growth in this sector (Vancouver Economic Commission, 2014), and it contributes considerably to the city's economy. For instance, it was estimated that in 2015, the Electric Vehicle industry in BC encompassed:

- Approximately 198 companies and organizations involved in all aspects of the Electric Vehicles sector supply chain;
- A direct employment of approximately 3,850 full-time equivalents which support additional indirect and induced employment 2,820 full-time equivalents; and
- Approximately $702 million in total economic activity.

AIR POLLUTION MANAGEMENT IN KAWASAKI, JAPAN

The city of Kawasaki is a great example of how wise environmental policies and public-private agreements can lead to exceptional environmental quality improvements and boost the industrial city economy.

During the 1950s, the industrial area, located on the waterfront of the city, was composed mainly of manufacturing industries such as steel, precision machinery, and petrochemistry. These industries transformed Kawasaki into one of the leading drivers of Japan's economic growth in the 1960s and 1970s, but the exponential growth of this sector soon led to an exponential increase in air pollutant emissions, and concern about the impacts of the industrial activity first arose when the agricultural sector suffered from the effects of air pollution. Since then, concentrations of SO2 significantly increased in Kawasaki, reaching dangerous levels. By the 1970s, photochemical smog was observed for the first time and several thousand citizens were officially recognized as patients with diseases related to air pollution (Kawasaki Environment Research Institute).

Important actions and policies were introduced in Kawasaki, where the local government, civil society, and the industrial sector strongly collaborated. These policies were successful, and by 1975 sulfur levels were significantly reduced, reaching values close to zero by 1985.

Collaboration among stakeholders in Kawasaki and the know-how acquired in this process led the city to become the first "Eco Town" of Japan.

The case of Kawasaki has been studied and documented for years. Authors like Kanada et al (2013) found that the actions undertaken by the city correspond to well-balanced policies, combined with voluntary measures and incentives, that were successful in reducing local pollution while simultaneously stimulating industrial innovations that promoted a change in the structure of the industry and cleaner, lower resource inputs. According to the authors, the design of these policies greatly influenced progress in the environmental and technological arena.

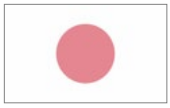
CITY WEDGE

Kawasaki city used all its administrative and legislative capacity to set a robust system for both the protection of air quality and economic growth. The city used soft measures, (such as formal voluntary agreements with the industry), and strong measures (such as the establishment of a monitoring system, an ordinance for pollution prevention, and an environmental impact assessment law) that generated positive responses from the private sector, decreasing air pollution and increasing energy savings and overall competitiveness.

Public and private stakeholders' engagement wedge

Important elements of Kawasaki's strategy were the agreements made between the local government and the industries. The city collaborated with 37 leading companies (39 plants) in 1970, and eight more in 1972 on establishing air pollution prevention measures. The active participation and engagement of the industries was key in improving air quality, and a necessary step towards the establishment of a formal legislation. Intermediate steps like the agreements made between the industries and the local government were also effective in providing flexibility and time for industries to adapt to new conditions, which resulted in a cleaner air and significant energy savings.

The continual cooperation between the city government and industries generated experience and know-how, which are now being invoked to address other anti-pollution measures and foster innovation, promoting a positive growth cycle of the economy and environment (World Bank & Japan International Cooperation Agency, 2011).



INTERGOVERNMENTAL RELATIONS WEDGE

Collaboration and coordination with national policies were important to efforts to reduce air pollution. Several regulations were enacted at the national level that complemented the actions taken at the city level, regulations which significantly supported to local efforts, particularly in the development of standards and technologies (Kanada et al., 2013).

The two main buckets of Kawasaki: Institutions & Regulations and Skills & Innovation

The actions taken by Kawasaki were mostly in the realm of establishing institutions and regulations. However, what makes this case interesting is the gradual and consensual way in which these measures were taken. Additionally, these actions opened a door for knowledge accumulation that transformed the city into an Eco Town in 1997.

INSTITUTIONS AND REGULATIONS

Kawasaki implemented several regulations carefully designed to improve air quality and enhance the efficiency of the industry sector.

The city started by establishing agreements on air pollution prevention with 37 leading companies (39 plants) in 1970. In 1972, eight companies were added to the agreement. The agreements required companies to:

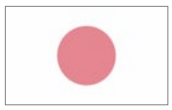
- Develop air pollution prevention plans
- Develop air pollution emergency response policies
- To report amounts of fuels and sulfur content

In 1972 Kawasaki installed a robust monitoring system. The city installed stationary source elements in 42 plants with the aim of enhancing monitoring of sulfur oxides. In 1979, the city started monitoring nitrogen oxides by telemeters. Currently, 12 plants are still under monitoring for sulfur oxide emissions and 23 for nitrogen oxide emissions.

The city also formulated the Kawasaki City Ordinance for Pollution Prevention, which introduced a total emission control by setting limits for emissions of pollutants for each facility (Kanada et al., 2013). This ordinance focused on:

- Setting the city's own environmental target values to ensure the safety of citizens and ecosystems alike
- Setting permissible total emission levels for each district
- Establishing plants' standards for air pollutant emissions (Kawasaki Environment Research Institute)

Later in 1976, the City enacted the Environmental Impact Assessment Law. This policy differed from others in the sense that it was the first one to introduce a comprehensive framework for pollution prevention (Kanada et al., 2013).



The private sector, in response to the new policies established in the city, adopted the following measures:

- Sulfur oxides control:
  a. Use of desulfurization fuel technologies
  b. Shift from heavy oil kerosene or gas to fuels with low sulfur content
- Nitrogen oxides control:
  a. Shift from heavy oil fuels to kerosene or gas
  b. Thorough combustion controls
  c. Installation of flue gas denitrification equipment
  d. Employment of low NOx equipment, such as low NOx burners and low NOx boilers.
- Dust control:
  a. Use of better-quality fuels
  b. Installation of dust-collecting equipment
- Other:
  a. Introduction of energy-saving measures
  b. Promotion of efficient use of resources

Better environmental management and performance

SKILLS AND INNOVATION

The response of the industry sector was to proactively invest in pollution prevention, enriching their engineering and technological resources through the training of engineers and technicians. This resulted in the production of advanced technologies (World Bank & Japan International Cooperation Agency, 2011).

This expansion of industrial know-how also benefited from Kawasaki's high concentration of R&D institutions (201 research institutions of private companies and 24 research institutions of universities and other). The city was then able to apply its newfound capacity to addressing other anti-pollution measures (World Bank & Japan International Cooperation Agency, 2011).

EFFECTS ON KAWASAKI'S COMPETITIVENESS

The pollution control policy in Kawasaki resulted in its industry sector achieving a competitive position in the environmental technology market (Kanada et al., 2013). A key element in the Kawasaki case is the partnership built between the city government and the business sector and the accumulation of experiences and know-how gained in the process. The collaborating between the government and the industries in reducing waste, recycling, and using waste by-products as feedstock paved the way for the city to become Japan's first "Eco-town" in 1997. The City is also highly engaged in climate change mitigation efforts through its "Carbon Challenge Kawasaki Eco-strategy (CC Kawasaki)" (World Bank & Japan International Cooperation Agency, 2011).

Today, Kawasaki is a model city of environmental pollution control and it is regionally recognized for being home to R&D organizations and companies specializing in environmental issues. Kawasaki is one of Japan's top 5 competitive cities, and it ranks 66th in the GUCP's Global Urban Competitiveness ranking of 2012 (Global Urban Competitiveness Research, 2012).

SOLID WASTE MANAGEMENT IN MUANGKLANG, THAILAND

Muangklang sets a good example for small municipalities with small budgets who need to implement cost-effective waste management systems. Muangklang is a small city of around 17,000 inhabitants located in the Rayong province, on the east coast of Thailand. The experience of Muangklang is remarkable: with a small budget, the city managed to completely change the waste management system, improving the quality of life of citizens, the quality of its rivers, and the city government's budget. The initiative created jobs and helped to increase savings. Today, Muangklang is recognized as a Low Carbon City by DEGLOSEA, and it aims to be a learning center for the study of Low Carbon Cities for other local governments (Menikpura et al.,2013).

CITY WEDGE

Muangklang being a small municipality, the mayor's role in the initiative was the linchpin of success. With a limited budget of only 1,000 Euro, the Mayor of Muangklang town launched a solid waste management program that turned the city into a livable environment (DEGLOSEA, 2010).

The project was financed by local government annual funds, private partners and funds from neighboring areas in Rayong Province. The waste-management plan was one part of a greater one to make Muangklang a green, sustainable, and low carbon city by 2020 (National Institute of Urban Affairs, 2015).

PUBLIC AND PRIVATE STAKEHOLDERS' ENGAGEMENT WEDGE

Though operating on a small scale, the city greatly benefited from building partnerships with city stakeholders. The city mayor implemented a public-private partnership with the market vendors of the municipal market that benefited both parties.

THE BUCKETS: LAND & INFRASTRUCTURE

The focus of the interventions in Muangklang was less about enacting regulations than about establishingting appropriate infrastructure and engaging citizens and city workers to participate in the initiative.

Instead of installing a sophisticated incinerator, the Mayor installed a simple outdoor conveyor belt for manual segregation of waste (separation of recyclable and non-recyclable materials and organic waste); a low-tech incinerator to dispose of non-recyclable and non-compostable waste; and a facility to collect and treat organic waste for compost production.

In addition, discarded vegetables and leaves from the municipal market are collected to produce effective microorganism (EM) concentrate, a which is added at regular points of the municipal sewer to improve water quality.

Grease traps were installed in houses and shops to reduce the river's organic load. The grease is transformed into fuel bars, which is utilized as a supplement fuel in the municipal slaughterhouse (this reduces the use of firewood). Biogas derived from the bio-digester is also used for this purpose (DEGLOSEA, 2010).

EFFECTS ON MUANGKLANG'S COMPETITIVENESS

The Solid Waste Management system implemented in Muangklang generated both savings for the city and income for citizens. For instance, the number of trips made by garbage trucks was reduced and the life of landfill was increased. Sales of composts, fuel, recyclable material, EM concentrate, and sales of locally grown vegetables cover operation costs and workers costs (National Institute of Urban Affairs, 2015). Farmland was also increased and water quality improved. Currently, the river can be used for recreational purposes, transport, and fishing.

The community actively joined the program. Citizens volunteered for the installation of grease traps, schools also joined the program, and market vendors now assist in the collection of organic waste.

Mungaklang's case has become widely known and the city has started cooperation efforts with national and international institutions like the Thailand Greenhouse Gas Management Organization, the Partnership for Democratic Local Governance in Southeast-Asia (DELGOSEA), the Asia Low Emission Development Strategies Partnership, UN-Habitat, and UNDP. Muangklang has also been recognized with several awards, including the Thailand Livable City Award. The city has also been selected as one of three model cities for Thailand's Low Carbon City Programs (WWF, 2017).

SOLID WASTE MANAGEMENT IN BAKU, AZERBAIJAN

While Muangklang's mayor's wedge was broad and influential, Baku provides a good example of how cities can solve their struggles with solid waste when their mayor's wedge is much slimmer.

Baku, the capital of the Republic of Azerbaijan, is an important port on the Caspian Sea and the center of Azerbaijan's oil production, refinery, and oil engineering industries. It is also a large industrial, scientific, and cultural center.

The oil industry activity in the city left several environmental impacts, namely the explosive population growth of Baku, which has almost doubled in the last 20 years and is expected to continue growing at an average annual rate of approximately 1.3 percent, reaching 4.3 million in 2030, and which has naturally increased the amount of waste generated (World Bank (b)).

Until 2008, solid waste collected on the Absheron Peninsula was disposed in formal and informal sites. Most of it used to be taken to the centrally located Balakhani Landfill, where conditions were severely deficient. Poorly managed fires were extremely common and produced smoke that affected nearby residential and industrial areas. Another concern was the waste leaching into the adjacent lake (Ministry of Economic Development, Republic of Azerbaijan, 2008).

According to the World Bank, the most pressing problems were:

- Lack of coverage: Preliminary data showed that only 60 percent of Baku's total generated waste was collected and delivered to an official disposal site. The remaining 40 percent ended up in informal dumping areas. Additionally, the collection system was fragmented, and only traditional apartment buildings were served, leaving individual houses severely underserved.
- Lack of quality: Houses outside the Executive Department of Housing and Communal Services' jurisdiction were poorly served, and municipalities often improvised to provide rudimentary services. Individual houses outside the city center were provided with some basic services by the Municipality, but coverage was estimated to be only 15-30 percent, due to the lack of equipment needed to extend collection, and the lack of financial resources to operate what little equipment there was.
- Lack of financial sustainability: For several reasons, solid waste collection was chronically under-funded. Many people were not billed, or if they were, they did not pay. Additionally, tariffs were too low and had not increased to keep up with the rising costs of service delivery, and government subsidies were insufficient to cover the gap between the service provision costs and household payments. (World Bank, 2013)

Currently, the World Bank and other financial organizations are assisting Azerbaijan's government in improving Baku's waste management system.

CITY WEDGE

Azerbaijan's government is highly centralized. The local government lacks the administrative and financial tools and power to take care of the environmental problems of the city, leaving the central government to lead the efforts to reduce pollution in the city. In 2006, the Government of the Republic of Azerbaijan established a comprehensive Environmental State Program (ESP), which includes decontamination operations as well as advanced environmental management. One of the components of the ESP is the improvement of solid waste management in Baku (Ministry of Economic Development, Republic of Azerbaijan, 2008).

PUBLIC AND PRIVATE STAKEHOLDERS' ENGAGEMENT WEDGE

Under the ESP frame, the government reassigned the overall responsibility of managing solid waste to the Ministry of Economic Development (MED). In August of 2008 the government founded a state-funded company, Tamiz Shahar JSC, which now manages the disposal operations of Baku's municipal waste. The creation and engagement of Tamiz Sahar has been a key element in the improvement of the Solid Waste Management System in Baku.

INTERGOVERNMENTAL RELATIONS WEDGE

Collaboration between the central government and Baku's municipality remains a relevant issue. Even though Tamiz Sahar is leading the efforts, collection and transportation of municipal solid remains a responsibility of the Baku City Executive Power.

Although this model of shared responsibility has worked so far, it is expected that the entire system will be managed by Tamiz Sahar in the future, since it can respond more efficiently to such a dynamic market.

BAKU'S BUCKETS: INSTITUTIONS AND REGULATIONS, LAND AND INFRASTRUCTURE AND SKILLS AND INNOVATION

Institutions and regulations

Several presidential degrees were enacted to establish the new waste management system, but the crucial component was the founding of Tamiz Shahar to manage the system.

LAND AND INFRASTRUCTURE

With the establishment of Tamiz Shahar the main changes were implemented:

- Rehabilitation of Balakhani Landfill: Tamiz Shahar JSC rehabilitated the Balakhani Landfill by securing the space to prevent unauthorized entry to the site; leveling and landscaping the area; providing personal protective equipment and uniforms to all staff; reconstructing internal roads; and ensuring that all waste delivered is recorded and weighed properly. These measures have prevented fires and acrid smoke. The company also established a sanitation program for trucks: the 400 trucks are washed and disinfected after emptying collected waste at the landfill (The Business Year, 2013).
- Closure of approximately 80 percent of the informal dump sites (World Bank (b), 2013).
- Installation of a Waste Recovery Facility: Currently, before the trash is disposed into the landfill, it is sorted in the new Waste Recovery Facility for recycling by more than 130 men and women, who now have government contracts and medical insurance. After a triage system using modern sorting machinery, metals, glass, plastics and other recyclables are separated from the non-reusable waste (World Bank, 2013).
- Installation of a Waste to Energy facility (WtE): The Government also installed a Waste to Energy (WtE) facility in the adjacent Balakhani landfill area. The WtE, inaugurated by president Aliyev on December 9 of 2012, has an annual capacity of 500,000 tons of municipal waste and 10,000 tons of medical waste, making it one of the largest in Europe and the first of its kind in the CIS region. The total amount of waste generated in Baku amounts to around 1.2 million tons per year, and about 40 percent of that waste is recyclable at the WtE (The Business Year, 2013).

SKILLS AND INNOVATION

The Government of Azerbaijan, in an effort to foster productivity and attract foreign investments, established an Eco-Industrial Park (Balakhani Industrial Park) in Baku, which was created within the framework of the "State Program on the socio-economic development of Baku city and its suburbs for 2011-2013" (Ministry of Economy, Republic of Azerbaijan, 2014). The main goal of the park is to create favorable conditions for potential entrepreneurs and investors in the recycling industry though the provision of infrastructure, facilities for production, and support for mechanical processes. The park is strategically located close to the Balakhani landfill and the WtE plant (Balakhani Industrial Park, 2017). There are currently three registered companies: Ekokat, which processes used motor oils, AzEkol, a plastic bottle recycling company, and EcoTire, a company that recovers tires through a cold processing method.

The establishment of the new waste management system has also helped create more jobs and skills through the training of 250 staff in solid waste management operations, financial management, budgeting, operation and maintenance, and monitoring and evaluation (World Bank (b), 2013).

EFFECTS ON BAKU'S PRODUCTIVITY

The new Waste Management System installed in Baku has improved the environmental quality of the city and it has brought great economic benefits. It is projected that the WtE plant, which was constructed using the latest technology and will comply with the most stringent Azerbaijani and EU environmental requirements, will generate 270 million kWh per year, delivering 85 percent to the electrical grid and consuming only 15 percent. The distributed electricity will meet the demand for more than 50,000 households and is expected to save the country energy that is roughly equal to 60 million cubic meters of natural gas per year. Furthermore, the ash generated during the incineration process is caught by special filters and after metals are removed and recycled, the bottom ash can be used as material for road construction. Additionally, the industrial water used for cooling during the waste incineration process is discharged into the sewers after extensive treatment (The Business Year, 2013).

The project has proven to be beneficial in both environmental and economic terms. Environmental and health impacts from waste mismanagement were greatly reduced through the integrated waste management system established. At the same time, more jobs were created and greater savings for the city were generated. The success of the project led to the preparation of a national solid waste management strategy, which is currently underway (World Bank, 2013).

Baku's economic growth has been exponential in the last decades, mainly due to the contributions of the oil sector. However, the Government of Azerbaijan is devoting efforts in diversifying Baku's economy and promote green economic growth.

One of the ambitious plans of Baku is to become a "White City" and leave behind the stigma of Baku as a Black City, daughter of the oil boom. Baku's mayoralty is planning on restoring an industrial site of 221 hectares located in the center of Baku Bay, creating a space of architectural diversity and ecological compatibility. The project intends to attract investment and construction activity, restore lands, and attract people to live and work in the area. Among other important goals, the project plans to house 50,000 residents and 48,000 workplaces (Baku White City, 2017).

KITAKYUSHU, A SUSTAINABLE AND COMPETITIVE CITY

Kitakyushu sets a robust example of how a city can use sustainability as a driver of both growth and competitiveness. Kitakyushu was created out of the merger of five contiguous cities in 1963 (Kokura, Moji, Tobata, Makamatsu, and Yahata), which transformed Kitakyushu into a heavily industrialized city. The manufacturing sector (chemicals, ceramics, and electronics) was boosted by Kitakyushu's coal reserves and its strategic port location, and the wartime periods made steel manufacturing flourish in the first half of the twentieth century. Kitakyushu's prodigious industrial growth raised per capita income to double the national average (OECD, 2013).

Air and water pollution grew exponentially during this period, and by late 1950, Kitakyushu's environment was already severely threatened. Concentrations of soot, dust, nitrous oxide (NOx), particulate matter, and sulfur dioxides were well over the WHO standards, and a rise in pollution-related diseases was observed during that time. On the other hand, water pollution increased due the city's limited sewer capacity and untreated industrial waste. The water was polluted to such an extent that the bay was called the "Sea of Death" (OECD, 2013).

However, Kitakyushu is now internationally recognized for its impressive achievements in good environmental quality. For instance, it is used as an Eco2 City example by the World Bank. Furthermore, in 2008 the City of Kitakyushu was designated as the Eco-Model City by the Japanese Government (World Bank & Japan International Cooperation Agency, 2011), which was created to demonstrate how cities can transform themselves and become low-carbon cities.

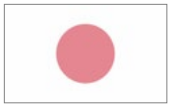
IMPROVEMENTS IN AIR QUALITY

After the implementation of several regulations and incentives, a structural change in the energy supply took place in the industry sector. Coal was the main fuel used by heavy industries in Kitakyushu, which caused negative environmental effects and serious health impacts. However, regulations helped to push out coal to be replaced by oil, which in turn was replaced by gas in the 1970s. The global oil crisis triggered an energy diversification and technological innovation process that resulted in a significant reduction in air pollution (OECD, 2013).

About 42 percent of pollution reduction was achieved by shifting energy supply and 33 percent through energy conservation measures. Some energy efficiency measures were more effective than others in reducing air pollution. The most effective ones included replacement of inefficient and polluting equipment (e.g. replacing small and middle-size boilers, and the use of heat in co-generation to optimize production processes), and the use of end-of-pipe technology, which contributed to another 25 percent of SOx reduction (OECD, 2013).

IMPROVEMENTS IN WATER QUALITY

Thanks to the Dokai Bay clean-up in 1972 and the implementation of wastewater regulation, the city removed and treated around 350,000 m3 of sludge, which contained over 30 parts per million of mercury. A relevant fact is that 71percent of the total cost was paid by private sources and the remaining 29percent was covered by the national and the Fukuoka and Kitakyushu's local governments (World Bank & Japan International Cooperation Agency, 2011). From the 1970s to 2006, sewerage coverage went from 20 percent to 99 percent thanks to the constant investment in infrastructure aimed to improve water quality and supply, such as pipes, pump stations, purification centers and wastewater operations.



IMPROVEMENTS IN WASTE MANAGEMENT

Thanks to the regulations and incentives put in place by the city government, Kitakyushu produces 506 grams of solid waste per person per day (2009), which is less than half of Japan's average. Recycling rates increased from 0.1 percent in 1991 to 30.4 percent in 2009 and the cost for waste separation went up from JPY 0.4 billion to JPY 0.6 billion over the 2001-2009 period. Furthermore, the overall waste management costs decreased from JPY 16.1 billion to JPY 13.8 billion over the same period and the waste volume was reduced by 30 percent ., cutting waste sent to landfill almost by half between 2003 and 2009 (from 109,482 tons to 55,181 tons) (OECD, 2013).

CITY WEDGE

Kitakyushu deployed all its legislative and fiscal powers to transform the city into an international model for sustainability and economic growth. Through a wide range of policies, platforms, and economic measures, the city was able to improve air and water quality and substantially reduce the amount of waste generated in the city. All this was accomplished while increasing its economic output (OECD, 2013).

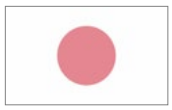
PUBLIC AND PRIVATE STAKEHOLDERS' ENGAGEMENT WEDGE

Kitakyushu also established important partnerships with the private sector. This collaboration was key for the success of the policies implemented in the city. For instance, between 1972 and 1991 the total investment in improving the environmental quality of Kitakyushu was estimated at JPY 805 billion, with 64 percent coming from the private sector and the remaining funds granted by the city (OECD, 2013). A relevant economic measure was the establishment of the Kitakyushu Financing System for Pollution Prevention, which prioritized the funding of capital costs (installation of machinery, purchasing of new land for relocation) (World Bank & Japan International Cooperation Agency, 2011).

Another important outcome from the collaboration between the city and the private sector was the establishment of the Eco Town Project, created in 1997 and which goal is to achieve zero emissions and zero waste by using all waste and materials in other industries. While Kitakyushu was facing a shortage of waste disposal, the heavy industries were on the decline due to economic recession. For both parties, the creation of the Eco Town project was an opportunity to solve these challenging problems and facilitate the city's transition from an industrial city to a green city.

Socio-environmental movements, concerned about the environmental quality and health of Kitakyushu's citizens, were also an important trigger in the process of change. Since the early 1950s, women's associations were at the forefront of Kitakyushu's environmental movement. Citizens' activism continued for over two decades, engaging local government and eventually local industries. Some remarkable milestones were the efforts of the Nakaburu Women's Society to get and install dust collectors at the Nakaburu and Kokura Diamond power plants in 1951 and the efforts made by the Sanroku Women's Association to force Yawata Steel Works to reduce pollution at its Tobata Iron Works plant. To validate their case with scientific data, the women's association collaborated with scholars from Yamaguchi University, and they also used the media to raise public awareness. In 1965 the campaign "We Want Our Skies Back" was launched by a federation of 13 women's societies, which helped mobilize the public sector to join forces with private companies to tackle industrial pollution (OECD, 2013).

Cooperation with research institutions was also an important factor in forming the Eco-Town: Fukuoka University, Kyushu University, Kyushu Institute of Technology, Saga University and nine private enterprises have actively collaborated in forming new technologies and innovative solutions.



KITAKYUSHU'S BUCKETS: INSTITUTIONS AND REGULATIONS, LAND AND INFRASTRUCTURE AND SKILLS AND INNOVATION

Institutions and Regulations

In 1970 Kitakyushu suffered a change in its governance structure, which allowed the local government to better control and reduce pollution. The city government was very successful in designing and implementing a wide range of water, air, and waste pollution control measures that benefited the economic output of the industry. These measures were in the form of regulations, platforms, economic measures and policies or plans.

Air Pollution: The city installed a warning system when it got the power to issue smog alerts, and it strengthened the monitoring stations and mobile pollution control units. It also created a new institutional network: the Kitakyushu Air Pollution Prevention Council, composed by members of the academia, citizens, industry representatives; a meteorological reporting system called "the Pollution Control Bureau" (1971); and the Regional Pollution Control Program (1972). This new institutional system facilitated the process of effectively planning and implementing pollution and emission mitigation strategies and measures, and to established stringent pollution standards compared to those established at the national level (OECD, 2013).

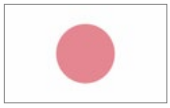
Specific regulations, platforms, policies and economic measures enacted by the city government and the central government are listed below:

- Establishment of the Kitakyushu City Pollution Prevention Council (Platform)
- Installing automatic air pollution monitoring equipment to sulfur oxides and suspended particulate matter (Platform)
- Enforcement of Basic Act for Environmental Pollution Control (Central Government – Regulatory Framework)
- Enactment of the Air Pollution Control (Central Government – Regulatory Framework)
- Establishment of Kitakyushu pollution prevention funding system (Economic measure)
- Enforcement of Kitakyushu Pollution Prevention Ordinance (Regulatory Framework)
- Establishment of Pollution Monitoring Center (Platform)
- Establishment of the Sanitation Bureau's Pollution Monitoring Department (Platform)
- Establishment of Pollution Control Bureau (Platform)
- Formulation of Kitakyushu Regional Plan on Pollution Prevention (Policy/Plan)
- Sign of Pollution Control Agreement between the local Government and companies (Regulatory Framework)

Water Management: Kitakyushu also undertook several successful measures to improve water quality. The most important drivers of change were the Regional Plan on Pollution control, the Pollution Control Bureau, the Kitakyushu Air Pollution Prevention Council, and measures like the establishment of national quality standards (World Bank & Japan International Cooperation Agency, 2011).

Waste Management: Kitakyushu also has achieved impressive results in reducing and recycling waste. The list of measures taken by the city are listed below:

- Subsidy program to provide households with composting containers for kitchen scraps (economic measures)
- Separate collection of cans and glass bottles (Regulatory Framework)
- Charge for the collection of oversized garbage (Economic measure)



- Act on the Promotion of Sorted Garbage Collection and Recycling of Containers and Packaging (partially enforced) (Central Government – Regulatory Framework)
- Separate collection of PET bottles (Regulatory Framework)
- Formulation of the Kitakyushu Eco-town plan and approval by METI (Policy/Plan)
- Charge for the designated garbage bags for household (Economic measure)
- Formulation of Kitakyushu City Fundamental Plan for Domestic Waste Management (Policy/Plan)
- Enforcement of Act for Recycling of Specified Kinds of Home Appliances (Central Government – Regulatory Framework)
- Act on Establishing a Sound Material-Cycle Society set the target of reducing the amount of waste per person at 20 percent (Central Government – Regulatory Framework)
- Review of the domestic waste collection system (Economic measure)
- Kitakyushu City Plastic Recycling Center (Encouragement/promotion/else)

LAND AND INFRASTRUCTURE

The city of Kitakyushu actively cooperated with industry and academia in the provision of land and installation of the Eco-Town Project. After a study that assessed how to use 2,000 hectares of reclaimed land that was without use in the coastal area, the Eco Town Project was born and launched in 1997.

SKILLS AND INNOVATION

The Eco-Town Project, which strives to achieve zero emissions and zero waste by using all waste and materials in other industrial processes, is the most symbolic project of Kitakyushu (World Bank & Japan International Cooperation Agency, 2011); (UN Habitat, 2012). It is composed of two main divisions: The Comprehensive Environmental Industrial Complex, which brings new technologies to the market, and the Practical Research Area, where industry, academia, and local government and institutions conduct R&D in waste treatment and recycling (UN Habitat, 2012). Within the Comprehensive Environmental Industrial Complex is the Hibiki Recycling Area, which supports small and medium sized companies through long-term leases of sites (UN Habitat, 2012).

Non-recyclable waste is used for waste-to-energy (WtE) generation, which powers all facilities located in Eco-Town, Kitakyushu's recycling complex.

It is noteworthy to mention that the first priority in Kitakyushu is reduction: waste generation has been reduced, recycling rates have increased, and waste incineration, instead of curbing recycling, was cut from 588,327 tons in 2003 to 367,661 tons in 2009 (OECD, 2013).

The Eco-Town project has brought several innovations in the recycling industry. For instance, Kitakyushu was the first city in Japan to recycle and reuse fluorescent tubes. Another impressive achievement is the recycling rate of automobiles, which reaches a 99 percent.

EFFECTS ON KITAKYUSHU'S ECONOMY

Investments in creating a clean and sustainable city transformed Kitakyushu in a competitive city. For instance, it is estimated that the construction and operation of the Eco-Town has generated UDS 1.34 billion in direct and indirect investments, and created 6,470 jobs (UN Habitat, 2012).

Strong evidence of this transformation as a driver of economic growth and competitiveness is the solid economic growth that occurred in parallel to the eco-transformation, in which Kitakyushu's GDP more than quadrupled between 1970 and 1990.

SAO PAULO, A MEGACITY STRUGGLING WITH AIR POLLUTION

The story of the Metropolitan Region of Sao Paulo (MRSP) sets a good example of how efforts at the national and local level can sometimes be insufficient if they fail to address the issue in an integrated manner. Sao Paulo, despite the policies implemented for decades to decrease air pollution, still struggles against high levels of PM2.5, PM10, O3 and NO2, which are well above national and WHO standards.

Vehicular congestion in Sao Paulo is severe. MRSP has the 2nd highest commuting time among large cities, and some studies estimate that in 2008, traffic costs represented roughly 10 percent of the city's economy. The last decade has seen a dramatic increase of the vehicular fleet in the past decade. Despite efforts made by the Brazilian government to invest in a better public transport system, trips made by public transportation dropped from 75 percent to 50 percent between the 1980s to 2000, and that is expected to keep declining to 18-30 percent of total trips by 2025 (Alvarez et al., 2014). The largest increase of ownership of private cars has been in the smaller metropolitan municipalities, which is associated with the segment of the population in suburban towns that must commute to work daily (Alvarez et al., 2014).

In terms of pollution, this is very worrisome. Vehicles in Sao Paulo make up a total: of 97.5percent of CO emissions; 79 percent of HC emissions 67.5 percent of NOx emissions; 22 percent of SOx emissions; and 40 percent of PM emissions (CETESB, 2015).

SAO PAULO'S BUCKETS: INSTITUTIONS AND REGULATIONS AND LAND AND INFRASTRUCTURE

Institutions and Regulations

Sao Paulo has been actively using its administrative tools to address air pollution for decades. The city began tackling air pollution in the 1960s, when, with technical and financial support from the Pan American Health Organization and the WHO, it installed a PM and SO2 monitoring network. By 1975, an air quality monitoring network was established under the control of the Environmental Sanitation Technology Company(CETESB), a company owned by the State of Sao Paulo. Air quality standards for total suspended particulates (TSP), breathable particulate matter (PM10 and PM2.5), sulfur dioxide (SO2), carbon monoxide (CO), ozone (O3), nitrogen dioxide (NO2) and smoke were stablished in 1976. By 1982 the control of emissions from the major sources of SO2 became mandatory, generating a shift from the use of fuels with high SO2 content to cleaner fuels and the replacement of fuel oil with electricity or natural gas. This, and the new regulations issued in 1990 requiring lower levels of sulfur content in diesel fuel, had positive effects in the decrease of SO2 concentrations in the atmosphere (Andrade et al., 2017).

As with any other city, Sao Paulo's environmental quality is under the influence of national policies and international trends. In 1975, the Brazilian government promoted a bold biofuel policy in response to high international prices of oil and low national prices of sugar cane, which had important effects on air quality. The Brazilian National Alcohol Program, as a first step, promoted the production of ethanol for blending into gasoline to the maximum extent feasible in existing vehicles (approximately 20 percent by volume). Later in 1979, the installation of assembly lines for 100 percent ethanol cars was made possible thanks to agreements made between the government and major car companies, which resulted in the production of 250,000 ethanol-only cars in 1980 and 350,000 by 1982. In addition, taxi drivers were provided with government incentives to convert their cars to 100 percent ethanol. The proportion of ethanol in the blend has increased over the years and is currently at 27 percent (Andrade, y otros, 2017).

In 2001, the government issued regulations to promote vehicles that run on blends of ethanol and gasoline, so-called flex fuel vehicles, by entitling them to preferential tax treatment (14 percent sales tax, as compared to a 16 percent sales tax on non-ethanol cars). By February 2006, more than 70 percent of new cars sold in Brazil were flex-fuel (Alvarez et al., 2014).

In addition to these regulations, CONAMA implemented vehicle emission control programs such as PROCONVE (Program for the Control of Air Pollution Emissions by Motor Vehicles) and PROMOT (Air Pollution Control Program for Motocycles and Similar Vehicles), which have been essential for the improvement of air quality (Andrade et al., 2017).

Efforts at the local level: The Vehicular Pollution Control Plan (PCPV), an instrument of PRONAR and PROCONVE, was introduced in the Sao Paulo in 2008, being the first municipal-level effort of this kind in Brazil. The program was gradually introduced for diesel vehicles, and today it mandates the entire registered vehicular fleet be inspected to ensure compliance with emissions standards recommended by CONAMA (Alvarez et al., 2014).

The Operation Winter Program, established in 1976, is a set of preventive and correction actions taken during winter months to combat acute air pollution. One tool used by CETESB is megacomando, in which agents set up surveillance points to monitor black smoke to give fines to diesel vehicles emitting levels of smoke that are above São Paulo's legal standards (Alvarez et al., 2014).

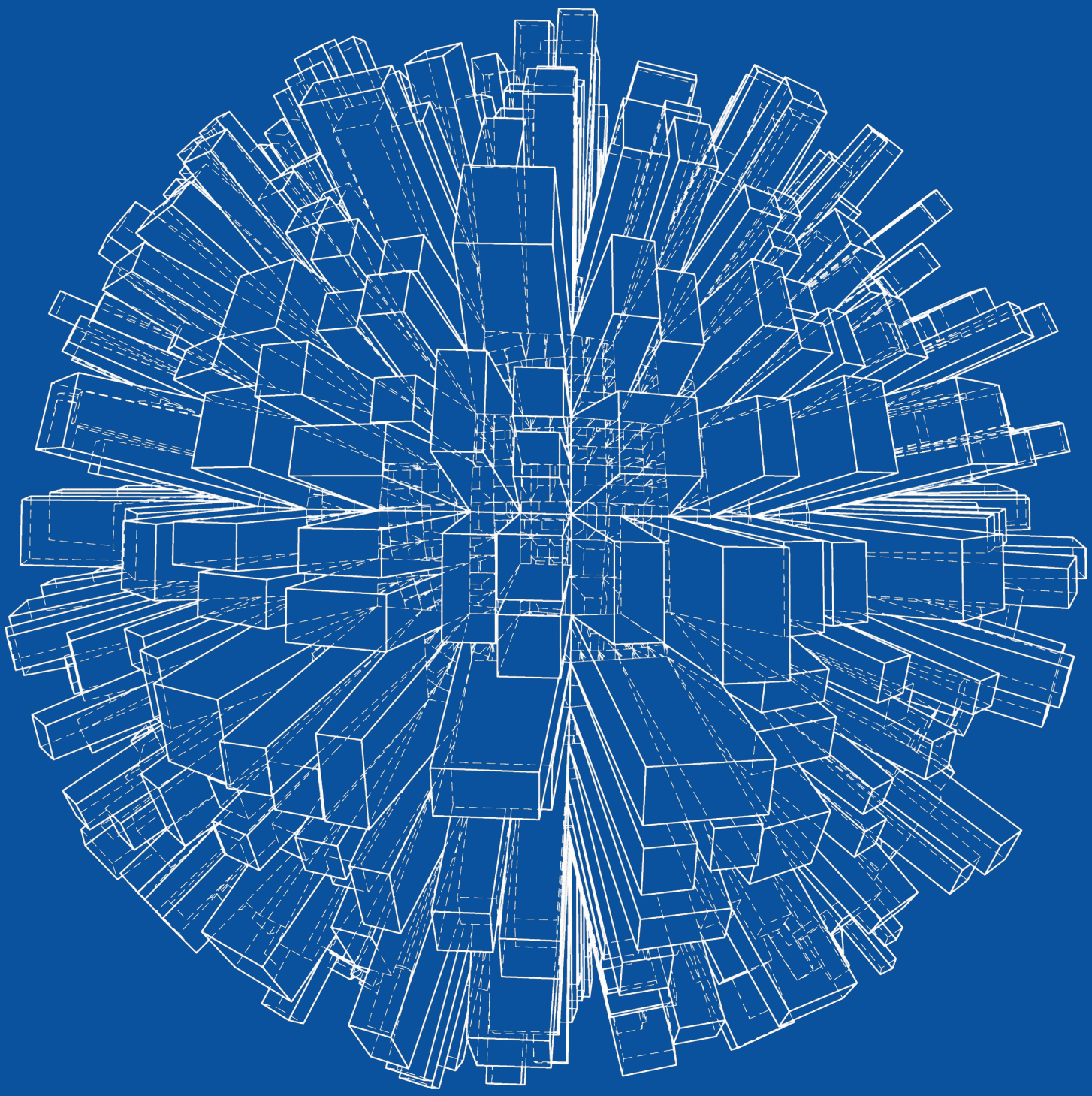
Another program implemented at the local level is radízio. Initially, the program prohibited each passenger car from being on the road one day per week. However, currently passenger cars are prohibited only during peak hours one day a week. The program has also been extended to diesel-powered vehicles (Andrade et al., 2017).

Land and Infrastructure

This is part of a $18 US million city and state plan aiming to expand the metro lines and bus terminals and improve traffic control and signaling. Through the Ecofleet program the city is updating old buses and through national laws is mandating the gradual conversion of public buses fueled by fossil fuels into a fleet running entirely on renewable sources (Alvarez et al., 2014).

WHY IS IT NOT WORKING?

Sao Paulo has identified the main sources of air pollution and it has implemented several strategies to combat this serious issue. However, it hasn't been completely successful in achieving healthy air quality levels and in taking advantage of the economic benefits that other measures would bring. As discussed, the problem of Sao Paulo is one of mobility: the congestion problem is increasing, and private car ownership is the main driver. This is evidence that Sao Paulo lacks comprehensive measures to discourage the use of private cars, such as carpooling lanes, congestion charges, park and ride systems (Siemens AG, 2010), and the promotion of bike use through the implementation of bike programs and construction of bike lanes. Evidence from other cities like Copenhagen show that investing in urban planning, zoning, agreements with the private sector and the public play a key role in the improvement of urban environmental quality and quality of life.



AND THE MAKING OF PROSPEROUS CITIES

REFERENCES

AirQo Blog. “Kampala Air Quality Improves By Up To 40 percent During The Covid-19 Lockdown. April 10, 2020. https://www.airqo.net/blog.

Alvarez, O., Marulanda, C., & Demosthenes, A. (2014). Air Quality Issues. Metropolitan Region of Sao Paulo.

Alvarez, O., Marulanda, C., & Demosthenes, A. (n.d.). Air Quality Issues. Metropolitan Region of Sao Paulo.

Andrade, M., Kumar, P., Dias de Freitas, E., Yuri, R., Martins, J., Martins, L., . . . Zhang, Y. (2017). Air Quality in the Mega City of Sao Paulo: Evolution over the last 30 years and future perspectives. Atmospheric Environment, 159, 66-82.

Angela R Harris, M. A. (2017). Fecal Contamination on Produce From Wholesale and Retail Food Markets in Dhaka, Bangladesh. The American Journal of Tropical Medicine and Hygiene, 287-294.

Asnap, F. (2012). 'What a Waste' Report Shows Alarming Rise in Amount, Costs of Garbage. Retrieved from The World Bank: http://www.worldbank.org/en/news/feature/2012/06/06/report-shows-alarming-rise-in-amount-costs-of-garbage

Baku White City. (n.d.). Retrieved from http://www.bakuwhitecity.com/en/

Baku White City. (2017). Retrieved from http://www.bakuwhitecity.com/en/

Balakhani Industrial Park. (n.d.). Retrieved from http://www.bsp.az/index.php

Balakhani Industrial Park. (2017). Retrieved from http://www.bsp.az/index.php

Ballance, A., Ryan, P., & Turpie, J. (2000). How much is a clean beach worth? The impact of litter on beach users in the Cape Peninsula, South Africa. South African Journal of Science , 2010-2013.

Bennett, N. (2017, Jan 27). Vancouver’s economy is on FIRE. Retrieved from Business Vancouver: https://www.biv.com/article/2017/1/vancouvers-economy-fire/

Carmichael, L., Racioppi, F., Calvert, T., & Sinnett, D. (2017). Environment and health for European cities in the 21st century: making a difference. World Health Organization.

CETESB. (2015). Qualidade do Ar No Estado de Sao Paulo. Retrieved from http://cetesb.sp.gov.br/ar/wp-content/uploads/sites/28/2013/12/RQAR-2015.pdf

Chaity, A. J. (2018, August 17). Dhaka Tribune. Retrieved from www.dhakatribune.com: https://www.dhakatribune.com/bangladesh/dhaka/2018/08/17/what-makes-dhaka-the-second-worst-city-to-live-in

Chang, T., Graff Zivin, J., Gross, T., & Neidell, M. (2016). "Particulate Pollution and the Productivity of Pear Packers". American Economic Journal: Economic Policy, 8(3), 141-169.

Ciccone, A. &. (1993). Productivity and the density of economic activity. NBER Working Papers Series(w4313).

City of Copenhagen (b). (2015). Copenhagen Climate Projects.

City of Copenhagen (b). (2016). CHP 2015 Climate Plan. Roadmap 2017 - 2020. Copenhagen.

City of Copenhagen (b). (2017). More Electric Vehicles in Copenhagen. Retrieved from State of Green: https://stateofgreen.com/en/profiles/city-of-copenhagen/solutions/more-electric-vehicles-in-copenhagen

City of Copenhagen. (2009). Impact of Copenhagen's Parking Strategy. The Technical and Environmental Administration. Traffic Department, Copenhagen.

City of Copenhagen. (2014). Better Mobility in Copenhagen. ITS Action Plan 2015-2016.

City of Copenhagen. (2014). Copenhagen. Solutions for Sustainable Cities. State of Green.

City of Copenhagen. (2015). Municipal Plan 2015. The Coherent City.

City of Copenhagen. (2016). Sustainable Urban Transportation. Creating Green Livable Cities. State of Green.

City of Copenhagen. (2017). The Environmental Zone in Copenhagen/Frederiksberg. Retrieved from Miljozone: http://www.miljozonen.dk/vognmand_english.php

City of Copenhagen. (n.d.). Clean Air Plan. Copenhagen.

City of Vancouver (b). (2016). Walking + Cycling in Vancouver. 2016 Report Card.

City of Vancouver (b). (2017). Green Transportation. Retrieved from Green Vancouver: http://vancouver.ca/green-vancouver/green-transportation.aspx

City of Vancouver (c). (2017). Green Transportation. Retrieved from Green Vancouver: http://vancouver.ca/green-vancouver/green-transportation.aspx

City of Vancouver (d). (2017). Walk + bike + roll: Getting around the Vancouver way. Retrieved from Streets and Transportation: http://vancouver.ca/streets-transportation/walk-bike-and-transit.aspx

City of Vancouver (e). (2017). Sustainable Commuting. Retrieved from Green Vancouver: http://vancouver.ca/green-vancouver/sustainable-commuting-for-staff.aspx

City of Vancouver (f). (2017). Renewable City Action Plan.

City of Vancouver. (2012). Transportation 2040. Moving Forward.

City of Vancouver. (2016). Greenest City. 2020 Action Plan. 2015-2016 Implementation Update.

City of Vancouver. (2017). Electric Vehicles. Retrieved from Streets and Transportation: http://vancouver.ca/streets-transportation/electric-vehicles.aspx

City of Vancouver. (n.d.). Transportation 2040. Moving Forward.

DEGLOSEA. (2010). Best Practice Muangklang: Low Carbon City.

Dodman, D., McGranahan, G., & Dalal-Clayton, B. (2013). Integrating the Environment in Urban Planning and Management. Key Principles and Approaches for Cities in the 21st century. United Nations Environmental Programme (UNEP). Nairobi: UNON/Publishing Section Services.

Duranton, G. (2008). From cities to productivity and growth in developing countries. Canadian Journal of Economics/ Revue canadienne d'économique, 41(3), 689-736.

Florida Center For Solid and Hazardous Waste Management. (1999). The Florida Litter Study: Economic Impacts of Litter on Florida's Businesses. Gainesville: State University System of Florida.

Florida Center for Solid and Hazardous Waste Management. (2000). The Florida Litter Study. Measuring and Managing Litter: Illegal Dumping City Costs. KAB Litter Index Review. Gainesville: State University System of Florida.

G.W. Taylor Consulting. (2002). Review of the AirCare On-Road (ACOR) program. Greater Vancouver Regional District.

Glaeser, E. (2014). A world of cities: The causes and consequences of urbanization in poorer countries. Journal of the European Economic Association, 12(5), 1154-1199.

Glaeser, E. L. (2012). Triumph of the city: How our greatest invention makes us richer, smarter, greener, healthier, and happier. Penguin.

Global Urban Competitiveness Research. (2012). Global Urban Competitiveness. Retrieved from Center for City and Competitiveness, CASS: http://www.gucp.org/cities/CountryCities/CityList_English?orderYear=2012&orderType=2

Global Urban Competitiveness Research. (n.d.). Global Urban Competitiveness 2012. Retrieved from Center for City and Competitiveness, CASS: http://www.gucp.org/cities/CountryCities/CityList_English?orderYear=2012&orderType=2

Graham, D. J. (2007). Variable returns to agglomeration and the effect of road traffic congestion. Journal of Urban Economics. Journal of Urban Economics, 62(1), 103-120.

Hammer, S. (2011). Cities and Green Growth: A Conceptual Framwork. OECD Regional Development Working Papers. OECD Publishing 2011/08. Retrieved from http://dx.doi.org/10.1787/5kgOtflmzx34-en

Humanitarian OpenstreetMap. (2020). Open Mapping for Productivity and Pollution Impacts in Duala Market Project.

Hutton, G. (2012). Global costs and benefits of drinking-water supply and sanitation interventions to reach the MDG target and universal coverage. WHO (World Health Organization).

INRIX. (2017). INRIX 2016 Traffic Scorecard. Retrieved from http://inrix.com/resources/inrix-2016-traffic-scorecard-us/

Izidoro, A. M. (2011). Marking up for lost time, New York: Economist Intelligence Unit.

Kahn, M., Lozano-Gracia, N., & & Soppelsa, M. (2019). Does Pollution Hinder Urban Competitiveness? WB Working Paper.

Kanada, M., Fujita, T., Fujii, M., & Ohnishi, S. (2013). The long-term impacts of air pollution control policy: historical links between municipal actions and industrial energy efficiency in Kawasaki City, Japan. Journal of Cleaner Production, 58, 92-101.

Kawasaki Environment Research Institute. (n.d.). Air Pollution Control Measures by Kawasaki City. Pollution Control measures that have lead to Economic Growth. Presentation. http://staging.unep.org/delc/Portals/119/documents/montevideo/air-pollution-control.pdf.

Kenneth C Shenge, C. M. (2015). Contamination of Tomatoes With Coliforms and Escherichia Coli on Farms and in Markets of Northwest Nigeria. Journal on Food Protection, 57-64.

Lozano-Gracia, N. &. (2019). Pollution and City Competitiveness: a Descriptive Analysis. WB Working Paper.

LSECities. (2014). Copenhagen. Green Economy Leader Report. LSE Cities, London School of Economics and Political Science.

Menikpura, S., Sang-Arun, J., & Bengtsson, M. (2013). Integrated Solid Waste Management: an approach for enhancing climate co-benefits through resource recovery. Journal of Cleaner Production, 1-9.

metrovancouver. (2011). Metro Vancouver Integrated Air Quality and Greenhouse Gas Management Plan. .

metrovancouver. (2014). Integrated Air Quality and Greenhouse Gas Management Plan Progress Report.

Ministry of Economic Development, Republic of Azerbaijan. (2008). Absheron Rehabilitation Program. Integrated Waste Management Project. Environmental Management Framework. Baku.

Ministry of Economy, Republic of Azerbaijan. (2014, July 07). The first two companies to operate Balakhani Industrial Park established. Retrieved from http://www.economy.gov.az/index.php?option=com_content&view=article&id=2484:bsp-07-07-2014&catid=8:news&Itemid=263&lang=en

Moss, J., Wolff, G., Gladden, G., & Gutierrez, E. (2003). Valuing Water for Better Governance. How to promote dialogue to balance social, environmental, and economic values?

National Institute of Urban Affairs. (2015). Urban Solid Waste Management. Compendium of Global Good Practices.

OECD. (2013). Green Growth in Kitakyushu, Japan. Paris: OECD Publishing. Retrieved from http://dx.doi.org/10.1787/9789264195134-en

Palfreman, J. (2015). Waste Management and Recycling in Dar es Salaam, Tanzania.

Sharing Copenhagen . (2014). Copenhagen European Green Capital. A Review.

Siemens AG. (2010). Latin American Green City Index. Munich.

Soppelsa, M., Lozano-Gracia, M., & Xu, C. (2019). The effects of Pollution and Business Environment on Firm Productivity in Africa. WB Working Paper.

Stockholm International Water Institute. (n.d.). Making Water a Part of Economic Development. The economic benefits of improved water management and services.

The Business Year. (2013). Keep it Clean. Retrieved from TBY: https://www.thebusinessyear.com/azerbaijan-2013/keep-it-clean/interview

U.S. Environmental Protection Agency . (n.d.). The Economics of Recyling in the Southeast: Understanding the Whole Picture. Archive Document.

UN Habitat. (2010). Solid Waste Management in the World's Cities: Water and Sanitation in the World's Cities 2010. London: United Nations Human Settlements Programme.

UN Habitat. (2012). Urban Patterns for a Green Economy: Clustering for competitiveness. Nairobi: UNON, Publishing Services Section.

UN Habitat. (2016). Chapter 7: A City that Plans: Reinventing Urban Planning. In WORLD CITIES REPORT.

United Nations. (2013). Chapter III. Towards Sustainable Cities. In U. Nations, World Economic and social survey 2013. Sustainable Development Challenges.

Value of Water Campaign. (2017). The Economic Benefits of Investing in Water Infrastructure.

Vancouver Economic Commission . (n.d.). Green Economy. Retrieved from Our Focus: http://www.vancouvereconomic.com/focus/green-economy/

Vancouver Economic Commission. (2014). Green and Local Food Jobs in the City of Vancouver.

World Bank & Japan International Cooperation Agency. (2011). Study of Japanese Experiences on Sustainable Development including Pollution Control and Management, Resource/Energy Efficiency and GHG Reduction.

World Bank (b). (2013). Project Paper on a Proposed Additional Loan in the Amount of UDS47.1 million and Restructuring to the Republic of Azerbaijan for the Integrated Solid Waste Management Project.

World Bank (b). (n.d.). AF-INTG SOLID WASTE MGT. GENERAL PROCUREMENT NOTICE. Retrieved from Projects & Operations: http://www.projects.worldbank.org/procurement/noticeoverview?id=OP00025902&lang=en&print=Y

World Bank. (2006). Bangladesh Country Environmental Analysis. Dhaka, Bangladesh: The World Bank.

World Bank. (2011). Emergency Monrovia Urban Sanitation Project (EMUS), Additional Financing PAD. Washington DC: World Bank.

World Bank. (2012). Republic of Côte d'Ivoire. Côte d'Ivoire Urbanization Review. The World Bank. GSURR. Africa.

World Bank. (2013, August 21). Slideshow: Managing Waste Safely in Azerbaijan. Retrieved from http://www.worldbank.org/en/news/video/2013/08/21/slideshow-managing-waste-safely-in-azerbaijan

World Bank. (2015). Bangladesh: More and Better Jobs to Accelerate Shared Growth and End Extreme Poverty - A Systematic Country Diagnostic. The World Bank.

World Bank. (2016). Competitive Cities for Jobs and Growth. What, Who, and How. Washington, DC: World Bank.

World Bank. (2018). Enhancing Opportunities for Clean and Resilient Growth in Urban Bangladesh. Washington, DC: World Bank.

World Bank. (2019). Gov Constraints to Service Delivery: Solid Waste Management. Washington DC: World Bank.

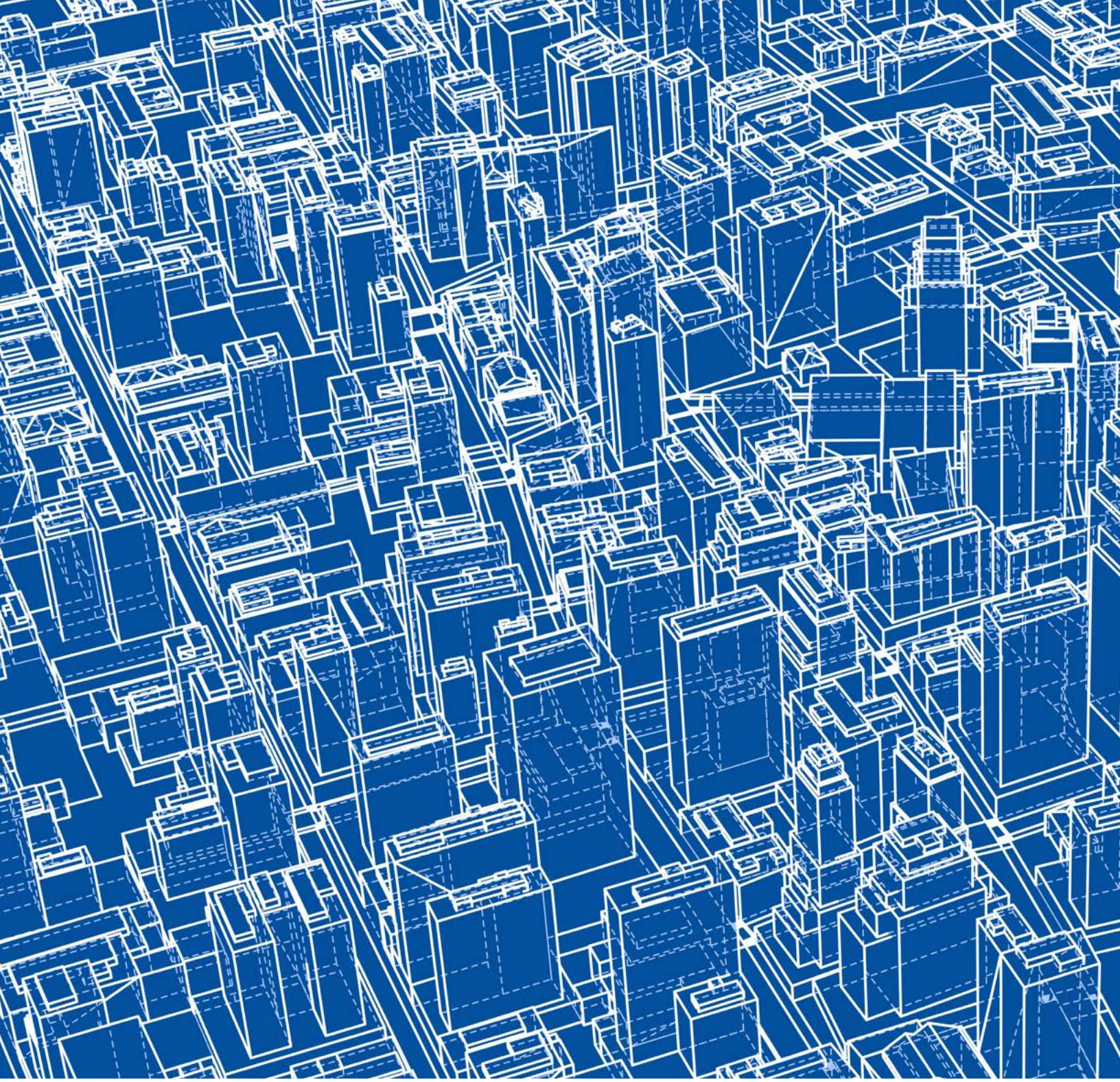
World Food Programme . (2015). Emergency Food Security Assessment Liberia. WFP.

WRG. (2015). An Analysis of Industrial Water Use in Bangladesh with a Focus on the Textile and Leather Industries. Water Resources Group 2030.

WWF. (2017, March 15). Muangklang. Pioneer of low-carbon planning. Retrieved from WWF Global: http://wwf.panda.org/what_we_do/footprint/one_planet_cities/urban_solutions/muangklang_us_2016/

Zanzibar Office of the Chief Government Statistician (OCGS). 2019. Zanzibar Statistical Abstract 2018.

Zanzibar Sustainable Programme. Working Group Report: water supply, waste water, flooding and drainage, Zanzibar Municipality, 2000b. 21pp.



Layout/graphic design by Carlos Plaza Design Studio.

POLLUTION MANAGEMENT & ENVIRONMENTAL HEALTH
For Healthy Living

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP