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Article

Making Asian Cities Greener: A Tool to Measure Environmental Performance Over Time and a Method to Implement a Green City Action Plan

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Abstract This paper uses the IHS Green City Conceptual Framework (IHS-GCCF) to present and discuss the development and application of a tool to measure Environmental Performance (EP) over time applied to ten Asian cities and a method using these results to implement a Green City Action Plan (GCAP) applied to the city of Manila. The tool measures EP over time and helps to explain possible factors contributing to the variation of the EPs in the studied time. The GCAP uses the EP results to develop a green city action plan to improve the current EP for a given period. Both tool and method fulfil gaps found in the green city literature, contain innovative approaches, and help cities to measure and plan improvements in their current EP. By applying the EP tool to ten Asian cities in two periods (2007–2009 and 2015–2018), the paper shows that Singapore and Hong Kong had the highest EPs and Bangalore had the lowest. Implementation of water management and climate change strategies are some factors explaining the improvement in Hong Kong's EP. A strong increase in population size is behind the EP reduction in Bangalore. The Manila GCAP proposes to improve the current EP of the city from 15.43 to 17.41 in twelve years.

Keywords green city; environmental performance index; green city action planning; climate change; sustainability

1. Introduction

Urbanization and urban growth have increased the proportion of the population living in cities, leading to uncontrolled use of fossil fuels, increasing the city's footprint, reducing our natural resources, and affecting multiple aspects of the citizen's quality of life and the city's sustainability [1–3].

As a result of this unsustainable model of development and with the advent of climate change, cities are trying to reinvent themselves and search for new approaches to deal with the complexity of, designing and managing their built environment (infrastructure), preserving, and protecting their nature (city environment) and at the same time improving the wellbeing of their citizens to become more sustainable (greener) [1,4–7].

In these last two decades many concepts, definitions, tools, and methods related to green cities have been developed [8–10]. Some of these studies on green cities have attempted to conceptualise and define them through methods and tools such as indexes to measure sustainability and environmental performances [11–13] and methodologies to develop Action Plans to help cities prioritise problems and define actions to improve environmental performance and become greener [14–18].

Despite all the studies conducted so far, the existence of a broad range of environmental and other urban-related issues within a city has not resulted in a single commonly agreed definition or concept of a green city [10,19,20]. Many gaps still exist in this field such as the lack of simple green city conceptual frameworks, definitions, tools separating qualitative and quantitative indicators to measure environmental performance, indicators rooted in a conceptual framework, simplified tools to track progress in cities' environmental performance over time, and integrated approaches and methods that use the cities' environmental performance to help in their planning and to prioritise actions to improve their current environmental performance [21,22].

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An attempt to fill the green city literature gap is the green city Conceptual Framework (IHS-GCCF) [19] developed by the Urban Sustainability & Climate Change Resilience department (USCCR) from IHS. The concept is an umbrella framework which attempts to facilitate the understanding of what a green city is. According to [19] the IHS-GCCF incorporates key elements of the three pillars of the theory of sustainability [11,23,24] and elements of other concepts such as green urbanism [1], compact city, and urban forms and design [1,6,25].

This conceptual framework [19] was used by the IHS USCCR department to develop the green city index (IHS-GCI) tool, in this article just called EP, to measure cities' environmental performance over time per continent; and a method that uses the results of this EP tool to develop a green city action plan named IHS-GCAP, in this article called GCAP. The tool and the method are important instruments developed to facilitate the planning and management processes of cities to become greener. The EP tool is rooted in the IHS-GCCF [19] and was developed by adapting the approach proposed in [12] to the IHS-GCCF.

To be able to measure environmental performance over time, this tool measures EPs in two different periods of time. This approach helps to identify factors behind the variation of the measured EPs of indicators, sectors, and cities for a studied period, and explain these variations. The identification of key factors contributing to the reduction of key measured EPs provides important information for the preparation of the GCAP. This action plan contains, among other steps, the goals with targets and actions to improve the measured EPs for a given period.

A GCAP is an essential part of the city's strategic planning process. The GCAP presented and discussed in this paper consists of steps borrowed from strategic and action plans such as vision and several long and short-term actions or changes to be implemented in a city to achieve proposed goals or objectives. It is a road map to help the city shift its business as usual development trajectory to a more sustainable and green development path [17]. A special feature of this GCAP is the fact that it uses the measured environmental performances of the most recent period using the EP tool as the baseline for the preparation of a vision, goals, strategies, and actions to improve the city's environmental performance for a determined period. This method was based on the long experience of the authors of this paper in preparing and implementing action plans for cities; this knowledge was complemented with information gathered from an extensive literature review on the subject [16–18,26].

The EP tool and the GCAP have been applied to more than 30 cities on five continents through IHS academic programs and in capacity-building projects.

The paper tries to contribute to the city's greening process by fulfilling some gaps related to the green city literature and by explaining the approaches used to develop both the tool and the method, and their application to Asian cities. The tool and the method can be adapted to each city's characteristics and needs.

In this paper the authors: introduce the process of developing the EP tool and the GCAP method sequentially, and present and discuss the practical application of the tool to measure the EPs of ten Asian cities in two different periods of time. They then identify some key possible factors behind the variation of a small number of EPs of the selected cities. Next, the authors present and discuss the application of the GCAP method to the city of Manila using the measured EPs of this city as the baseline in order to propose a vision, goals, strategies and actions to improve the city's EPs in a given timeline.

2. Material and Methods

This section is divided into two parts: the first part introduces the EP tool and the IHS-GCAP method followed by a short explanation of how to use the tool (steps) and the method; the second part describes the approach used to measure the EPs of ten Asian cities and the application of the GCAP to the city of Manila.

2.1. The Environmental Performance (EP) Tool

The EP tool contains two separate sets of indicators: one is quantitative and is used to measure the EP of the cities over time, and the other is qualitative and is intended to help to explain the factors possibly contributing to the variation or non-variation of the calculated EPs during the studied time period.

The sections below briefly describe the steps of the EP tool and explain how to use them.

2.1.1. Selection of Indicators

The EP tool was developed by choosing the quantitative indicators of the index proposed by [12] for the Asian continent linked to the thematic areas of the IHS-GCCF proposed by [19].

The criterion for choosing the indicators of the EP tool was that they should be linked with at least one of the entry point(s) and/or thematic areas of the IHS-GCCF proposed by [19].

All indicators were selected purposively, including the data collected for the indicators in [12] during 2007–2009.

The data collected for Asia cities by [12] were used as the baseline data to prepare the IHS score system. This score system allows to calculate the EP of any Asia city for subsequent periods, and the period 2007–2009 is the baseline period. Detailed information on the scoring system can be found in Section 2.1.2, Step 2.

The list of the indicators selected for the EP tool can be seen in Table 1.

Table 1. List of the indicators and definitions of the EP tool.

Group	Sector (Thematic Area)	Indicator Name	Definitions
Environment	CO_2 and energy	CO_2 emissions	Total annual CO_2 emissions in tonnes/capita.
		Energy consumption per unit of GDP	Total annual electricity consumption, in megajoules/unit of GDP (thousands of US$).
	Green space and land use	Green spaces per capita	∑ public parks, recreation areas, greenways, waterways, and other protected areas accessible to the public in m^2/habitants.
		Population density	Persons/km^2
	Transport	Length of the mass transport network	The total length of all public transport (BRT, tram, light rail, subway) measured in terms of the area of the city in km/km^2.
	Waste	% Waste collected by the city and adequately disposed	% Waste adequately disposed of in sanitary landfills, incinerated or in regulated recycling facilities. Expressed in a total volume of waste generated by the city (%).
		Waste generated per capita	Total annual volume of waste generated by the city, including waste not officially collected and disposed of in kg/capita.
	Water	Water consumption per capita	Total water consumed in litres per capita per day.
		Water system leakages	Share of water lost in transmission between supplier and end-user, excluding illegally sourced water or on-site leakages, expressed in terms of total water supplied.
	Sanitation	Population with access to improved sanitation	% of the total population with direct connection to sewerage, or access to improved on-site sources (septic tanks, improved latrines not accessible to the public). Excluding open public latrines or sewers and other shared facilities.
		Share of wastewater treated	Share of wastewater produced by the city that is collected and treated to at least a basic/primary level.
	Air quality	Nitrogen dioxide concentration levels (ug/m^3)	The annual daily mean of NO_2 concentrations.
		Sulphur dioxide concentration levels (ug/m^3)	The annual daily mean of SO_2 concentrations.
		Daily suspended particle levels	The annual mean of PM10 levels in ug/m^3.

A set of quantitative socio-economic indicators related to key elements of the IHS-GCCF were selected from [11–16] and added to the EP tool but were not included in the calculation of the EPs (Table 2). They were not included because the aim of this tool was to measure only environmental performance. The socio-economic indicators were included in the EP tool to help the discussion and explanation of the variation or non-variation of the EPs over time. The explanation of the variation should be complemented by qualitative indicators such as policies, plans, programmes, projects, awareness campaigns, etc., related to the indicator or sector in question which are found on the internet and in other sources.

The primary function of the EP tool related to explaining the variation of the measured EPs over time is to identify possible factors that may have contributed to the increase or reduction of EPs rather than to identify causal relationships between the EPs and the factors. The identification of these factors will be useful when proposing goals with strategies and actions to improve the measured EPs during the preparation of the GCAP for the city.

Table 2. Set of quantitative socio-economic indicators added to the tool EP but not included in the calculation of the environmental performance.

	Total Population	Number of Inhabitants in Administrative Area
Socio-economic	Annual population growth per year	% of growth in population in the administrative area
	GDP per capita	GDP in US$ PPP
	Life expectancy	Years
	Gini index	0 to 100
	Unemployment rate	% of the total population in the labour force
	Total internet penetration (ICT)	Percentage of broadband per household

2.1.2. Steps of the EP tool

The EP tool consists of four steps. These steps are presented and described below with a short explanation of how to use them.

Step 1: Assigning weights for the indicators

Weights were included in the index to represent the importance that the users (individuals or organizations) using the tool give to each indicator in relation to their relevance for the IHS-GCCF.

The weights should be assigned to each indicator of the tool in a way that the total for each sector is 100%.

Procedures to assign weights to each indicator in the index

Once the users of the tool have been introduced to the IHS-GCCF, each user assigns a weight for each indicator of the tool. The weights should be assigned in a way that the total for each sector is 100%.

When all the weights for all indicators are assigned by the different users, the average weight of each indicator is calculated and put into an Excel spreadsheet as shown in Figure 1. This Excel sheet shows all the information that needs to be collected and processed by the users of the EP tool. To fill in the Excel sheet the users need to follow the description provided in the subsequent steps for calculating the environmental performance over time of indicators, sectors and the city.

STEP 1 IHS GREEN CITY INDEX - HONG KONG																						
#	SECTOR	INDICATOR (Quantitative)	DESCRIPTION	WEIGHT (Wav) (%) (Average weight of groups)	DATA VALUE (V)					IHS SCORE (Normalization and range)					Scores using V1 and V2		ACTUAL				QUALITATIVE INDICATORS (name and description)	EXPLANATION AND JUSTIFICATION (changes and no changes between S1.Wav and S2.Wav)
					V1		V2										Env. Perf. / indicator		Env. Perf. / sector			
					From Siemens report	Year	Updated from other sources	Year	Source	WELL BELOW AVERAGE (1 points)	BELOW AVERAGE (2-point)	AVERAGE (3 points)	ABOVE AVERAGE (4 points)	WELL ABOVE AVERAGE (5 points)	S1 (score indicator's value from Siemens report)	S2 (score the updated value of each indicator)	(S1. Wav)	Updated (S2.Wav)	Σ S1.Wav	Updated Σ S2.Wav		
1	CO2 and ENERGY	CO2 emissions from electricity consumption per capita*	Total annual CO2 emissions in tonnes/capita from electricity consumption	47,5	5,4	2008	6,18	2013	1	more than 7,4	7,4 - 5,2	5,2 - 3,7	3,7 - 1,5	less than 1,5	2	2	1	1	3,58	3,58	2010: Hong Kong's Climate Change Strategy and Action Agenda Consultation document	
		Energy consumption per unit of GDP (electricity)	Total annual electricity consumption, in megajoules/unit of GDP (thousands US$)	52,5	1,5	2009	1,03	2013	2	more than 14,8	10 - 14,8	6,5 - 10	4 - 6,5	less than 4	5	5	2,6	2,6			2005: The Energy Efficiency (labelling of products) Ordinance, Cap. 525 published in the Gazette on 9.5.2005	

Note 1. The source for each new collected data (V2) needs to be added at the bottom of this excel sheet.

Figure 1. Sample of the excel spreadsheet to calculate the EP over time showing the elements of the tool applied to one sector for the city of Hong Kong.

Step 2: IHS-GCI (EP) scoring system

The EP scoring system for Asia was created using the data published in the Asia green city index [12] for the period 2007 to 2009. All the data for each quantitative indicator of the twenty-two Asian cities surveyed by [12] matching the selected indicators of the EP tool were copied and put in a database. This database was then normalised by using a range from 1 to 5. The scores were classified as 1 point (well below average), 2 points (below average), 3 points (average), 4 points (above average) and 5 points (well above average). This normalisation procedure was made to allow the different data values to be comparable and to construct aggregate scores for each city. The score in the index represents the rank of the cities examined on a quintile-based comparison. A city that has a score of 1 is in the bottom 20% of all cities, a score of 2 implies the city is between the bottom 20% and 40% of all cities and so on. A city with a score of five, means that it is better than 80% of cities.

Step 3: Calculating environmental performance (EP) over time

These procedures guide the users through the process of calculating the EPs of the indicators, sectors, and the city, using the Excel spreadsheet shown in Figure 1. In the "Sector" and "Indicator" columns the user will find the names of the sectors and the indicators per sector with their respective definitions.

In the "Average Weight (Wav)" column the user assigns the average value calculated as described in Step 1. In the "V1" column and named "Old Value", the user will copy and insert the data values for each indicator of the study city for the period 2007 to 2009 using reference [12]. In the next column, "Year", the user needs to fill in the year and source of the data collected in [12].

In the "V2" column, named "Updated Value", the user should insert updated data found on the internet and other sources for each of the fourteen indicators. In the next column, "Year", the user should enter the year and source of each updated data.

Now, using the IHS scoring system in Figure 1, the user needs to score the data for indicator V1 and enter the result in column S1. Repeat the same procedure for indicator V2 and enter the result in column S2. The values of the old and updated data are ranked in the range of 1 to 5 from "well below average" (1 point) to "well above average" (5 points) (see Step 3 of the method).

The next procedures concern the calculation of initial (old) and updated Environmental Performance (EP). The EP of the indicators is called "weighted score" (weight times the score). These values are entered into columns "Weighted S1 Score (S1wav)" and "Weighted Updated Score (S2wav)". The EP of the sector is calculated by adding the weighted score for all sector indicators: Finally, the total EP of the city for the two study periods is calculated as the Σ (S1wav) EPs of all sectors for period 1 and the Σ updated (S2wav) EPs of all sectors for period 2.

Step 4: Explaining the variation or non-variation of EPs over time

The columns "Qualitative Indicators" and "Explanation" in Figure 1 should be used in this step.

In the "Qualitative Indicators" column the user(s) need(s) to search on the internet and in other sources for qualitative indicators such as policies, plans, programmes, projects, awareness campaigns, etc., related to any indicator for the sector which has been implemented in the city during the studied period.

In the column "Explanation" the user(s) should provide a short discussion using the identified qualitative indicators plus the socio-economic data collected and filled in Table 2 for the studied period to try to explain any changes (increase, reduction, or no change) in the calculated EP over time. If necessary, any other relevant information, such as factors related to migration, political changes, governance problems, can be used in the discussion and explanation.

2.2. The IHS Green City Action Plan (GCAP) Method

The CGAP method presented and discussed below is the result of an in-depth literature overview on methodologies to develop green city action plans [13,14,17,18,26] and the systematization and adaptation of academic and advisory experiences acquired by the authors over the last fifteen years with the implementation of strategic and action plans for different cities across the continents, and more recently with academic and advisory works on green cities issues. The authors have applied the GCAP method for academic purposes to more than thirty cities on five continents and also in capacity-building projects implemented as part of IHS activities.

The GCAP contains some innovative approaches mentioned in the green city literature such as the measurement of the current environmental performance of the city using the EP tool as part of the preparation of the urban profile of the city, the preparation of a realistic vision that assigns goals and targets to improve the measured EPs and consider the existent city's resources and political will to implement the vision, embedding the GCAP into the city institutional structure.

The method is a translation of the theoretical concept of Green Cities [19] into a practical and systematic approach towards planning for green cities. It outlines various stages of Green City Action Planning starting from an existing situation analysis to an institutional embedding of the plan.

For the purpose of this method, a green city is envisaged as a city that is sustainable, healthy, liveable and competitive, a city that introduces and adopts measures for energy efficiency; extensively uses renewable energy in all sectors; prioritizes greening approaches, land compactness, and mix uses in its spatial development; and embeds the principles of green growth with equity and inclusiveness in its local development. This envisaged green city combines various developmental approaches, such as the use of smart technology, innovative investments in infrastructure development, human resources development, natural capital conservation, and technological innovations. A GCAP is a roadmap to help the city in shifting its trajectory from business as usual to a more sustainable and green development path.

2.2.1. Steps of the IHS-GCAP

The method contains seven steps. These steps are described below together with a short explanation of how to use them.

Step 1: Nomination of a GCAP team and identification of a team leader and resources

The GCAP process starts by nominating a GCAP team, including a team leader who will coordinate the various activities involved in the GCAP preparation process; this will include the identification and allocation of human and financial resources required for preparing the plan.

The GCAP team is responsible for choosing the key green criteria to be used in the preparation of the GCAP. This method proposes that the users include among these criteria key aspects of the IHS-GCCF [14] and the tool developed to calculate the EP.

Step 2: City Green Profile (Green Urban Profile)

The green urban profile in this method uses the results of the tool EP described in Section 2.1.

The urban profile is a complete diagnostic of a city comprising environmental, socio-economic, institutional, legal, industrial and other important data. It represents the current situation of the studied city and is the key document to plan and formulate scenarios and choose actions for promoting the green development of the city. In this method the preparation of a green urban profile involves three sub-steps:

A: To identify and analyse the existing regulations linked to the green city issues. These include existing plans, procedures and regulations at a municipal, provincial and national level and policies related to green issues and programs.

B: To conduct a detailed stakeholder analysis identifying the key stakeholders who could help the implementation of the GCAP and those that need to be contacted to reduce their possible opposition [14,15].

C: To conduct a detailed baseline study of the current environmental situation of the studied city including the measurement of the current Environmental performance using the tool EP described in Section 2.1.

Step 3: Realistic Vision: Goals and targets for the indicators

A green city vision reveals how the city wants to be in relation to green issues for a chosen period and is the guiding principle of the local GCAP authority. A comparison between the vision and the local current situation is the basis for identifying what actions and measures are needed to reach the desired goals.

A vision is developed for a selected medium to long-term period of time. It contains goals and the goals contain objectives that contain actions. The goals are long-term objectives proposed for each sector and the objectives are short-term objectives developed to achieve the goal.

In this method the vision should be realistic, meaning that it should consider the existing socio-economic, environmental, political, and other local conditions during the preparation of the realistic vision. It should also use a more quantitative approach to develop the realistic vision while still providing something new, adding real value and breaking some old boundaries that do not have real justification anymore.

Figure 2 shows the elements of the excel matrix prepared to use the tool EP and guide the development of a realistic vision. The first part of the matrix displays the elements used to calculate the EP described in Section 2.1. In the first part of the Figure 2, the values of the EP of each indicator of each sector are calculated by multiplying the assigned weight for the indicator times the score of the data of the indicator obtained using the normalisation (ranges) described in Section 2.1. The weighted score is called the EP. In the second part of Figure 2, the last five columns of the right side of the table shows the elements used to prepare the realistic vision. These elements are described below:

Proposing targets for improving the existing ENVIRONMENTAL PERFORMANCE for a given time horizon																				
A S I A (insert name of your city)																				
#	SECTOR	INDICATOR (Quantitative)	DESCRIPTION	WEIGHT (%)	V2		SCORE (Normalization and range)					S2 (score the updated value of each indicator)	WEIGHTED SCORE Environmental performance / sector		Proposing Target (%) for the indicators of the sector to improve the data V2 of your exercise 1	V3: Obtained by multiplying the proposing target to the value of V2	S3: New score V3	Improved performance (Exercise 1)	
					Updated from other sources	Year	WELL BELOW AVERAGE (1 points)	BELOW AVERAGE (2-point)	AVERAGE (3 points)	ABOVE AVERAGE (4 points)	WELL ABOVE AVERAGE (5 points)		Updated (S2.Wav)	Updated Σ S2.Wav				Environmental performance / indicator with target	Environmental performance / sector with target
																		S3.W	Σ S3.W
Initial vision for given time horizon																				
		GOAL/S																		
1	CO2 and ENERGY	CO2 emissions from electricity consumption per capita*	Total annual CO2 emissions in tonnes/capita from electricity consumption				more than7,4	7,4 - 5,2	5,2 - 3,7	3,7 - 1,5	less than 1,5								
		Energy consumption per unit of GDP (electricity)	Total annual electricity consumption, in megajoules/unit of GDP (thousands US$)				more than 14,8	10 - 14,8	6,5 - 10	4 - 6,5	less than 4								

Figure 2. Sample of the excel matrix developed for preparing a realistic vision of the GCAP method.

2.2.2. Developing a Realistic Vision Using Figure 2

The process of developing the realistic vision starts by proposing an initial (dream) vision for the current (calculated) EP of the sectors of the tool, and the city itself, to be achieved in an *X* number of years (white line, Figure 2).

We recommend that the process of developing the realistic vision to be guided by an appointed GCAP team. This is justified by the fact that the preparation of the action or strategic plan requires a preliminary estimation of the resources and costs to be used to implement the vision for the proposed *X* timeline.

At the beginning of the process, the GCAP team invites and guides some key stakeholders of the city to develop an initial vision (let's say to be achieved in ten or twenty years). This vision is developed using the results of the calculated EPs for each indicator and sector of the EP tool. The initial vision is primarily developed according to the expectations, and experiences of each stakeholder (user) and should incorporate key issues of the IHS-GCCF. This initial vision is called the "dream vision".

From this initial vision, the GCAP team guides the stakeholders (users) to develop a realistic vision (steps shown in the second part of the matrix, Figure 2), The process starts by asking the users to propose goals for each sector of the tool to achieve the dream vision. This is done by assigning improvement targets in percentage for each indicator of each sector of the EP tool. Using these targets, the user(s) will calculate the new EPs of each indicator, sector and city.

Once the calculation of the new EPs using the proposed improvement targets is finished, the users need to double-check if the new calculated environmental performances are aligned with the proposed goal(s) developed for the dream vision and if they are realistic. Realistic means whether the city has resources (manpower, technology, finances, etc.) to implement the proposed goals. If not, consider revising the goals and or reducing the proposed improvement targets and calculate again the new environmental or green performances until you obtain a result that is considered realistic with the current social, economic, financial, and political conditions of the city. Rewrite the dream vision considering the new revised improvement targets and/or goals. This revised vision is what we call a more realistic vision that will be used in the next steps of the GCAP.

Tip: Proposing improvement targets is not only a question of mathematics but a number that is chosen after considering several financial, socio-economic, environmental, technical, human resources feasibility, regulations, local governance, political stability factors, etc.

Step 4: Strategies and actions

This step of the GCAP is divided into three parts: developing strategies and actions, prioritisation of strategies and actions and detailing the prioritised actions. Detailed information on each of these parts can be found in [18].

a. Formulating strategies and actions

A GCAP must contain a clear outline of the strategic actions that the city authority intends to take to reach the vision, goals and targets proposed for the indicators. A strategy is a structured set of actions that, when implemented, will contribute to the achievement of a particular goal. Strategies and actions should be proposed for achieving long-term goals. As the achievement of the goals takes a long time, it is necessary to propose short-term actions (1 to 3 years) that, as a group, will contribute to achieving the goals.

b. Prioritisation of strategies and or actions

Different kinds of actions and measures may contribute to the achievement of the goals. Undertaking the entire list of possible actions will often surpass the current capabilities of the local authority, in terms of budget, project management capacities, etc. In addition, some of them may be mutually exclusive. This is why an adequate selection of actions for a given time period is necessary.

Very often a GCAP may contain around 10 goals and more than 150 related projects/actions to be implemented. In a situation like this, it is important to select key actions to be implemented first and others to be phased out. This approach helps the city select actions that can be grouped into investment packages that can be implemented progressively.

This methodology uses the Goal Achievement Matrix (GAM) to prioritize strategies and actions. GAM is part of the method called Multi-Criteria Analysis (MCA). The principal purpose of the GAM is to identify a set of key objectives or "impacts" to be achieved by an action, with an indication of the relative contribution of each impact towards the achievement of the goal as a whole [18].

c. Detailing the prioritised actions

Once the actions have been selected, it is necessary to plan and detail them carefully so that they can be translated into reality. This detailing process helps the implementing organization to prepare detailed project reports, which will in turn help in identifying relevant funding sources (such as state, central and international agencies).

The detailing of the prioritised actions also includes the identification of tasks, responsibilities, and timing: the word "task" in this methodology is used interchangeably with "activity". The key characteristics of a task are: name of the task (this is only for identification), actors and responsibilities. Who is the person who will have the main responsibility for the task? And who are the other people/organizations who will be involved in each task [18]?

Step 5: Recommendations for capacity and skills needed to implement the GCAP

The GCAP should identify the capacity and skills needed to implement the city's greening activities. It is important that the CGAP team could interact with and eventually be supported by local universities, research organizations and private sector to provide the development of green and smart technology, awareness, training programs, etc.

Step 6: Communication strategy

The Communication Strategy is a framework to guide all external stakeholders and internal staff communications regarding the implementation of the GCAP. The aim of a GCAP Communications Strategy is to raise public awareness and support for Green City Action Plan and to ensure that there is an ongoing commitment to the delivery of the plan by the different actors. Full procedures and explanation of how to prepare a communication strategy for the IHS-GCAP can be seen in [18].

Step 7: Embedding the GCAP into the city institutional structure

Implementing a GCAP is a challenging and time-consuming process that must be systematically planned and continuously managed. It requires collaboration and coordination between various departments in the local administration, such as Environmental Protection, Land Use and Spatial Planning, Economics and Social Affairs, Buildings and Infrastructure Management, Mobility and Transport, Budget and Finance, and Procurement.

A clear organisational structure and assignment of responsibilities are prerequisites for the successful and sustainable establishment of the GCAP. The organization that is going to lead the GCAP needs to be strongly embedded into the existing institutional structure of the city, to have a clear legal mandate and financial and human resources. This method recommends identifying a preferred organization within the current institutional structure of the city to implement the green city action plan. Another option is to propose the creation of a new organization. This option has advantages and disadvantages: a new organization can be an opportunity to better integrate some existing key organizations but can also increase bureaucracy and costs.

Some cities have created a so-called GCAP Committee which is a multidisciplinary body responsible for the GCAP. This central and/or designated organization is expected to work in coordination with central and state government organizations as well as with universities, research centres, key private institutions and the various NGO groups and associations to implement the GCAP.

In general, a GCAP organizational structure has a steering committee, constituted by politicians and senior managers with a mission to provide strategic direction and the necessary political support to the process, and one or several working group(s), constituted by the managers of the different city departments public agencies, etc. Their task would be to undertake the implementation of the GCAP, to ensure stakeholders' participation, to organise monitoring, and to produce reports, etc.

2.3. Calculating EPs of Ten Asian Cities and Apply the IHS-GCAP Method to Manila

2.3.1. Calculating EPs of Ten Asian Cities

The EPs of the ten Asian cities (Manila, Shanghai, Hong Kong, Delhi, Singapore, Bangalore, Jakarta, Kolkata, Kuala Lumpur, and Mumbai) were calculated using the EP tool described in Section 2.1 of this article.

Data for the indicators of the EP tool were collected for two periods: the first period (before) covered the years 2007 to 2009 using the data collected from [12], and the second period (after) the years 2015 to 2018. The period 2007–2009 refers to the period [12] collected for the Asian cities. These data were used to prepare the IHS scoring system of the EP tool as explained in Section 2.1.2, Step 2. The data for the second period was collected by professionals, practitioners and academic students of the green city for eco-efficiency course, the master's programme and capacity-building programs undertaken by IHS involving the authors of this paper. For the purpose of this article, the data collected for the ten cities included in this paper was double-checked to be sure the information collected was correct. The environmental performance of an indicator in the EP tool is measured by multiplying the average weight of each indicator by the score of the indicator obtained using the IHS scoring system. The EPs of each of the ten cities selected for this paper were calculated by ten different groups of professionals, each one using their own assigned weights. To harmonize the EPs of each indicator using the same average weight, we have calculated an average weight using the previous weight assigned for all the indicators of the ten cities and used this average to calculate again the EP of indicators, sectors and cities used for this paper. The check of the data and the use of the average weights of the ten cities to recalculate the EPs did not cause substantial changes in the results obtained by the groups.

2.3.2. Application of the IHS-GCAP Method to the City of Manila

The IHS-GCAP method was applied to almost all of these ten Asian cities in the period 2015 to 2018 through the academic and advisory work of IHS in the mentioned period. This article has selected the GCAP of Manila (Metro Manila) to present and discuss the practical application of the IHS-GCAP. This GCAP was developed in 2018 as part of the activities of the professional course "Green City for Eco-efficiency". The Manila group calculated the environmental performances over time for the city of Manila following the EP instructions described in Section 2.1 and developed the IHS-GCAP according to the instructions presented in Section 2.2 of this article. Not all steps of GCAP were selected to be displayed and discussed in this article but only those containing innovative approaches.

3. Results and Discussion

3.1. Application of the EP Tool for Two Periods of Time to Ten Asian Cities

This section presents some selected results of the application of the tool EP to ten Asian cities (Manila, Shanghai, Hong Kong, Delhi, Singapore, Bangalore, Jakarta, Kolkata, Kuala Lumpur, and Mumbai) as part of IHS' academic and advisory work between the years 2015 and 2018.

3.1.1. Data Quality

The data used to measure the EPs for the period 2007–2009 were obtained from [12] as explained in Section 2.1.2. According to [12], wherever possible, the data were taken from publicly available official sources, such as national or regional statistical offices, local city authorities, local utility companies, municipal and regional environmental bureaus, environmental ministries, and multilateral organizations. We have used this same approach to collect the new data for the period 2015–2018.

The availability and comparability of data across cities was more limited for cities with the lowest GDP per capita. In general, these cities have less capacity to gather and publish information quickly. Almost all the data collected for the second period comes from the city administrative areas. Manila is the only exception with the data collected from the metropolitan area. CO_2 and length of mass transport network indicators were the ones for which updated data were most difficult to find. When there was no data for an administrative area, data from metropolitan and provincial areas were used. In sectors where indicator data were not available (blank), the weight of the indicators was redistributed among the other indicators within the sector to be in line with the criteria that the total weight of the indicators within a sector adds up to 100%.

Representativeness and consistency were assured by collecting data from official global, regional, and municipal sources wherever possible and avoiding as much as possible specific documents and other reports where differences in definitions and methods of the collection could be an issue for data consistency. A record of original data sources is kept at IHS.

Despite following a strict data collection protocol, we acknowledge that some inaccuracies might remain within the data set due to inconsistencies in definitions, measurements, data collection methods and lack of data. This means that the data should be considered with a degree of caution.

3.1.2. Results and Discussion

Figure 3 presents the results of the environmental performances of the ten Asian cities over time for two periods of time: 2007–2009 and 2015–1018.

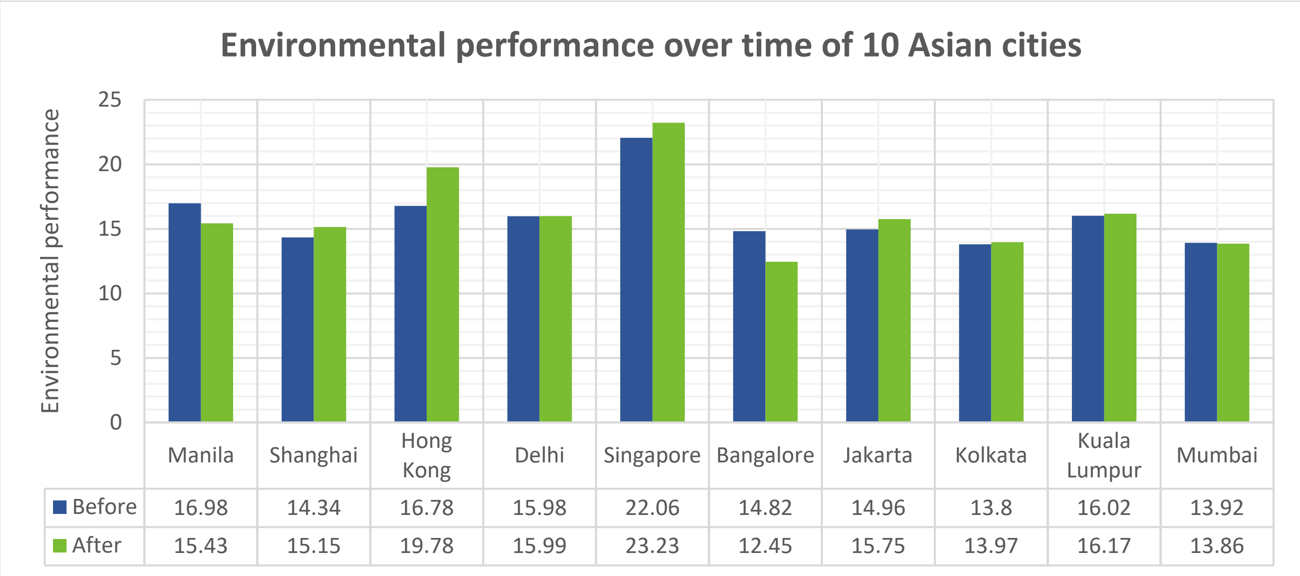

Figure 3. Environmental performance of ten Asian cities overtime for 2007–2009 (before) and 2015–2018 (after).

The total EP of each Asian city is the result of the sum of the calculated EPs of each of the fourteen indicators of the EP tool. Detailed information on how these EPs were obtained can be found in Section 2.1 of this article.

From Figure 3 Singapore and Hong Kong are the two cities presenting the highest total EPs for the two study periods, while Bangalore is the city presenting the lowest EP for the period "after" (12.45) and Kolkata for the "before" period (13.80).

These results show that seven out of ten cities have improved their total EP in the study period. Bangalore, Manila and Mumbai are the cities that have experienced a reduction in their

EPs. Bangalore is the city that has experienced the biggest reduction in its EP (14.82 to 12.45) followed by Manila (16.91 to 15.91). Hong Kong experienced the biggest EP improvement.

Social, economic, environmental, political, and governance demography planning capacity among other factors, may have contributed to the variation in the EPs measured over time for the ten cities selected for this paper. Very often these factors impact the EPs of cities from developing countries more than those of rich countries [3,19].

The EP tool is an instrument that helps cities to identify and explain some of the factors behind the EP variation during the period studied. The extent and accuracy of the identification of these factors and their explanation vary with the degree of expertise of the users of the tool.

The factors and respective explanations selected for discussion in this paper were identified by the groups of professionals working with the measurement of the EPs of these cities. They represent a small sample of the many factors identified for each sector of each of the ten cities selected for this paper.

The identification, explanation and discussion of these factors rely on the degree of expertise of the professionals involved in the measurements, and on the literature they have consulted. This explanation as stated in the Section 2.1.1 is primarily focused on the contributions of the identified factors to the increase or reduction of the measured EPs over time, and not on the identification of causal relationships between these factors and the measured EPs.

The sources used to identify the factors are social-economic data, policies, plans, programs, projects and any other activities (factors) that happened in the city during the studied period that may have contributed to the variation of the EPs of the sectors and the city.

A large increase in population size and the lack of city planning capacity are some of the factors attributed to the important reduction in the EP of Bangalore during the studied period. In Bangalore, the population increased by 50% and its GDP doubled thanks to the boom in the IT industry. Although it has become richer, it seems that the huge increase in population has placed enormous pressure on basic public service sectors such as land use and building, CO_2 and energy, waste, and water. All these sectors showed important reductions in their EPs.

In Manila, besides the increase in population, a rapid increase in the number of automotive vehicles, the establishment of new industries, the lack of enforcement of air quality regulations together with the lack of investment in the sanitation system, were some of the factors attributed to the reduction of the EP of the air quality sector and the no variation of the EP of the sanitation sector. These EP results ended up contributing to the city EP reduction in the studied period.

Population and GDP are important factors contributing to the reduction and increase of EPs. Population in general has an inverse correlation with the EPs of cities, and GDP has a direct correlation [19]. The increase in population in general puts pressure on basic public service sectors such as land use and building, CO_2 and energy, waste and water that have had an important increase or reduction in EPs [3,19]. The implementation of plans and strategies focusing on energy and water efficiency was one of the factors cited as contributing to the improvement of Hong Kong's EP.

Mumbai has seen a slight reduction in its EP. Solid waste and drinking water sectors were those that have contributed most to the reduction of the city's EP. The increase in the number of slums in the city, the deterioration of the solid waste collection system and an increase in leakages in the drinking water system were some factors identified behind the reduction of the EP of these respective sectors.

The important improvement in Hong Kong's EP in the study period can be attributed to the important improvement in the EPs of the water and sanitation sectors. The factors attributed to this improvement were the implementation of two important strategies: A water management strategy that has led to the replacement and rehabilitation of the city water mains, the extension of the voluntary water efficiency labelling schemes, the implementation of an active water leakage control program and the extension and upgrading of the existing sanitation systems including the construction of new wastewater treatment plants. In addition, Hong Kong's Climate Change Strategy has promoted energy efficiency and the enforcement of green labelling for products. The climate change strategy has contributed to keeping EP of the CO_2 and Energy sector unchanged during the period under study despite the slight population growth.

3.2. Practical Application of the IHS-GCAP to the City of Manila

This part contains a summary of a select number of steps of the IHS-GCAP (Figure 4) applied to the city of Manila (Metro Manila). Detailed information about the development and the explanation of how to use each of these steps can be found in Section 2.2 of this article.

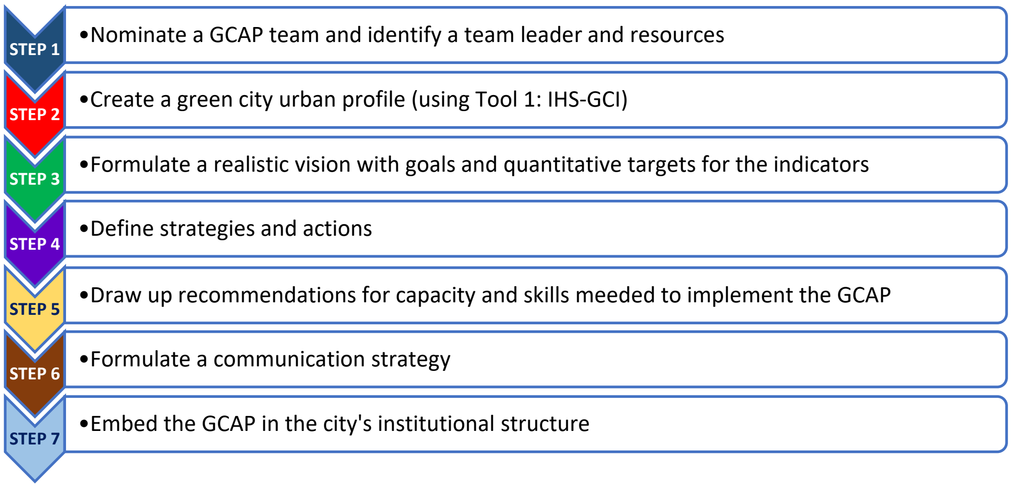

Figure 4. IHS-*Green City Action Plan (GCAP)*.

The administrative area of Metro Manila covers 636 square kilometres and has a population of 11.6 million which is growing at an annual rate of 1.78% according to the last census. The city has a GDP per capita of US$ 5,365, an unemployment rate of about 13%, a literacy rate of 99.2% and a life expectancy of 69 years for males and 76 years for females. The Gini index is 40.8 and ICT coverage is 11%. For more information on the definition of these indicators, see Table 2 (socio-economic indicators). The sources of the data collected by the GCAP Metro Manila team were annexed to Excel sheets used in the exercise by the group.

3.2.1. Green Urban Profile

The GCAP includes three sub-steps in the preparation of a city's green profile: the collection and systematization of existing data on green issues, the preparation of a stakeholder analysis and the calculation of the current EPs for the city. The results of the stakeholder analysis developed by the Manila group identified the National agencies, real estate and property developers and communities as the ones having the strongest influence in the city.

The EPs of the city were calculated using the EP tool for Metro Manila as shown in Table 3. From this table, we can see that the total city EP of the area has fallen between the study periods. The air quality sector EP is the one that has experienced the biggest deterioration, from 3.14 to 1.0. The increase in the number of private cars, industries, and lack of enforcement of air quality regulations are the factors cited as being behind this result. The sanitation sector has remained constant with a low EP. The EP of this sector was unchanged with a low EP in the period studied despite the government has developed a plan to improve the sector. The increase of the population living in slums and the government's failure to implement planned sanitation measures were identified as some of the factors contributing to this unchanged EP. The water sector was the one that improved most. An important reduction in the leakage of the drinking water system was cited to be behind the improvement of this sector. Because of the need to limit the size of this article, the subsequent results will focus on the sector with the lowest EP in the two-period studied, namely sanitation.

3.2.2. Vision, Goals, and Quantitative Targets for Indicators

One of the innovative approaches of the GCAP is the formulation of a realistic vision (Section 2.2, Step 3). This is prepared in two steps as shown in Table 4. Here it can be seen that the Metro Manila GCAP team has drafted an initial vision and formulated goals with targets to achieve it (left side of Table 4).

Table 3. Urban Green Profile using tool EP for Metro Manila, Step 2.

Sector	Indicator (QT)	Actual Environmental Peformance	
		Environmental Performance/Sector	
		Siemens [12]	Current (Updated)
CO_2 and energy	CO_2 emissions from electricity consumption per capita Energy consumption per unit of GDP	3.15	3.16
Land use and buildings	Green spaces per capita Population density	2.32	2.32
Transport	Length of the mass transport network	2.0	2.0
Waste	Share of waste collected by the city and adequately disposed Waste generated per capita	2.41	2.47
Water	Water consumption per capita Water system leakages	2.96	3.96
Sanitation	Population with access to improved sanitation Share of wastewater treated	1.0	1.0
Air quality	Nitrogen dioxide concentration levels (ug/m^3) Sulphur dioxide concentration levels (ug/m^3) Daily suspended particulate matter levels (ug/m^3)	3.14	1.0
TOTAL		**16.98**	**15.43**

Table 4. Formulating a realistic vision with goals and targets for Metro Manila, Step 3.

Initial Vision for 2030		Final Vision after Targets 2030	
Metro Manila: A safe, resilient and eco-efficient city that is accessible and liveable for all		Green Manila: A safe, healthy and energy-efficient city that is accessible and liveable for all	
Sectors	**Goals per indicator**	**Current EP**	**Improved performance w/target**
CO_2 and energy	To reduce 10% emissions and increase energy 40%	3.16	3.62
Land use and buildings	To increase 40% actual green space and 10% population	2.32	2.32
Transport	To increase 1000% mass transport network from	2	2
Waste	To increase 10% collection and disposal and to decrease 5% waste generated/capita	2.47	2.47
Water	Reduce water consumption by 25% and reduce leakage by 10%	3.48	3.48
Sanitation	To increase 40% access to sanitation and to increase 50% treatment capacity	1	2.08
Air quality	To reduce 10% concentrations of nitrogen and sulphur dioxide and 10 PM 10 concentrations	1	1.44
Total Environmental Performance		**15.43**	**17.41**

The final (realistic) vision is shown on the right side of Table 4. It incorporates the proposed improvement targets for the indicators and the goals shown on the left side of Table 4, and the expected EPs of the sectors and the city in the chosen time period. As can be seen on the right-side of Table 4, the final (realistic) vision is slightly different from the initial vision. It is important to remind that setting targets for the indicators is not a question of mathematics but of formulating realistic targets considering the local socio-economic, environmental and political reality as described in the GCAP section.

3.2.3. Strategies and Actions for the Sanitation Sector

The Manila GCAP team proposed three strategies to implement the goals of each sector. These strategies were subsequently prioritized using the GAM method (Section 2.2.1, Step 4).

The proposed goal for the sanitation sector was to increase the proportion of the population with access to sanitation from 53% in 2016 to 74% in 2030 (an increase of 40%), and the share of wastewater treated by 50% by 2030 as shown in Table 4. The prioritized strategy was "increasing the population with access to sanitation by improving sanitation facilities and operating efficiency". This was subsequently broken down into several actions containing key descriptions of the tasks such as responsibility and financial resources and a timeline was set. These procedures were repeated for each strategy and sector.

3.2.4. Embedding the GCAP into the City Institutional Arrangement

Another innovative approach in the IHS-GCAP includes the revision of the city's current institutional structure to include an organization that will be responsible for implementing the GCAP. In addition, the resources (human, technical, financial, etc.) and the capacity needed by the organization to implement the GCAP need to be identified and allocated.

The Metro Manila team created a new organization called the Manila GCAP Committee (Figure 5) and placed this organization within the current city institutional structure under the existing Environmental Management Bureau.

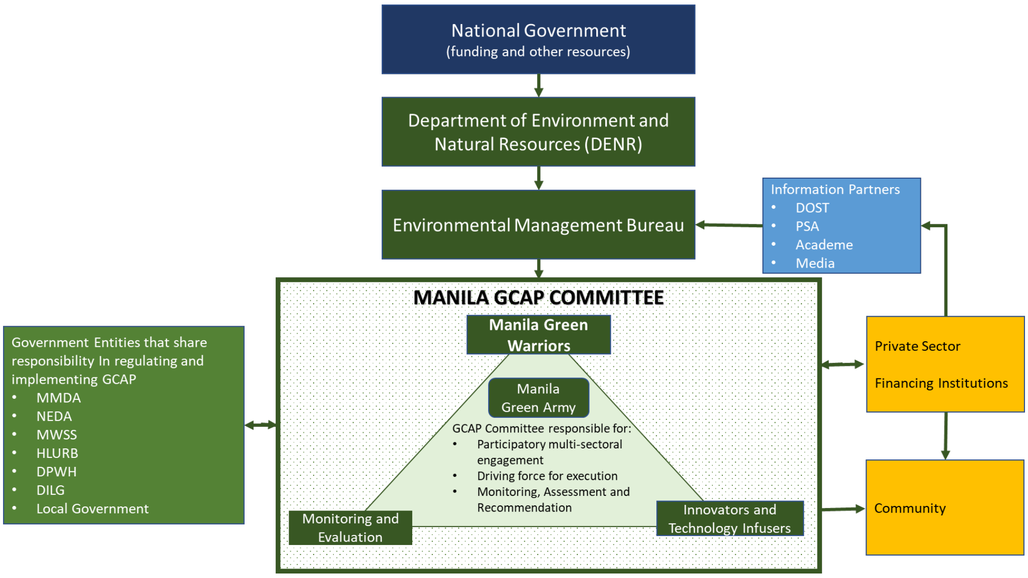

Figure 5. Institutionalizing the GCAP.

The group has justified the creation of a new organization because currently there is a fragmentation of responsibilities about green issues distributed among diverse municipal organizations. This new organization will contribute to consolidating these fragmented responsibilities under its responsibility. It will also act as a steer organization to promote the development of the GCAP goals and targets among the diverse other local organizations.

4. Conclusion

The paper tried to contribute to the city's greening process by explaining the approaches used to develop a tool to calculate and explain variations in the environmental performance of cities over time, and a practical and systematic method containing some innovative approaches to developing a green city action plan (GCAP) that uses the results of the EP tool. It further has presented and discussed the application of the tool and the GCAP to Asian cities. The tool and the method can be adapted to each city's characteristics and needs.

It is not the aim of the article to compare the environmental performances among cities but to disclose the process of measuring EPs over time and use the results to help city planners to identify possible factors behind the EP variation. Cities can use these results to prepare a GCAP to improve their current environmental performances. However, when the tool is applied to several cities of the same continent, cities may use the EP results to brand themselves in relation to green issues.

The EP tool and GCAP method fill some gaps found in the green city literature mentioned in the introduction of this paper such as the development of tools, separating qualitative and quantitative indicators to measure environmental performance, indicators rooted in a conceptual framework, simplified tools to track progress in cities' environmental performance over time and integrated approaches and methods that use the cities' environmental performance to help in their planning and to prioritise actions to improve their current environmental performance.

Both the tool and GCAP are useful in helping cities in the planning processes to become greener. Cities can use the tool to know where they are in terms of environmental performance and to brand themselves in relation to other cities on the same continent. It also helps cities to identify and explain possible factors contributing to the variation of the measured environmental performances over time. In addition, they can use the measured EPs as baselines in a green city action plan (GCAP) with goals, targets and actions to improve current EPs and track the achievement of the proposed targets. Both the tool and method are adaptable to individual city needs and can be used separately or together. In this article, they are used in a sequential order such as measuring the EPs and then using these results to prepare a GCAP.

The application of the EP tool to ten cities showed that Hong Kong and Singapore have the highest EPs for both initial and later periods. Singapore and Hong Kong experienced the biggest improvement in their EPs during the period studied and Bangalore the lowest.

An important increase in the population of Bangalore and Manila together with the lack of planning capacity, deterioration of air quality and lack of investment in basic sanitation are some of the factors attributed to the reduction of the measured EPs of these two cities in the studied period.

The GCAP is seen as a process that helps the city to become greener by providing a method containing innovative approaches such as the measurement of the current environmental performance of the city using the EP tool as part of the preparation of the urban profile, the preparation of a realistic vision that uses goals and targets to improve the measured EPs and consider the existent resources and political will to implement the vision, and embedding the GCAP into the city institutional structure. It is also an operational platform that helps integrate different sectors and activities in the city to achieve the goal of becoming greener and more sustainable. This method can contribute to helping cities to move away from their current business as usual model to a more sustainable (green) path of development.

As discussed in Section 3.1.1, reliable and accurate data collection is the main limitation found in applying the EP tool. Inaccuracies might exist within the data set due to inconsistencies in definitions, measurements, data collection methods, lack of data and discontinuity in regularly updating data. This is more important in cities with a low GDP. Another limitation concerns the extent and accuracy of the identification and explanation of factors contributing to the variation of the measured EPs over time. They depend on the degree of expertise and practices of the users of the tool related to environment, socio-economic and urban planning issues.

We recommend more empirical research, especially longitudinal action research which applies the tool and GCAP method and monitors and evaluates the results. We further welcome more research to explore the linkages of the environment, socio-economic and especially governance mechanisms with the processes of making cities greener.

Data Availability

Data used in the article are available with the authors.

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Author Contributions

The first author was responsible for the Supervision and Administration of the research including conceptualization and methodology. The second author together with the first author were responsible for the Formal Analysis, Investigation, Validation, Data Collection (data curation), Writing—Review & Editing of the article.

Conflicts of Interest

The authors declare no conflict of interest.

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