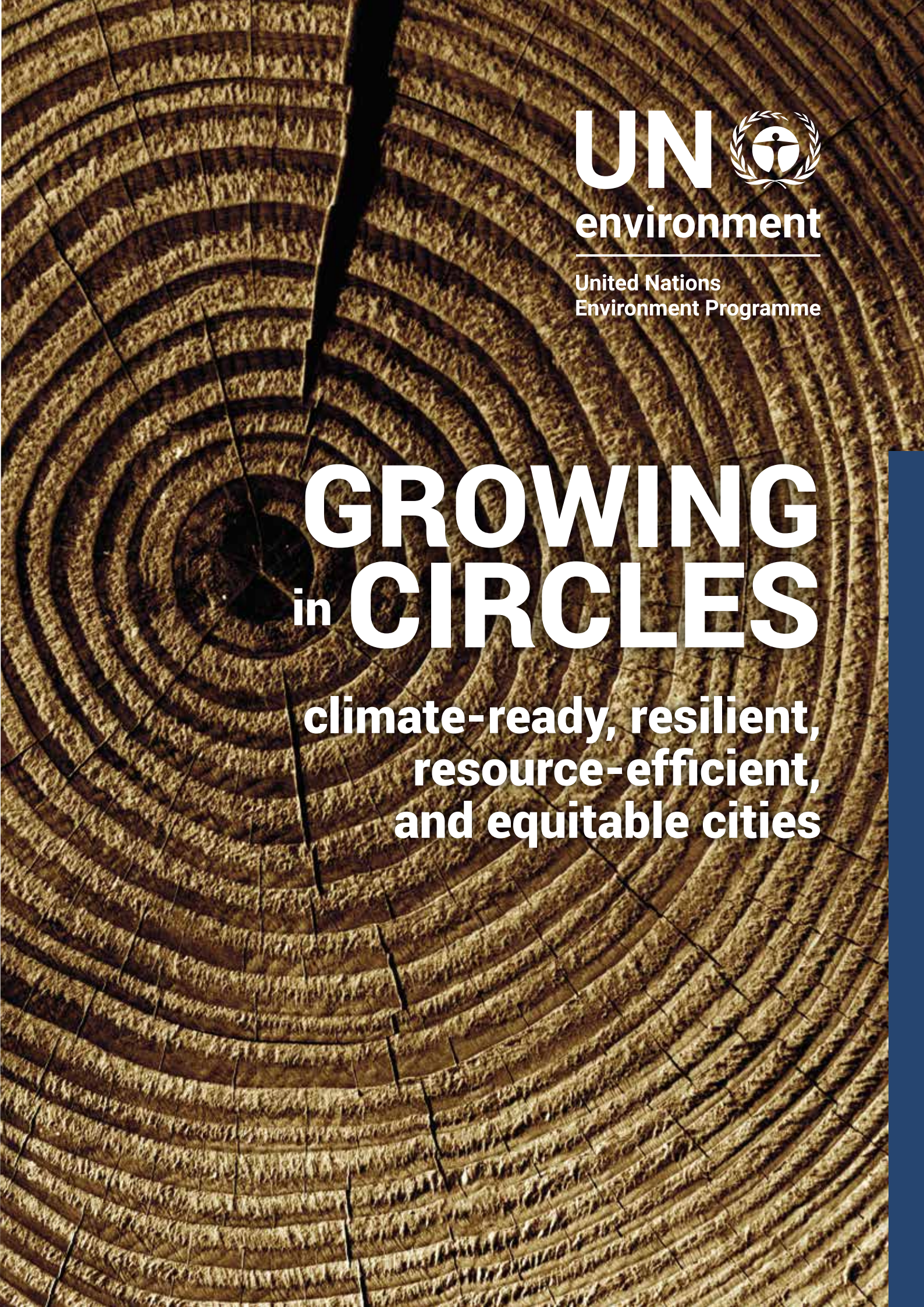

UN environment

United Nations
Environment Programme

GROWING in CIRCLES

climate-ready, resilient, resource-efficient, and equitable cities

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CONTENTS

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This document serves as the final report of the first phase of the Global Initiative for Resource Efficient Cities (GI-REC). UN Environment would like to thank the partners of the GI-REC for their support: Bruxelles Environnement / Leefmilieu Brussel, Centro de Gestão e Estudos Estratégicos (CGEE), China-ASEAN Environmental Cooperation Centre (CAEC), Circle Economy, Cities Alliance, Ecocity Builders, Energies 2050, ICLEI – Local Governments for Sustainability (ICLEI), International Institute for Environment and Development (IIED), International Initiative for a Sustainable Built Environment (iiSBE), League of Cities of the Philippines, Metabolism of Cities, Massachusetts Institute of Technology (MIT), Programa Cidades Sustentáveis, Sustainability Institute, Sustainable Healthy Cities Network, UN Habitat, University of Sheffield, World Council on City Data (WCCD)

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FOREWORD

Resource extraction and use is a major concern and impacts the environment, biodiversity, and the climate, with cities as the major consumers. This will only be exacerbated by the ever-increasing global urban population. UNEP has been working on sustainable consumption at the national and local level for over two decades and serves as the lead custodian of Sustainable Development Goal (SDG) 12 on sustainable consumption and production. UN Environment is also the Secretariat to the International Resource Panel (IRP), a group of some of the world's leading resource scientists.

Twenty years after the first Earth Summit held in Rio de Janeiro, UNEP launched the Global Initiative for Resource Efficient Cities (GI-REC), with the goal of applying integrated approaches and analyses such as urban metabolism in city planning and management. The Initiative was based on the results of the International Resource Panel (IRP) report on city-level decoupling (2013) which emphasized the need to decouple economic growth, especially in cities, from resource extraction. An integrated approach to urban infrastructure will be key to stem the impact of issues related to unplanned urbanization and its consequent implications on resource use, biodiversity, and the climate. The IRP's "Weight of Cities" report states that cities can achieve some 30-55% reduction of GHG emissions, consumption of resources (such as water, metal, etc.) and land-use, by leveraging connections and resource sharing across urban systems, combined with strategic densification. Within cities, integrated urban projects are piloted where cost-effective, but often without being linked to a broader policy and planning approach at the local and national levels. This results in missed opportunities and isolated demonstrations that are not replicated, scaled up, or considered in the context of sustainable development and climate strategies.

GI-REC was tasked with developing practical applications of academic concepts highlighted by the IRP's reports. This meant bringing together both scientists and policy makers, and ensuring that their different worlds and priorities connected. Through these various science-policy collaborations, tools were developed and piloted by GI-REC in several cities around the world.

This summary report describes the original work that has been developed under GI-REC. It comes at an opportune time, when cities are at the forefront of global environmental discussions. In addition to bringing together professionals of different disciplines, GI-REC also brought together two separate work streams of climate and resource efficiency. By looking at cities from a systems perspective, the Initiative provided guidance on the transition of cities from a linear to a circular economy, and on alternatives to the way our cities are being planned and built.

The results of the GI-REC highlight that integrated planning is key to sustainable urban development. UNEP will take the insights from and recommendations of the Initiative as tools to better navigate the interconnectedness of the climate, resources, and biodiversity debate. Currently, we are looking at the transition to a circular economy from both environmental and social perspectives by measuring the number and the distribution of jobs created in a circular economy at the city level. Moreover, as lead agency of the GEF's Sustainable Cities Impact Programme, we hope to work with more national and local governments in shifting global urban development trajectory towards one that is integrated, low-carbon, resilient, and resource efficient.

Ligia Noronha
Director
Economy Division
UN Environment Programme

Testimonials from the Steering Committee

UN-Habitat

Raf Tuts Director, Programme Division

"By focusing on the role of cities in ensuring sustainable consumption and consumption patterns, the Global Initiative on Resource Efficient Cities (GI-REC) has played an important role in exploring and demystifying the linkages between SDG 11 and SDG 12.

The New Urban Agenda calls for a paradigm shift in how we plan, finance, develop, govern and manage cities, towards achieving the SDGs. This will only be possible when addressing the challenges of urban metabolism. The tools and city pilots developed through GI-REC provide inspiration to concretize resource efficiency principles through city action. Pioneering cities should be encouraged to share their lessons and expertise with their peers.

Moving forward, UN-Habitat's new strategic plan for 2020-2023 includes an outcome area on 'improved resource efficiency and protection of ecological assets', contributing to strengthened climate action and an improved urban environment. We are convinced that the knowledge developed through GI-REC will play an important role to achieve this outcome area.

We thank UN Environment to have nurtured this initiative in a true spirit of partnership!"

ICLEI – Local Governments for Sustainability

Mr. Gino Van Begin Secretary General

"UN Environment's Global Initiative for Resource Efficient Cities has been instrumental in raising awareness on the climate, biodiversity and resilience impacts of linear resource management models at the local level. This report offers practice-oriented insights into how the framework of urban metabolism and the circular economy can help cities address resource related challenges, such as water scarcity in Cape Town and sustainable agriculture in Sorsogon. Having supported the GI-REC since its early stages, ICLEI is looking forward to many more years of collaboration to drive circular development at the local level."

Testimonials from Partners

Ecocity Builders

Kirstin Miller Executive Director

"Growing in circles city-wide requires hyper-focused systemic change at the local level. It means designing reverse logistics to redirect materials back into urban flows instead of abandoning them as waste. Hardest of all, it demands a behavioral shift and the emergence of a new cultural fabric that can weave into a zero waste economy. These are the challenges that inspire and motivate our organization every day. We are honored to have been able to explore and accelerate critical aspects of circularity with our esteemed partners, which has resulted in this report."

International Institute for Environment and Development (IIED)

Dr. David Dodman Director, Human Settlements

"Current patterns of global resource use are unsustainable and the earth's population is growing, yet billions of people lack the essential requirements for living safe, healthy, productive lives. This report, and the initiative that it is based on, represent a major effort at squaring this circle, by showing how a diverse range of cities have tackled resource use and socio-economic challenges in an integrated way. Much more needs to be done – but positive examples such as these have an important role to play in facing these critical 21st century challenges."

League of Cities of the Philippines

Atty. Shereen Gail Yu-Pamintuan Executive Director

"On behalf of the 145 members of the League of Cities of the Philippines, we would like to congratulate the United Nations Environment Programme for coming up with this report. 'Growing in Circles' which summarizes the lessons and insights from the work of the Global Initiative for Resource Efficient Cities aptly mirrors the realities in achieving resource efficiency at the city-level. While no one-size-fits-all, the report succinctly narrates the journey of the city pilots, a clear indication of the efforts of cities to be more resource efficient and sustainable. We find our 145 cities in the pilot sites. By sharing the various pathways in achieving resource efficiency, namely: Circular Economy in Cities, Recognizing Linkages, and Community-Scale Action, the report acknowledges the efforts and struggles of cities. The Summary Table on page 19 is a great feature to remind us of how all the initiatives fit.

Thank you for this report. We certainly believe that this is what our cities need at this time to promote integrated planning, which is a priority among our Philippine cities. We will share this report and the results of the piloting to our members. We believe that regardless of their progress in coming up with their mandated plans, Philippine cities will find nuggets of wisdom in the experiences of Medellin, Recife, Dongguan, Brussels, and Sorsogon.

This report is valuable. Thank you for your thorough work and for partnering with the League of Cities of the Philippines."

Metabolism of Cities

Aristide Athanassiadis
Co-founder - and Chair, Circular Economy and Urban Metabolism
Université Libre de Bruxelles (ULB)

"GI-REC is perhaps the only long-term multi-stakeholder initiative that focuses on how to address resource use and pollution emissions of cities from a systemic point of view. Their use of the urban metabolism concept to tackle major local and global challenges was innovative and well in advance of other existing initiatives. Yet, instead of just using this metaphor that is frequently confined in the academic realm, the GI-REC wished to operationalise it with in pilot cities with different contexts and set of challenges. For Metabolism of Cities, it was a great opportunity to be part of a larger community of experts to advance the uptake of urban metabolism in policy and practice. While a number of new learning, capacity building, analysis, and decision making tools and activities still need to be implemented to transition towards resource efficient cities, we think that initiatives such as the GI-REC are evident catalysts and we wish to help towards this goal."

The Sustainability Institute

Jess Schulschenk Director

"The Sustainability Institute is proud to support the work of UN Environment's Global Initiative for Resource Efficient Cities in raising the profile of urban resource management in the sustainable development agenda. Optimising the value derived from resources and 'wastes' in cities is a crucial lever for addressing sustainability challenges in urban areas, and for advancing multiple SDGs. This report illustrates that there is great value in understanding how cities operate from a resource perspective, and that such approaches provide significant opportunities to help rapidly growing cities to design and implement more sustainable systems."

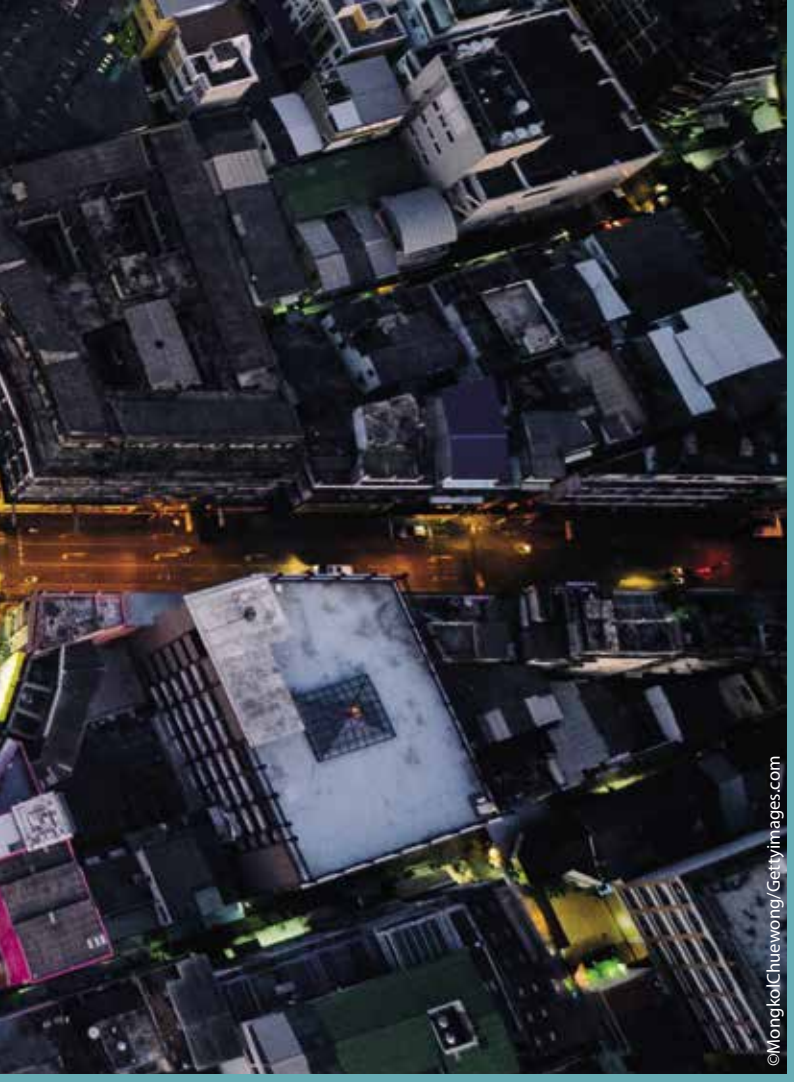
INTRODUCTION

Reports on the global environment to date are clear about the need to change our patterns of resource use. The 2018 report by the Intergovernmental Panel on Climate Change (IPCC) warns that an unprecedented shift in energy and transport systems is needed to keep global temperatures from rising more than 1.5 degrees Celsius. Broader, integrated solutions are needed that address the current patterns of resource use and extraction. This is particularly relevant for urban areas, where demand for resources is highest and drives production everywhere else in the world.

According to the International Resource Panel (United Nations Environment Programme [UNEP] 2016), the amount of primary materials extracted from the Earth through mines, quarries, farms, forests and fisheries each year rose from 22 billion tonnes in 1970 to a staggering 70 billion tonnes in 2010, and is expected to reach 90 billion tonnes by 2050. The extraction, processing, transport, and end use of these materials all contribute to climate change.

Resource extraction is also taking a toll on biodiversity and ecosystems. The World Wildlife Fund estimated in 2014 that more than 50% of the planet's biodiversity was lost over the previous 40 years (WWF 2014). The loss of pollinators translates to critical issues in our food supply, the destruction of forests worsens air and water quality, and damage to corals and other marine life threatens local and global fisheries.

Without significant changes, the demand for resources will only increase along with the growing urban population, which is expected to increase by 2.5 billion between 2040 and 2050 (United Nations Department of Economic and Social Affairs [UN DESA] 2014), with growth concentrated in cities in the global south (these cities, in particular, will need new infrastructure that would consume a lot of resources; hence, it is necessary to work with these cities to avoid infrastructure lock-in). City governments face a pressing set of challenges as they manage competing demands, changing consumption patterns and priorities, and seek to improve public services for an increasing number of urban residents while reducing emissions and resource use and at the same time ensuring equitable distribution of these resources.



GI-REC

Operationalizing Urban Metabolism at the City Level

The Global Initiative for Resource Efficient Cities (GI-REC) was launched by UNEP in 2012 (and houses its Secretariat), targeting the potential for cities to lead resource efficiency efforts. Urban areas are at the centre of the resource overconsumption issue, accounting for more than 70% of global resource use and generating 60% of emissions and waste. GI-REC was designed to identify and test promising approaches and tools in pilot cities around the world, especially in the global south.

During the early stages of the GI-REC (2013/2014), a comprehensive review was conducted to define the focus of the Initiative. Concepts and tools related to resource efficiency were reviewed with the Sustainability Institute (SI) to set the research agenda. A survey was conducted with ICLEI-Local Governments for Sustainability to get input from 100 cities around the world, and a mapping of institutions working on resource efficiency was conducted with a group of independent experts. The review revealed that integrated planning is a priority for cities but that local governments were not equipped with the institutional and individual capacity to make it happen. Research also identified urban metabolism as a robust approach that would enable cities to implement integrated planning and management, but found that the urban metabolism concept was not widely used or well understood by policymakers. Thus, it became one of the primary goals of the Initiative to improve policymaker understanding of urban metabolism and systems approaches to city planning that took into consideration the long-term implications of resource use.

This report gathers the lessons and insights from GI-REC's work with city leaders and technical professionals and summarizes practical pathways towards resource efficiency and a circular economy. By providing research highlights and giving examples of cities with a bold ambition and strong political will, this report hopes to inspire a paradigm shift in the way cities think of 'growth' and initiate change in the way cities are planned and managed.

GI-REC Partner Engagement Snapshot

KNOWLEDGE CREATION	CONTRIBUTION TO GLOBAL PROCESS	PILOTING
International Institute for Environment and Development (IIED)		
Sustainability Institute, South Africa (SI)		
Ecocity Builder		Ecocity Builders
	Sustainable Cities Programme, Brazil	
League of Cities of the Philippines (LCP)		
Metabolism of Cities		Metabolism of Cities
China-ASEAN Environment Cooperation Center (CAEC)		
World Council on City Data (WCCD)		
		Brussels Environment
		ARIES, Recife (Brazil)
Massachusetts Institute of Technology (MIT)		
University of Minnesota (Sustainable Healthy Cities Network)		
		Bicol University
ENERGIES 2050		
Cities Alliance		
International Initiative for a Sustainable Built Environment (iiSBE)		
ICLEI - Local Governments for Sustainability		
UN Habitat		
	FIDIC	
		Centro de Gestao e Estudios Estrategicos, Brazil (CGEE)

CITY PILOTS

Much of the work of GI-REC is based on the recommendations of the International Resource Panel expert report on City Level Decoupling (This report can be found at: www.resourcepanel.org/reports/city-level-decoupling; UN Environment 2013a). The report advocates using the concept of urban metabolism, which makes sense of a city's complexity by seeing it as a living organism with continuous flows of inputs and outputs. Using the urban metabolism concept, a city can have a clearer picture of its resource use and take concrete steps towards reducing overall consumption. GI-REC looked at how the urban metabolism concept is being implemented globally, and found that while small pilots exist, effective integrated approaches that tackle city-level consumption continue to be a challenge[1].

GI-REC worked with academics and city practitioners around the world to address this issue. Key concepts related to reducing overall consumption, such as resource efficiency and circular economy, were studied and discussed with subject experts.

While research and global advocacy were crucial, pilot projects formed the cornerstone of the GI-REC approach. It was from engaging directly with cities that gaps were identified.

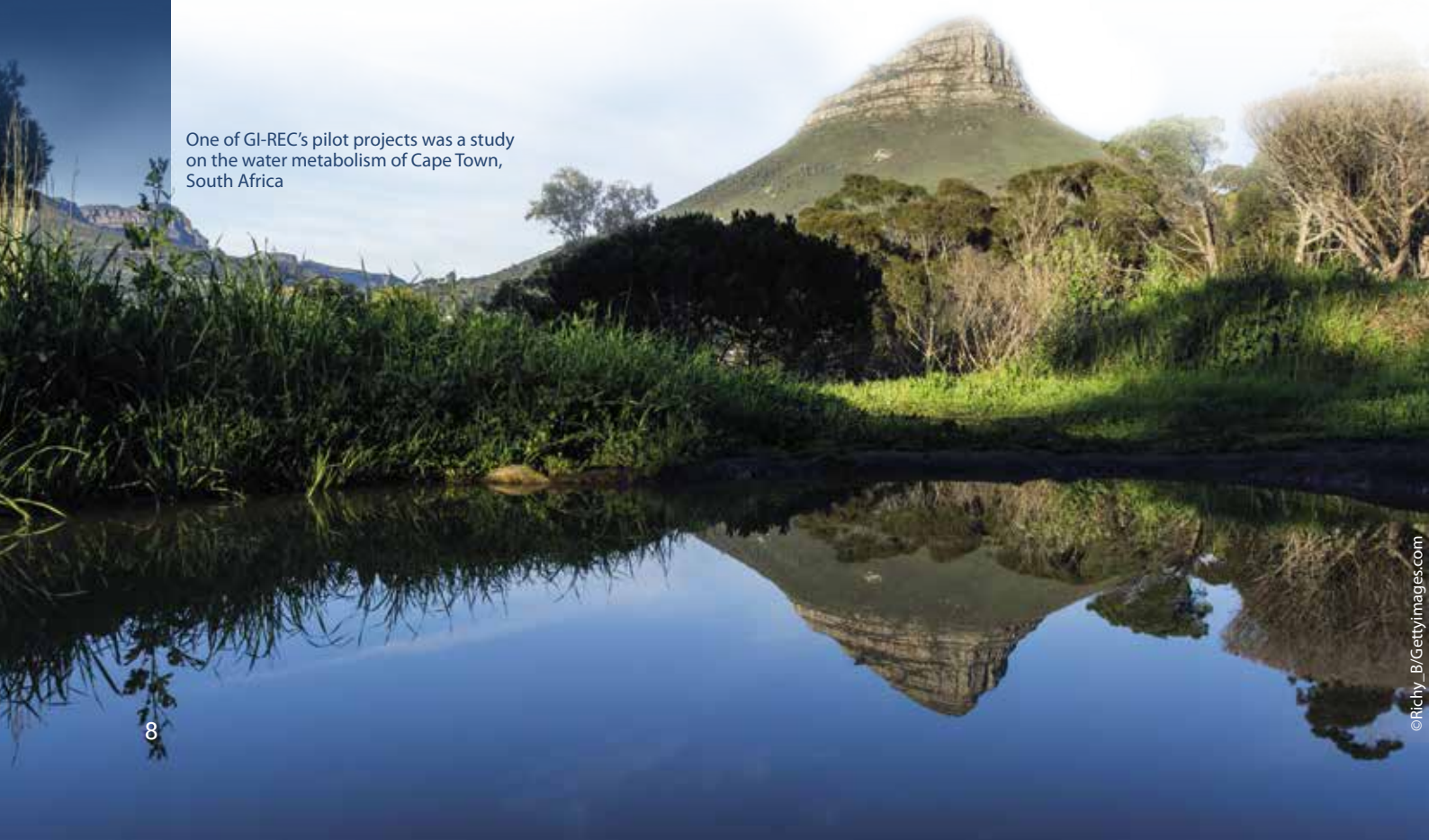
GI-REC piloted resource flow analysis at various scales in eight cities (of which full separate reports are available online).[2] In each location, The Initiative worked closely with local government, researchers and civil society using a participatory approach to design a pilot project that was relevant for the local context. The goal was to provide practical assistance with research, analysis and policy tools that would enable decision-making and action.

The pilot process followed a six-point intervention cycle in each of the cities, enabling GI-REC to investigate both vertical (national to city to neighbourhood) and horizontal (across sectors) integration. The intervention cycle is similar to approaches used by GI-REC partners such as ICLEI and Ecocity Builders.

The intervention cycle was applied differently depending on factors unique to each of the pilot cities, such as (a) willingness of the government to engage, (b) budget available to support piloting process, (c) technical capacity in the city and the country, and (d) political boundaries and relationships.

1 Unpublished Comprehensive Review (UN Environment 2013b).

2 Case studies for the pilot projects are available at www.resourceefficientcities.org /cities. Detailed case studies are available for Brussels, Belgium; Cape Town, South Africa; Dongguan, China; Recife, Brazil; and Sorsogon, Philippines. For Cusco, Peru; Medellín, Colombia; and São Paulo, Brazil, physical and financial plans (and videos) developed by the communities for their neighbourhoods are available.



One of GI-REC's pilot projects was a study on the water metabolism of Cape Town, South Africa

Pilot Project Partnerships

MEDELLÍN, COLOMBIA

Physical and financial plan using resource flow analysis for a community based in a former dumpsite.

BRUSSELS, BELGIUM

Roadmap for circular economy with indicators to monitor progress.

DONGGUAN, CHINA

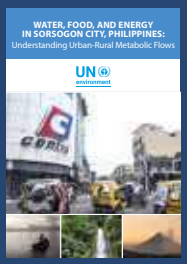
Analysis of residential and industrial material flows to identify priorities for consumption reduction.

CUSCO, PERU

Resource use and how it can preserve cultural heritage.

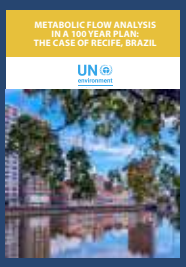
SÃO PAULO, BRAZIL

Urban metabolism data gathered at neighbourhood scale was used as an argument for city support of community-led environment actions.



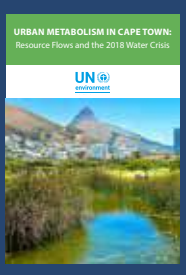
SORSOGON, PHILIPPINES

Research into water and agricultural flows had an impact on city budget and policies.



RECIFE, BRAZIL

Integration of urban metabolism approaches into the city's data management system and 100-year plan.



CAPE TOWN, SOUTH AFRICA

Research on how urban metabolism analysis could address water scarcity.

The reports on these pilot cities can be found on: www.resourceefficientcities.org/cities

For example, while there was less transparency and data availability in Dongguan, China compared to Recife, Brazil, there was also more funding available to gather data in Dongguan, and GI-REC was able to work closely with the internationally respected Tsinghua University to address data gaps. Given the wide range of city types, political situations, and contexts, the case studies that accompany this report have varying degrees of depth.

In common to all of GI-REC's interventions is a collaborative and participatory approach. A wide range of stakeholders were engaged through the different stages of the process, from problem identification to solution implementation. At least three stakeholder groups were engaged in each site. Through extensive consultation, the project was able to determine the priorities of the city, its most important resource-related issues, and possible solutions.

This consistent but flexible intervention process gave adequate space for creativity in each pilot city, allowing solutions to emerge that would fit city needs.

The GI-REC pilot process followed a six-point intervention cycle in each of the cities, enabling it to investigate both vertical (national to city to neighbourhood) and horizontal (across sectors) integration. It ensures that its solutions are practical and useful to city/country, attuned to local processes and plans and builds local capacity, and participatory in nature.

PATHWAYS

From the complex river systems of Recife, to the tall commercial buildings of Dongguan, to Sorsogon's volcanoes, and the rich cultural heritage of Cusco, GI-REC has worked with and in cities with different needs and priorities. The variety of cities involved in the piloting has allowed the Initiative to explore varied pathways for a city to achieve resource efficiency.

Three pathways were most predominant in the piloting experience. They are presented and described separately in succeeding text for the sake of clarity, but they are, in reality, complementary and should ideally, be used in combination.

PATHWAY 1 Circular economy in cities

One of the primary narratives that emerged during the implementation of GI-REC is circular economy. While the concept is not new, its application in the past has been primarily at the global and national scale. Possible applications at the city level are gaining ground only recently. Due to the novel nature of circular economy in cities, there have been various interpretations. Some cities imagine circular economy to be better recycling, less plastic waste, or minimalist lifestyles. Any of these activities could be part of a broader circular economy strategy but **an effective circular economy approach at city level must be systemic**. A circular economy balances economic development with environmental and resource protection and emphasizes efficient use and recycling (UN Environment 2016). Its goals are to rebuild natural capital, to keep products and materials in use as long as possible, and reduce pollution and waste (Ellen MacArthur Foundation 2017).

There are many benefits to shifting towards a circular economy, including cost savings from reduced resource use, emissions reduction, and inclusive and equitable job creation.

The Circularity Gap report (Circle Economy 2018) estimates that a transition to a circular economy could create between $380 to $630 billion in annual net material cost-saving opportunities. McKinsey research shows that a transition to a circular economy in the mobility, food, and built environment sectors alone could lead to emissions reductions of 48% by 2030, and 85% by 2050, compared with 2012 levels (McKinsey Center for Business and Environment, 2015). European Union studies indicate that the EU circular economy package would produce cost savings of around €600 billion through actions such as waste prevention, eco-design, and re-use, while contributing to the creation of more jobs (European Commission 2015).

Attracted by the potential for combining sustained economic growth and improved environmental performance, several cities (including Amsterdam, Paris, London, Brussels, Toronto and Melbourne) have developed circular economy strategies to make the transition a reality. Often, these strategies form part of the cities' overall sustainable urban development plans.

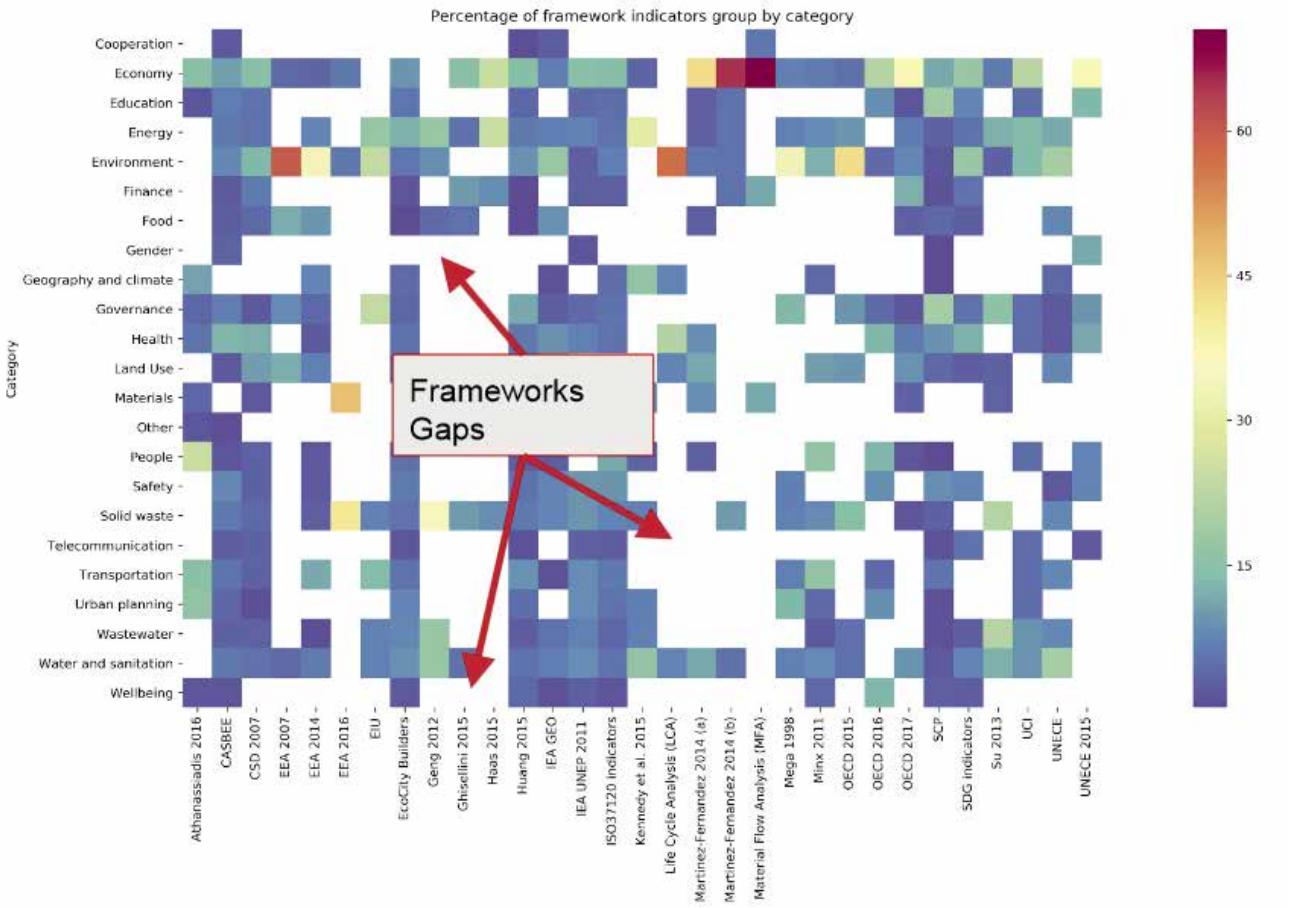
Plaza de Armas, Cusco, Peru)
Source: https://commons.wikimedia.org/wiki/File:Plaza_de_Armas_Cusco,_Peru.jpg

The social and economic aspects of a circular economy are important to a city's strategic planning and political priorities. Many of the cities' circular economy strategies incorporated social and economic aspects as well as environmental, with quality of life, health, and well-being as part of their overall goals. However, research by UNEP (through the heatmap analysis, as seen below) found that none of them had indicator frameworks which could fully capture the potential socio-economic impacts of a circular economy (UN Environment 2018a).

To address this gap, GI-REC worked with Brussels Environment, Ecocity Builders and the World Council on City Data. to develop a monitoring framework that evaluates impacts on quality of life particularly on the vulnerable and marginalized groups of society.

Attempting to quantify quality of life led to using 'circular economy jobs' not only as a primary indicator of well-being but also as an indicator of a city's overall circularity [described further under tools in this report]. GI-REC found that one of the particularities of implementing circular economy in cities is the difficulty in defining boundaries of material flows. By anchoring material import dependencies to employment data and national economic sectors, we are able to keep the geographical boundaries and provide the city with a robust number that can be used for policy making.

A heatmap indicating the gaps in the global indicator frameworks studied by UNEP



This heatmap analysis made the thematic focus of each indicator framework more evident. The higher the number of indicators regarding a specific theme - such as economy, food, gender, etc. - in the indicator framework, the "warmer" the color ("red" indicating very warm, and "purple" very cold).

PATHWAY 2 Recognizing linkages

The second pathway is obvious, but one that is often sacrificed for political expediency – the need for a city to go beyond its boundaries to effectively manage its resources.

Cities do not exist in isolation, and to be sustainable, must develop as part of a broader urban and peri-urban area. This is especially true for cities that aspire to build a circular economy since circularity is very difficult – if not impossible – to achieve in cities that import many of its basic needs. Important material flows often occur between the city and surrounding area, such as with Sorsogon City and the surrounding farms which grow much of the city's food. And in Recife, the city centre receives inflows of workers on a daily basis from the larger urban area.

UNEP and its partners considered how best to understand and manage the interconnections of the city and its periphery. In each case, it was important to create a concrete picture of this connection.

Expanded input-output tables, Material Flow Analyses, Sankey diagrams, and interactive visualizations [described further in the "Research and Tools" section] were helpful in interpreting data about the flows coming in and out of a city. In Sorsogon, data analysis for the city's water flows and the agricultural sector (see table below) showed Sorsogon's water flows and consumption patterns (particularly in its agricultural sector) while at the same time showing that the city imports almost 26% of its rice. This finding demonstrated the potential for Sorsogon to become more self-sufficient in rice production through increased water efficiency measures in the agricultural sector and helped the mayor justify the expansion of the city's organic farming programme. Sorsogon now produces organic rice for local use.

Economy-wide Material Flow Analysis for rice production and consumption in Sorsogon

INPUT		SOCIETY/ECONOMY		OUTPUT	
		Material Accumulation	tons/ year		
Unused Local Extraction	6 936.55 tons/ year				
Local Extraction	12 945.08 tons/ year	**Material Troughput (Local Consumption)**	18 408.05 tons/ year	**Unused Local Extraction**	6 936.55 tons/ year
				To Nature (Local)	1 400.77 tons/ year
Imports	6 926.65 tons/year			**Exports**	62.92 tons/ year
26 808.28 tons/year		**18 408.05 tons/year**		**8 400.23 tons/year**	

PATHWAY 3

Community-scale action: The neighbourhood approach

Community-scale action was the third pathway that emerged from the pilots as a means for cities to take action following a resource analysis.

UNEP identified neighbourhoods (hence called the 'neighbourhood approach') as windows for immediate action. Acting as innovation labs, neighbourhoods are able to pursue activities at a smaller scale that can then be used as proof of concept for replication at city level. Working at a smaller scale also allows intersectoral action (Pathway 2) without involving too many people or large bureaucracies.

In Medellín, Colombia, the neighbourhood approach was an effective starting point to joint work.

GI-REC worked with the international non-profit Ecocity Builders and the city of Medellín to develop a physical plan for the neighbourhood of Moravia. The neighbourhood is constructed on a former dump site that was upgraded as part of the city's urban renewal programme, and was having issues with the local government over plans for relocation due to instability of the land and possible health issues from toxic waste. Metabolic flow analysis helped the city to understand the flow of people and the importance of connectivity for resident livelihoods. The residents also understood the health risks due to soil quality and other environmental elements. The result was an integrated physical plan that articulated the residents' aspirations (e.g. access to livelihoods) and the local government's priorities (e.g. safety and security). The project has triggered discussions on participatory planning in Medellín and how a resource-based approach can enable pragmatic discussions.

In the case of Jardim Helian, São Paulo, Brazil; GI-REC, with the Sustainable Cities Programme and the Federal University of São Paulo, co-created with the residents a sophisticated indicator framework that helped the community better articulate its problems to the local government. Using locally-generated data, researchers from the university and residents analyzed issues of waste management, biodiversity conservation, and vulnerability of their homes to flooding.

At the end of the project, residents were able to present a robust integrated physical and financial plan to the local government and potential external donors. The plan highlighted community concerns and linked them with local government priorities while keeping the aspirations within a reasonable budget. It covered a broad range of issues that looked at the community from a systems perspective – from the installation of waste-collection points to the recovery of bulky items and construction rubble, to urban forestry to maintain green areas, and the installation of bus stops and the creation of proper schedules.

Neighbourhood approach in Jardim Helian, São Paulo

"The idea of the project was, based on indicators, to make a survey, establish priorities and, from these priorities, to think about projects that could help to improve the environmental quality of the region," says Clara Meyer, Indicators Coordinator, Sustainable Cities Programme.

To learn more, visit: http://tiny.cc/gi-rec-brazil

RESEARCH AND TOOLS

In spite of the differences, technical experts in Belgium, China, Brazil, and the Philippines had one thing in common: difficulty grasping the details of the *implementation* of circular economy and a systemic approach to resource planning and management at city level during discussions. The integration of the long-term limitations of resources into city planning is quite novel and reflected the need to develop tools and approaches that would make this easier for city practitioners.

GI-REC developed tools designed to improve policymakers' understanding of urban metabolism, circular economy, and related concepts that aim at enabling city practitioners to plan from a systems perspective. These tools built on UNEP publications such as *Resilience and Resource Efficiency in Cities* (UN Environment 2017) and *Sustainable Urban Infrastructure Transitions in the ASEAN Region: A Resource Perspective* (UN Environment 2018b) which summarize some of the conceptual foundations of the piloting process.

More difficult than developing the tools themselves was adapting these tools to local conditions (e.g. addressing the lack of data-gathering capacity) and translating the products into guidance for policy action – all the while keeping costs low enough for it to be accessible to emerging cities.

Challenges forced the Initiative to look for alternative solutions. In addition to online tools and materials, the GI-REC consortium built local capacity to conduct resource flow analysis, worked on data visualization, created open source modeling software, and developed a tool to measure circular economy jobs at city level.

Resource flow analysis

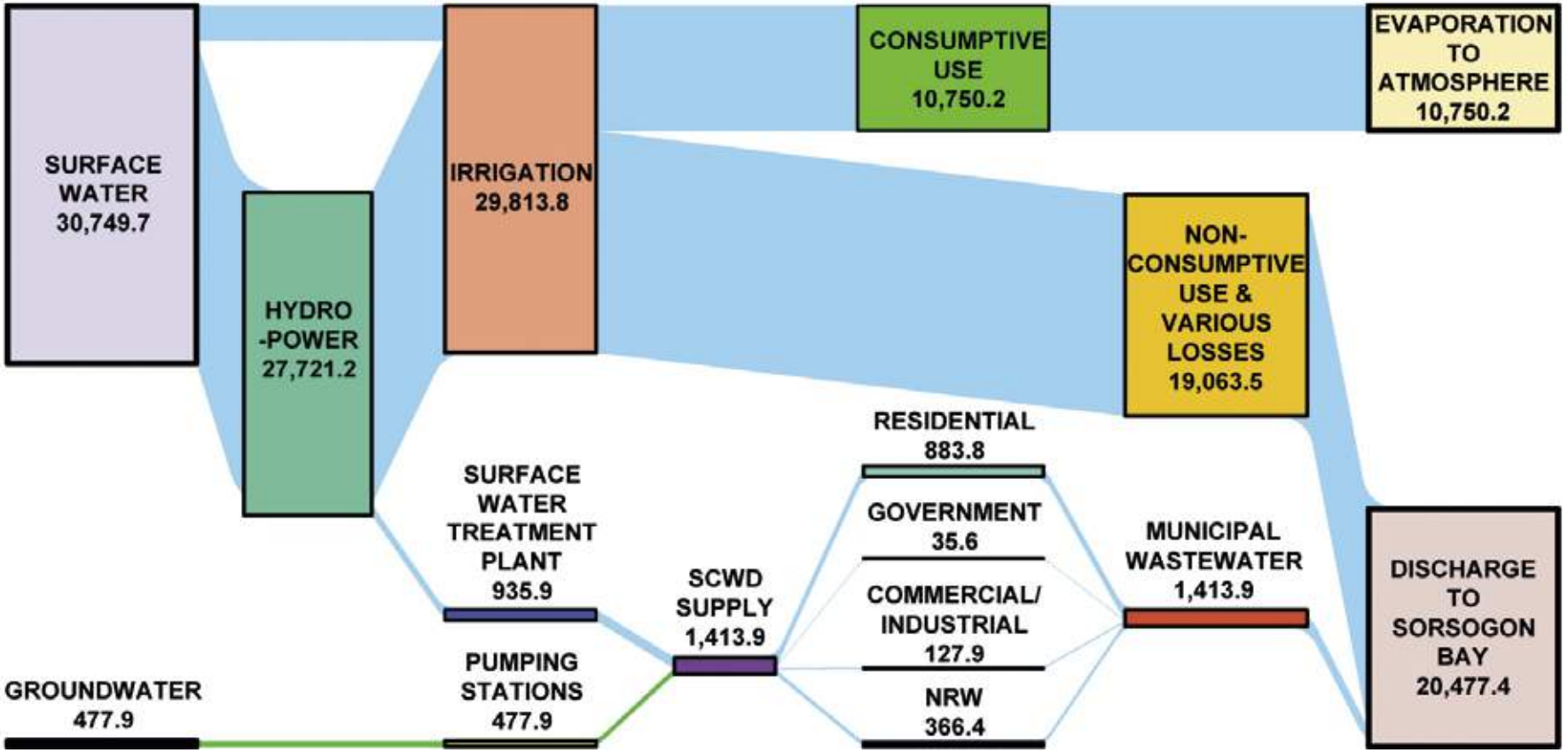
GI-REC undertook analyses of resource flows drawing on key concepts from established urban metabolism methodologies. Material Flow Accounting and Input-Output tables (Kennedy, Cuddihy, and Engel-Yan 2007) were used to understand how resources were moving in and out of the city, using actual data when possible. These resource flow analyses determine the amount of resources coming in (as inputs), the amount of resources being used and stocked within the city, and the resources going out of the city (as outputs). Applying the technical tools was challenging at times – in Sorsogon, developing an Economy-wide Material Flow Analysis (as shown on page 13) to better visualize the flow of resources in and out of the city was time-consuming, with a substantial amount of time invested to explain the concept to national and local experts. This experience illustrated the need to further simplify tools to improve accessibility.

Visualizations were critical for understanding flows more intuitively. Sankey diagrams (which are graphic illustrations "of flows - like energy, material or money - where they can be combined, split and traced through a series of events or stages") allowed officials to clearly see the potential impact of the transfer (or flow) of a resource from one part of the system to another. The width of each arrow is proportional to the quantity of the flow.

Below are two examples of Sankey diagrams used in the piloting:

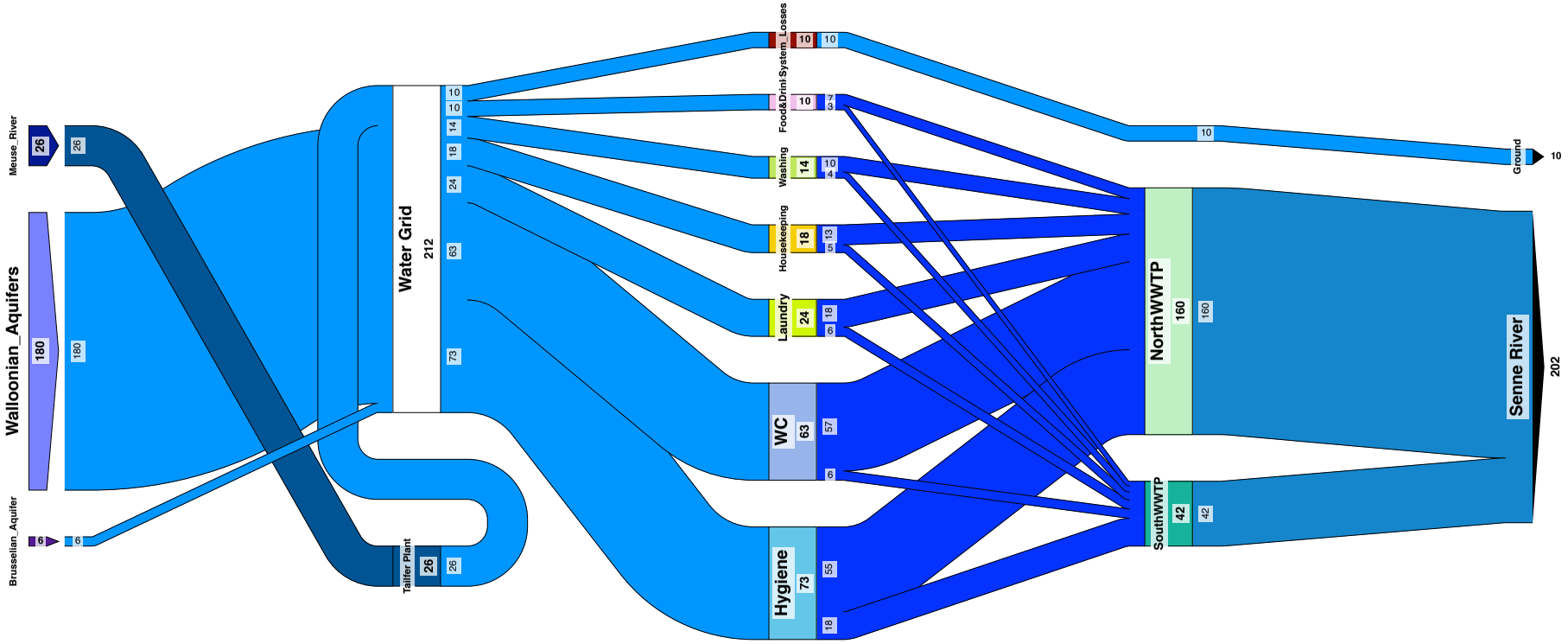
Flow of water for a specific watershed in Sorsogon City, Philippines

Estimated water flow in Ticol-Cawayan sub-watershed in 2016 (thousand cubic meters)



Flow of water in litres per day through a typical Brussels Capital Region residential household

(by Ecocity Builders © Ecocity Builders 2018)



The diagram on page 16 shows that irrigation is the major user of water in this particular watershed in Sorsogon City, accounting for 95.5% of the total water used during the year – a powerful image of the dominance of the agriculture sector in water usage. It also showed that a large amount of water use is unaccounted for ('Non-consumptive use and various losses'). This Sankey diagram allowed the mayor to better understand where there would be the most potential impact in curbing water loss and concentrate efforts in these areas. Rather than launching an expensive campaign on individual residential consumption, for example, the mayor invested in educating the agriculture sector and monitoring water loss.

The second diagram on page 17 is an illustrative Sankey diagram for the City of Brussels that serves as a snapshot of how and where water is coming from and going to as it meets household demands. In this diagram, the largest share of water use is for hygiene, which suggests that Brussels might benefit from encouraging shorter showers. In addition, recycled water is not used and instead a unitary sewage system mixes both greywater and rainwater together; thus the city's wastewater treatment plants are treating twice the amount they should be treating).

Data management tools

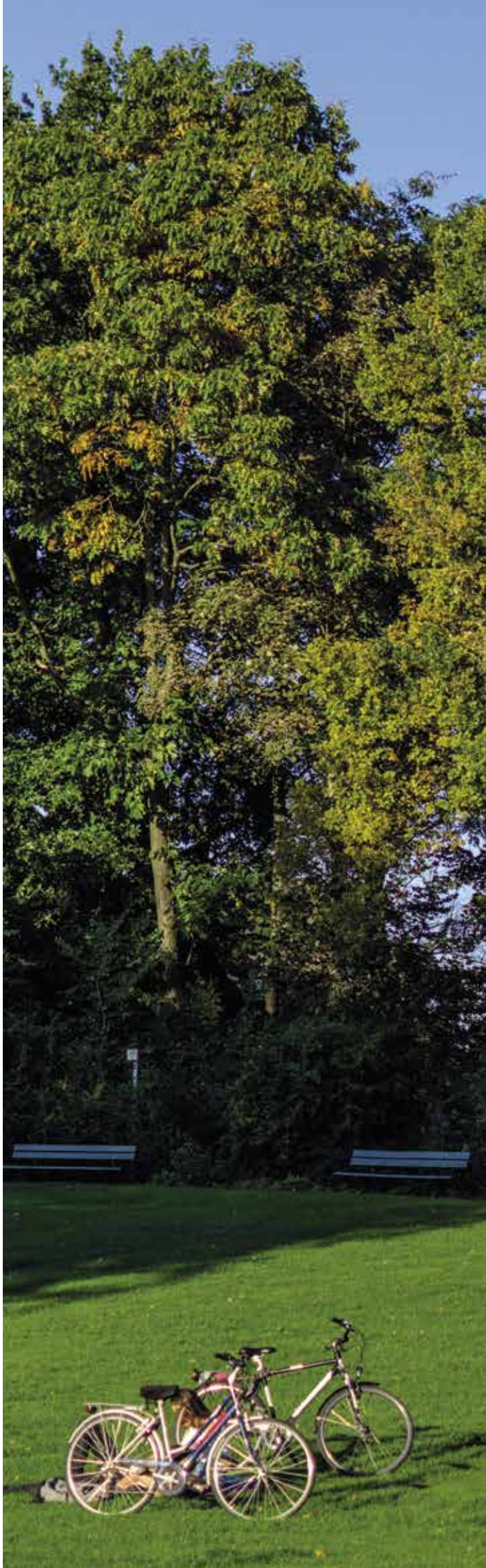
Improving data management capacity was a critical element of successful piloting. Local governments need data to carry out an analysis of resource flows, but often data analytics are outsourced, and if funding runs out the city is unable to continue good data management practices. Pilot cities were also encouraged to promote a "data culture."

UNEP made an effort to connect with career officials and ensure that they were directly involved in gathering, processing, and analysis of data. Building capacity was a challenging but rewarding endeavour.

UNEP and its partners in the GI-REC also chose to use existing data management frameworks and use open source national data, rather than pay for new data or develop a new indicator framework. This strategy was meant to ensure replicability in the country since other cities which would want to do the same thing may not have external support. We also found that many cities already adopted various frameworks initiated by international organizations and there was some level of 'indicator fatigue'.

A few of the frameworks that are widely used are:

- ISO 37120: Sustainable Cities and Communities – Indicators for city services and quality of life (International Organization for Standardization 2018)
- City Prosperity Index (United Nations Human Settlements Programme [UN-Habitat] 2014)



- Comprehensive Assessment System for Built Environment Efficiency (CASBEE) for Cities
  (Japan Sustainable Building Consortium and Institute for Building Environment and Energy Conservation 2015)
- International Ecocity Standards (Ecocity Builders 2018)
- Global Environment Facility's (GEF) Urban Sustainability Framework used by GEF pilot cities
- Sustainable Cities Programme (Brazil)

Major cities in developed countries (particularly in Western Europe and North America) often have the requisite infrastructure and capacity to gather, process, and analyze data. In secondary cities (particularly in the global South) this is not often the case. GI-REC found gaps in data quality, availability, and accessibility, and the pilot projects encountered several data-related challenges:

- Data management was distributed throughout different government offices without any effort to connect datasets and ensure shared utility.
- Quality and access to data was inconsistent. Larger cities had more data-gathering capacity while smaller cities had only outdated data, which was often stored at the national level. In some cases, data was machine readable and in an open format; in others, data gathering and analysis was done manually.
- City practitioners and elected officials were often wary of sharing data.

UNEP found a clear gap in data management and analysis capacity and embarked on a joint effort with GI-REC consortium partners to make tools/technology more accessible to partners and bring the content to a wider audience. The GI-REC consortium of global experts [notably China-ASEAN Environment Cooperation Centre, Ecocity Builders, International Institute for Environment and Development, the League of Cities of the Philippines, Metabolism of Cities, and Sustainability Institute] developed several products with the goal of making circular economy and resource efficiency accessible and useful especially to developing countries. The approach was not about making new indicators and standards but rather building capacity to use materials that already exist. These included:

- A short video explaining urban metabolism (2017).
- A publication entitled "Urban Metabolism for Resource-Efficient Cities: from Theory to Implementation" (2017) that simplified the concepts of urban metabolism for policymakers.
- A collection of online materials (videos, blog posts, etc.). showcasing city experiences on the use of urban metabolism in cities.
- A Massive Open Online Course (MOOC) on Urban Metabolism (2018).

These materials can be found on the GI-REC website:
www.resourceefficientcities.org/resources

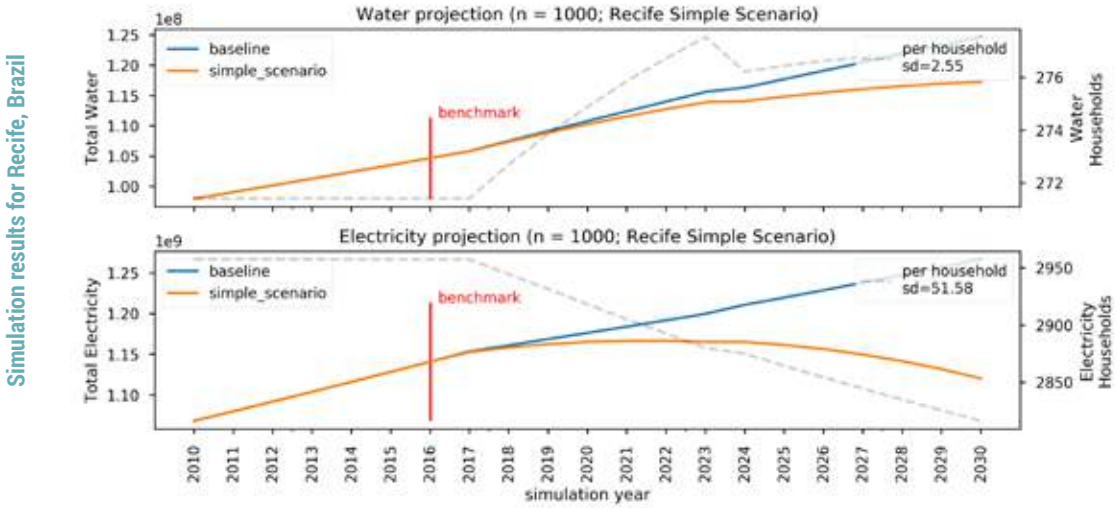
Scenario building and planning

Piloting also revealed that the tools to address gaps in data availability are often ill-equipped to address the issues faced by developing countries, and do not specifically address resource flows. For cities with limited resources, UN Environment developed a Spatial Microsimulation Urban Metabolism (SMUM) tool that combines two powerful approaches for the simulation of resource flows within cities: spatial microsimulation (SM) and urban metabolism (UM).

The SMUM tool (www.resourceefficientcities.org/resources/smum/) can be used to assess the impact of a city's policies on resource flows and requirements. Unlike other tools that model policy impacts on a city-wide level, SMUM provides insights on individual groups in the population, broken down for instance by income, education, age, or household size. This can be of great value for cities to make sure that their policies are fair and reach everyone in the population, which aligns with the New Urban Agenda (UN-Habitat 2017) and the Sustainable Development Goals (United Nations, General Assembly 2015). The SMUM tool can:

- Support the downscaling of national-level data for use at the local level in data-scarce environments.
- Include a spatial element in scenario planning calculations to ensure equitable distribution of resources during circular economy transitions.
- Support the calculation of circular economy jobs and job distribution.

An example of a simulation result (in this case, for Recife), can be seen below.
The development of a better interface for the SMUM tool is one of the next steps in the GI-REC's work.



Calculating the shift towards a circular economy through circular economy jobs

In the course of piloting, GI-REC faced with the dilemma of how to calculate a systemic shift in the city towards a circular economy. Data on raw material consumption is available at global and national level but it is difficult to delineate what consumption occurs within the permeable borders of a city.

Another issue that was mentioned previously in this report is the lack of sufficient indicators to measure social impacts and quality of life. Systems approaches to city planning and management such as circular economy or resource efficiency often had robust data for environment and economy but quality of life measures were not explicitly included.

GI-REC worked closely with Ecocity Builders and the World Council on City Data to develop a solution for measuring overall circularity and incorporating quality of life indicators.

Drawing from the experience of Paris, London, and Amsterdam, the consortium of GI-REC, Ecocity Builders, and the World Council on City Data developed a monitoring framework for Brussels that took into consideration demographic data, environmental sustainability, and quality of life. GI-REC found that there were sufficient indicators for environment and economy in Brussels but few for quality of life. It was decided jointly with expert partners and Brussels Environment that considering the political importance of the unemployment issue

in Brussels, the number of jobs created would be a good quality of life indicator.

UNEP also collaborated with Circle Economy to further develop a calculation method for circular economy jobs, as an indicator of a city's overall shift towards greater circularity. UNEP material import dependency data (downscaled from the national level), demographic data, and employment data (using national-level sectoral classifications) to calculate circular economy jobs and this has been found to also be a good indicator of a city-level shift.

There are plans to pursue this work stream this year. A consolidated circular economy jobs calculation methodology is now in progress with UNEP, Circle Economy and ICLEI as the main consortium partners. While still in its nascent stages, this methodology is already getting interest from potential pilot cities and the global community.

CONCLUSION

Cities are at the forefront of effectively addressing the challenges of climate change, resource scarcity, and poverty are global in scale. The research and piloting of the Global Initiative for Resource Efficient Cities provides qualitative and quantitative evidence that cities can have a catalytic role in shifting global trends in resource consumption.

With a systems approach to city planning and management, local governments can effectively utilize resource consumption data in their policymaking, take action on resources and carbon, and address socio-economic issues through a circular economy approach. The work of the Initiative to date sets the stage for further implementation and experimentation with a broader set of cities.

EFFECTIVE USE OF DATA IN LOCAL LEVEL POLICYMAKING

Piloting under the GI-REC demonstrated that material consumption is a useful measure that gives city leaders valuable insight in policymaking. More importantly, these are actions that are within their jurisdiction. Through the implementation of the GI-REC, UNEP gathered a set of strategies and tools that support cities in their selected pathway to resource efficiency.

Understanding resource flows makes local governments more aware of their opportunities and limitations:

- Sorsogon City in the Philippines, for instance, found an opportunity to make an impact in overall water use through better management of the agriculture sector.
- Brussels is now taking steps to make its circular economy goals a reality by incorporating quality of life along with its environmental objectives.
- A better understanding of resource flows gave both cities insight to possible budget priorities.

Tools gathered and developed still need further adaptation and outreach to become more accessible to cities in the developing world. Accompanying training and advocacy would also help local practitioners better understand the utility and applications of the tools and concepts. Replication of neighbourhood and city efforts towards a more circular economy at the national level is also a logical next step.

SUMMARY TABLE

PATHWAYS	UTILITY IN POLICY AND DECISION-MAKING	TOOLS GATHERED AND DEVELOPED
Circular economy in cities	Useful for enabling a shift to a more circular economy over time	Circular economy jobs calculation, SMUM open-source scenario planning, data and resource flow analysis
Recognizing linkages	Important for understanding system flows and priorities for interventions	Data and resource flow analysis, Sankey diagram visualizations
Community action approach	Bottom-up action to test interventions that may be replicated more widely	Spatial microsimulation urban metabolism model downscaling/upscaling of data sets, community-level data gathering

CONCLUSION

TAKING ACTION ON RESOURCES AND CARBON

Cities have a leading role to play in tackling climate change. Reducing emissions is essential to slow the rapid warming of the planet but focusing on carbon targets is not enough. The situation has in fact gotten worse. According to UNEP's Emissions Gap Report (UN Environment 2018c), global CO_2 emissions increased in 2017 after 3 years of stagnation.

While climate change and resource efficiency are two separate work streams at the global level, at the city level, climate change and resource efficiency initiatives have many shared goals, and integrating analysis and policy efforts can help policymakers tackle these environmental challenges more effectively. Data on resource usage and flows can be used to inform choices about types of transport and energy infrastructure, incorporating issues such as the product life cycle of photovoltaic technologies to design policies that maximize emissions reductions and also have the best overall environmental impact.

Climate change adaptation and resource efficiency also go hand in hand. A city is more resilient to the effects of climate change if it has prioritized the long-term sustainability of key resources such as water, food, and energy. This ensures that cities are prepared not only for shocks but also long-term stresses (UN Environment 2017).

ADDRESSING SOCIO-ECONOMIC CHALLENGES THROUGH A CIRCULAR ECONOMY

UNEP's research into circular economy in cities raised the uncomfortable question of how environmental justice and equity – particularly in access to resources – is not adequately addressed. The growing disparity between rich and poor in cities has given rise to social unrest in countries as different as Zimbabwe and France, and all this manifested most clearly at the city level. At the global level, the disparity is even more severe, with an average inhabitant of Europe consuming three or four times more resources, than a resident of Asia or Africa. Inhabitants of rich countries consume up to 10 times more than those in developing countries (Lorek and Fuchs 2013). The efforts of cities in the global North to improve their resource efficiency make some progress towards reducing that disparity.

There is space to better define and refine the circular economy narrative for cities using the tools developed and identified under the GI-REC. This includes plans for UNEP to continue to look at the issue of circular economy jobs together with partners like Circle Economy and ICLEI. The circular economy jobs methodology research and application will focus on tracking not only the shift from linear to circular from the perspective of economic sectors but also the impact to those who are not socially mobile.

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THE EVOLUTION OF CITY GROWTH

As cities continue to plan, manage and adapt to their own local context and constraints, there is a larger conceptual debate over degrowth and green growth—'degrowth' advocates the redirection of economies away from the perpetual pursuit of growth, while 'green growth' espouses economic growth and development while ensuring sustainability of natural resources.

A city could pursue either strategy as a means to enhance competitiveness, livability, and quality of life. A quaint small town like Sorsogon could choose a degrowth path to ensure that it keeps its charm and attraction for tourists, while a big industrial city like Dongguan could pursue a green growth path in line with the goals of its manufacturing sector. The investments towards either strategy can both lead to a more circular economy but with two cities choosing drastically different urban forms.

UNEP 6th Global Environmental Outlook (UN Environment 2019) reminds us that growth in the next few decades will not come from the megacities and world cities but rather in smaller urban centers with current populations of less than half a million. The location of future growth gives us an inkling of the immense variation in how cities will continue to develop and grow.

Throughout its implementation, the Global Initiative for Resource Efficient Cities has been a witness to the tireless and committed local government officials and urban practitioners that work on local-level actions that address global environmental concerns. The best of these professionals recognize that their actions are most effective when linked with national and international concerns, but must also remain relevant to their own citizens.

To paraphrase urbanist PD Smith, the goal is not to develop an 'ideal city', but rather urban areas that can evolve as they face global challenges. The most successful cities learn, unlearn, and relearn in a continuous cycle of growth. And increasingly, those cities are taking responsibility for the long-term health and wellbeing of their citizens by looking beyond their own boundaries.

It is with the inspiring examples seen in GI-REC's work of how to balance individual and global priorities, the political and the practical, and immediate and long-term objectives, that we will continue to support the constant evolution of cities and harness local strength for global action.

"But ideal cities are very much the product of their own ages. Designed as complete urban statements, they bear the unmistakable imprint of their own culture and world view in every street and building. And yet to be successful a city has to be open to continuous development, free to evolve and grow with the demands of new times. Like science fiction accounts of the future, ideal cities quickly become outmoded."
– PD Smith "City: A Guidebook for an Urban Age"

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