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Article

A Strategy-Based Model for Low Carbon Cities

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Abstract: Low carbon cities are increasingly forming a distinct strand of sustainability literature. Models have been developed to measure the performance of low carbon cities. The purpose of this paper is to formulate a strategy-based model to evaluate current performance and predict future conditions of low carbon cities. It examines the dynamic interrelationships between key performance indicators (KPIs), induces changes to city plan targets, and then instantly predicts the outcome of these changes. Designed to be generic and flexible, the proposed model shows how low carbon targets could be used to guide the transformation of low carbon cities under four strategies: (1) Passive intervention, (2) problem solving, (3) trend modifying, and (4) opportunity seeking. Further, the model has been applied to 17 cities and then tested on five cities: London, New York, Barcelona, Dubai, and Istanbul. The paper concludes with policy implications to realign city plans and support low carbon innovation.

Keywords: climate change; carbon emissions; low carbon city; sustainability; strategy-based model; SMLC

1. Introduction

Climate change is recognized as a threat to the environment because of its impacts: Increasing temperatures, rising sea levels, extreme weather change, and changing rainfall patterns. Although cities are major drivers of economic and social development, they are nonetheless responsible for 76% of total carbon emissions worldwide, arising primarily from the consumption of fossil fuel [1]. Concerted global efforts to mitigate climate change were initiated by Intergovernmental Panel on Climate Change (IPCC) in 1989, followed by the establishment of United Nations Framework Convention on Climate Change (UNFCCC) together with Rio 20+ in 1992 and the Kyoto Protocol in 1994, which became the world's first greenhouse gas (GHG) reduction treaty [2]. Two decades later, the Paris Agreement was concluded featuring the second impacts assessment of IPCC that became the essential guideline for GHG reduction [3].

Likewise, efforts to reduce carbon emissions have been initiated, such as impact studies of urbanization, economic growth, transportation, and energy. Various models have been formulated to measure carbon emissions: STIRPAT, EKC, STELLA, DPSIR, Fuzzy Delphi Method, GMLC, and USDM to mention but a few. These models tend to be general or specific, global or local, theoretical or practical, flexible or rigid, simple or extensive, descriptive or analytical, evaluative or predictive, and static or dynamic. Therefore, the purpose of this paper is to construct a strategy-based model for low carbon cities (SMLC) to evaluate and predict future performance. It attempts to introduce an innovative thinking framework to supplement conventional low carbon city development strategies. Being flexible and generic, the proposed SMLC model could be applied to any city. It analyses the dynamic interrelationships between key performance indicators (KPIs), induces changes to city plans and policies, and then predicts the outcome of these changes.

SMLC has been applied to touristic cities for which there are abundant sustainability data. Moreover, the contribution of tourism appears to be underestimated, though it accounts for 10% of the total world GDP and 8% of global GHG emissions. Between 2000 and 2007, international tourism has grown by 110% in developed countries, offered sustainable development opportunities to many developing countries, and created direct and indirect jobs. However, the negative impacts of tourism on the environment can be evidenced in the transport and hospitality sectors. While the former contributes 75% of carbon emissions, the latter adds 20%.

The paper introduces SMLC by defining its characteristics, addresses criteria and benchmarks, evaluates city performance, and models low carbon impacts. First, by using a cumulative score method, a pilot study on major touristic cities was conducted and categorized cities as sustainable cities or unsustainable. Second, by reference to a benchmark, the proposed model was used to forecast the performance of five cities: London, New York, Barcelona, Dubai, and Istanbul. Two versions of the SMLC model were formulated, evaluative and predictive. The evaluative model is static or conventional in that it canvasses the continuation of current city conditions, sets out criteria and indicators, evaluates city performance, and then obtains results. By contrast, the predictive model is dynamic in that it forecasts future city conditions under four strategies: Passive intervention, problem-solving, trend modifying, and opportunity seeking. These strategies are designed to identify drivers of change, reveal implications of current trajectories, and inform urban policies. To achieve low carbon city performance, SMLC's results can be controlled by inducing changes to criteria. For instance, if a city falls below environmental benchmarks and municipal authorities intend to realign city plans, changes can be introduced by the model to forecast low carbon status.

2. Literature Review

There is abundant literature on low carbon cities, the majority of which deals with impact studies, modelling, and performance measurement to mention but a few. Models have been formulated to advance theoretical and analytical frameworks and test models' applicability against real conditions. In fact, IPAT, STIRPAT, and EKC are common models to measure the impact of urbanization on carbon emissions [4,5]. These were supplemented by USDM to offer a breakdown of urban sector drivers of carbon emissions [6]. Multi-criteria evaluation models were built to measure low carbon using the entropy weight coefficient method [7–9]. A generic multi-criteria evaluation model (GMLC) was also developed to quickly identify whether a city is low carbon or not [10].

Purpose built models, or specific models were constructed by, amongst others [4,11], to examine the impact of urban activities on carbon emissions in China. Likewise, Yang and Sadorsky measured the contribution of economic growth to carbon emissions [12,13]. Similarly, Horng, Shahbaz, Yeh, and Liao examined the impact of energy on carbon emissions [14–16].

Scenario based models were formulated by Herbert Kahn in 1976 to forecast future qualitative and quantitative projections operating under different assumptions. Scenarios were conceived as hypothetical sequences of events constructed to focus attention on casual processes and decisions. One common scenario refers to the expected continuation of current trajectories [17]. Another scenario comes from probable variations by reason of changes and assumptions. For example, the differences between the climatic scenarios of the IPCC are determined by assumptions of demography, social, economic, technical, and environmental development [18].

Within the low carbon city context, the utilization of scenario-based planning has been applied by leading researchers. Turnpenny built a model for climate change adaptation and mitigation by adopting the idea of back casting [19]. Through four scenarios, the method was simulated on a regional scale and applied to the west of England. Shimada refined their model by estimating socio-economic indicators and carbon emissions under three different scenarios in Shiga prefecture, Japan [20]. Gomi built a model to deal with the uncertainty of socio-economic factors by capturing quantitative and assertive future conditions [21]. Peterson developed a scenario planning consisting of six sequent stages: Identification of focal issue, assessment, identification of alternatives, building scenarios, testing scenarios, and policy screening [17].

Performance measurement has become fundamental to evidence-based decisions. It has enabled policy makers to measure city performance, and to compare and benchmark cities [22]. Likewise, multivariate data analysis and multi-dimensional decision analysis were reformed and applied by Akgun to evaluate sustainable development [23]. The composite indicator method was also developed to assess sustainability, human development, and economic affluence [24]. Using an index, it evaluates and forecasts certain conditions by measuring the probability distribution of mutually exclusive events [25]. Recently, Xing constructed a model to achieve higher accuracy in evaluating low carbon performance [26]. Using rough set (RS) and support vector machine (SVM), he neatly summed up the comprehensive evaluation of low-carbon into six categories: Low-carbon, medium-low carbon, medium-carbon, medium-high carbon, high-carbon, and ultra-high-carbon.

Drivers, pressures, state, impact and response model of intervention (DPSIR) and Life Cycle Assessment (LCA) frameworks have emerged as analytical tools to facilitate SMLC model formulation. DPSIR is a conceptual framework that is used to analyze the cause-effect relationship between society and the environment and to support decisions in response to environmental issues [27]. Further, the DPSIR framework considers driving forces, such as human activities, that exert pressure on the environment, leading to ecological changes [28]. LCA, on the other hand, is a comprehensive framework designed to describe activities and environmental impacts in a correlation method between the input and output [29]. LCA consists of four phases: Goal and scope definition, inventory analysis, impact assessment, and interpretation. In the proposed SMLC model, both DPSIR and LCA were useful to link KPIs to their effects and strategies to policies and consequently revealed drivers of change and trajectories of current conditions.

3. Methods

3.1. Model Building Process

The proposed model SMLC builds on the framework of Gomi [21], who modelled the potential to reduce carbon emissions in Kyoto by 2030 and the generic model of low carbon cities, GMLC [10]. By reformulating both the generic and specific models, the proposed model, SMLC, can evaluate and predict low carbon city performance. It attempts to examine sustainability by two different methods: First, a static model (A) featuring direct input-output evaluation. Second, a dynamic model (B) exhibiting an input with multiple outputs that are formulated according to strategies (Figure 1).

Being strategy-based, model B brings flexibility to forecast methods, applies various scenarios, and ends by comparable outputs. It affords a new approach to predict the current urban strategy to achieve low carbon city goals by employing the dominant sector(s) (economy, social, environmental) in a cumulative scoring method. Thus, comparable results under different strategies are immediately obtained. Further, the proposed model, SMLC, is generic and can be applied to any city, particularly touristic cities for which there are abundant sustainability indicators. The authors assume that the cities under examination will flourish for an indefinite period. Average growth is assumed to be 1%–2%. It is also assumed that tourism will grow by 3% annually until 2027. This assumption is similar to the assumption of United Nations-World Tourism Organization (UNWTO), which estimates that tourism will grow by 3.3% [30]. The static SMLC model (A) assumes that the current condition will continue in the future. However, the dynamic SMLC model (B) assumes that current conditions will be transformed to different trajectories because of policies that will be put in place. The SMLC model produces various trajectories/scenarios, which are determined by differences in assumptions in each sector, regarding the growth rate, low (5%–10%) and high (10%–25%).

Four strategies with varying degrees of specificity are used to transform societies from one stage to another, from high carbon to low carbon. While the passive intervention strategy calculates the score and then forecasts the current trend without any intervention, the problem-solving strategy identifies the lowest score (negative) in certain indicator(s) that will bring it up to the benchmark level. For example, a city that has the lowest score in economy, the indicators of which are the total tourists per unit area, GDP contribution, employment contribution, and percentage average room used, will be geared towards the benchmark. The trend modifying strategy identifies global trends of sustainability and induces changes which will lead to adjustment of the trend, with a view to bringing indicators to a higher score above the benchmark. Current tourism problems and trends drive opportunity seeking strategies to induce changes to the indicators. For example, if environmental indicators are within normal limits, the municipal authority might embark on policies to upgrade the environment for touristic purposes, resulting in a higher performance of the city. This strategy is based on three different sectors: Economy, social, and environmental. Each sector was divided into two sub-groups with low and high growth rates. When three sectors and two growth rates are combined, six scenarios are formed.

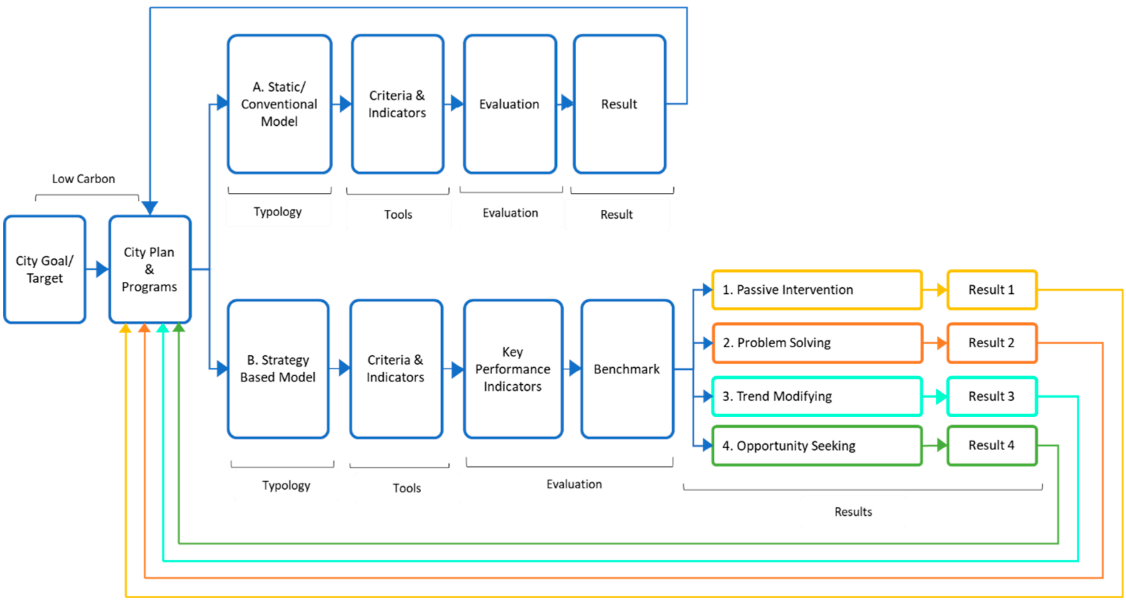

Figure 1. Strategy-based modelling framework.

3.2. Score Calculation

Based on a review of the literature and best practices, the authors developed a set of criteria and key performance indicators (KPIs). An Excel-based tool consisting of a score calculator was developed to facilitate the evaluation of a low carbon city. A cumulative score is thus attained, allowing a city's performance to be directly measured against benchmarks, current performance (model A), and future performance (model B).

The scores are calculated using the generic model of low carbon cities (GMLC) [10]. This method consists of two stages. First, a cumulative SMLC index score was calculated to determine whether a city is categorized as low carbon or not. The model is slightly modified to generate an index score between (−1) and (1) for the worst to best performance. Second, the value of each key performance indicator (KPI) is measured. The results can enable the investigator to directly evaluate and predict the impact of future policies in each sector (economy, social, environmental). To obtain a cumulative SMLC index, equal weight is assigned to all KPIs. The data normalization equation is set out in Equations (1) and (2):

$$y_i = \frac{x_i - x_b}{max\{x_i\} - x_b} \quad (1)$$

$$y_i = \frac{x_b - x_i}{x_b - \min\{x_i\}} \quad (2)$$

where y_i denotes the normalized data of the assessed object on the i indicator, x_i is the original value of the object on the i^{th} indicator, max$\{x_i\}$ is the highest value in the i^{th} indicator, x_b is the benchmark value of the i^{th} indicator. While Equation (1) is used for indicators with positive effects on carbon emissions, Equation (2) is used for indicators with negative effects, which recognizes $\min\{x_i\}$ as the minimum value in the i^{th} indicator that is 0.

The calculation of the proposed evaluation model, SMLC, is shown in Equation (3):

$$S_t = \sum_{c=1}^{6} \frac{(S_c \times w_c)}{6} \quad (3)$$

where S_t denotes the total score of assessed city, w_c measures the weight factor of the c category, and S_c calculates the total score of y_{ic} in the c^{th} category. To obtain a cumulative SMLC index score, an equal weight is assigned to six KPIs, the result of which features a low carbon city scale from: Unsustainable (−1 to −0.49); high carbon (−0.5 to 0.99); low carbon (0 to 0.49); and sustainable (0.5 to 1), as illustrated in Figure 2.

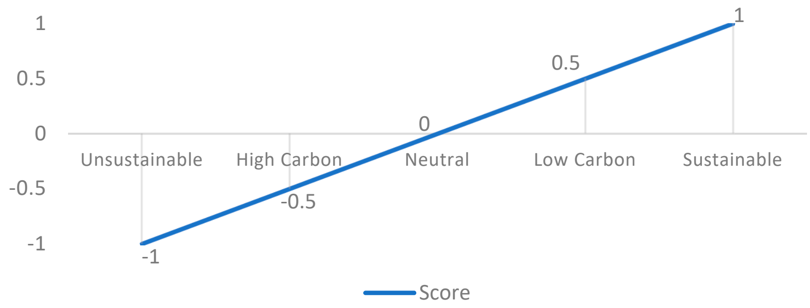

Figure 2. Low carbon city scale.

3.3. Model Application

The authors have applied the SMLC model on tourism because of its growing recognition as a major contributor to carbon emissions. Based on the best performance in each continent by the WTTC [31], the pilot study on major touristic cities was conducted by selecting 17 high performance touristic cities, the primary functions of which are: Capital cities, business centers, and high-density population hubs. SMLC was tested under the static model (A) to extrapolate current conditions, and then under the dynamic model (B) to show future trajectories. It calculated the current score of each target sector, economic, environmental, and social, to show which sector is under or over performing. An annual growth of 3% is assumed, the percentage of which is similar to the projection of WTTC [32]. Six key performance indicators (KPIs) were selected and benchmarks were calculated (Table 1). These KPIs were derived from United Nations Environment Programme-World Tourism Organization (UNEP-WTO) [33] and published research. A set of simple quantifiable indicators from the above were used to build a generic sustainable touristic city model. Two types of benchmarks were considered: Targets set out by credible international organizations, such as UNWTO and UNEP; and a benchmark for each indicator calculated from the mean values of pilot cities [1].

Table 1. Key performance indicators and benchmarks.

Indicators	Symbol	Effect	Parameter	Benchmark	Source
Daily intensity of tourist uses	I_1	+	Total tourists per unit area	89.41 tourist/km/day	[31]
Pollutant emissions	I_2	-	Level of CO_2	2.19 ton/capita	[34]
Contribution of tourism to GDP	I_3	+	Percentage of GDP attributable to the activities of hotels and restaurants	10.4%	[33]
Employment contribution	I_4	+	Percentage of employees in the tourism sector with respect to the total volume of employment in the city	9.9%	[35]
Hotel occupancy	I_5	+	% average of room usage	71.23%	[31]
Social-carrying capacity	I_6	-	Ratio of tourists to locals	4.5%	[31]

We realize that each city has different challenges that should be solved with different approach. Moreover, six scenarios were built to address the opportunity seeking strategy for low and high growth rates under three major sectors: economy, social and environmental (Table 2).

Table 2. Effect of key performance indicators in the economy, social, and environmental sectors.

Indicators	Symbol	Economy		Social		Environmental	
		Low	High	Low	High	Low	High
Intensity of tourist use	I_1	+10%	+20%	−25%	−50%	−10%	−20%
Pollutant emissions	I_2	−5%	−10%	+5%	+10%	+25%	+50%
Contribution of tourism to GDP	I_3	+5%	+10%	−5%	−10%	+5%	+10%
Employment contribution	I_4	+5%	+10%	−5%	−10%	+5%	+10%
Hotel occupancy	I_5	+5%	+10%	−5%	−10%	−5%	−10%
Social-carrying capacity	I_6	−10%	−20%	+10%	+20%	+10%	+20%

Source: Fong [36], Vaz et al. [37], and Fang et al. [38].

4. Results

4.1. Static Model

The result of the static model (model A) is shown in Figure 3, featuring four low carbon touristic cities: Marrakech, San Francisco, Barcelona, and Mexico City; the remaining cities are not. While the highest low carbon performance was achieved by Marrakech (0.155), San Francisco (0.141), Barcelona (0.109), and Mexico City (0.017), respectively, the lowest was scored by Munich (−0.455), Prague (−0.450), and Kuala Lumpur (−0.316), apparently due to pollutant emissions.

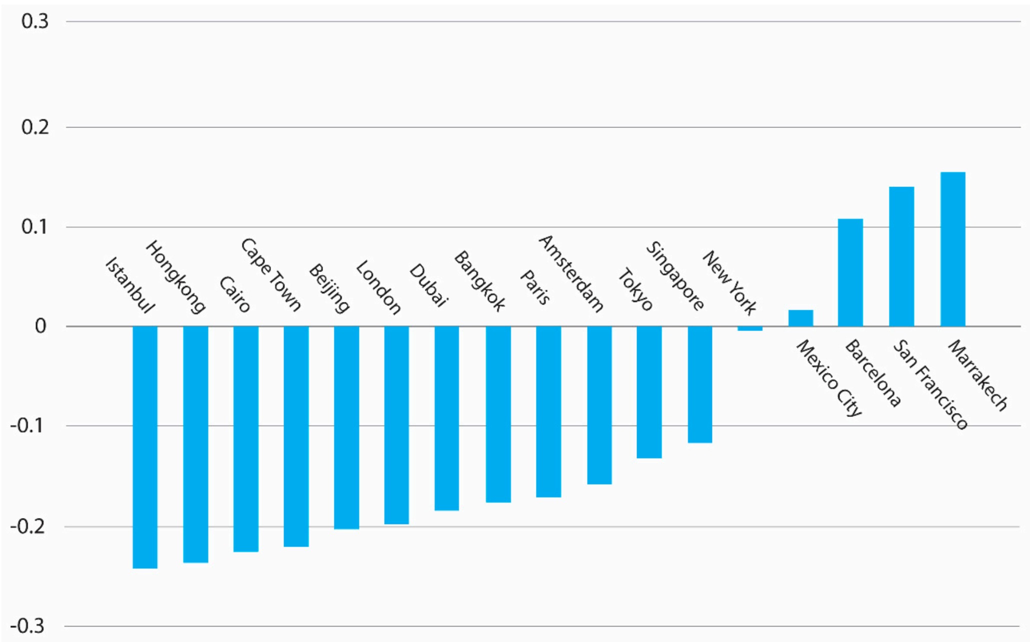

Figure 3. The result of SMLC (Model A) of major touristic cities.

4.2. Dynamic Model

Five low carbon and non-low carbon touristic cities were selected for model testing, namely; London, New York, Barcelona, Dubai, and Istanbul. The result of the SMLC (model B) is presented in Table 3 and Figure 4. Under the strategies of passive intervention, problem solving, trend modifying, and opportunity seeking, Barcelona has the highest scores: (0.258), (0.366), (0.430), and (0.548), respectively. Despite the status of New York as an unsustainable city, the adoption of a passive intervention strategy could transform it to a low carbon city (0.035), the score of which is calculated from: Pollutant emissions (−1.000), contribution to GDP (−0.398), and employment contribution (−0.136). Moreover, New York could excel under the problem-solving strategy as low carbon, with the proviso that development is focused on the environment to reduce pollutant emissions from 4.83 to 2.19 metric tons per capita. Likewise, London and Dubai are high carbon cities, but could become low carbon with the adoption of a problem-solving strategy, the scores of which are (0.114) and (0.026), respectively. No significant change has been noted in the trend modifying strategy for the five tested cities across the board. Further, when opportunity seeking strategies are applied, all cities become low carbon, with Barcelona (0.469), New York (0.315), London (0.259), Dubai (0.148), and Istanbul (0.139).

Table 3. The results of SMLC (model B) on the tested cities.

KPI	Passive Intervention	Problem Solving	Trend Modifying	Opportunity Seeking		
				ECONOMY	SOCIAL	ENVIRONMENT
	Result 1	Result 2	Result 3	Result 4		
A. LONDON						
I_1	−0.225	0.000	0.175	0.287	−0.106	0.062
I_2	−0.279	−0.279	−0.407	−0.548	−0.267	0.296
I_3	−0.500	0.000	0.063	0.132	−0.006	0.132
I_4	−0.476	0.000	0.067	0.141	−0.007	0.141
I_5	0.508	0.508	0.971	1.000	0.461	0.461
I_6	0.458	0.458	0.404	0.345	0.523	0.464
Total	**−0.086**	**0.114**	**0.212**	**0.226**	**0.100**	**0.259**
B. NEW YORK						
I_1	0.058	0.095	0.313	0.453	−0.036	0.173
I_2	−1.000	0.000	−0.100	−0.210	0.010	0.450
I_3	−0.398	−0.398	−0.375	−0.350	−0.400	−0.350
I_4	−0.136	−0.136	−0.082	−0.023	−0.141	−0.023
I_5	1.000	1.000	1.000	1.000	0.949	0.949
I_6	0.686	0.688	0.656	0.622	0.725	0.691
Total	**0.035**	**0.208**	**0.235**	**0.249**	**0.184**	**0.315**
C. BARCELONA						
I_1	1.000	1.000	1.000	1.000	0.775	1.000
I_2	0.126	0.128	0.041	−0.055	0.137	0.520
I_3	−0.307	0.000	0.063	0.132	−0.006	0.132
I_4	−0.333	0.000	0.067	0.141	−0.007	0.141
I_5	0.600	0.600	1.000	1.000	0.553	0.553
I_6	0.464	0.465	0.411	0.353	0.529	0.470
Total	**0.258**	**0.366**	**0.430**	**0.428**	**0.330**	**0.469**
D. DUBAI						
I_1	−0.323	−0.323	−0.295	−0.277	−0.340	−0.313
I_2	−1.000	0.000	−0.100	−0.210	0.010	0.450
I_3	0.012	0.012	0.076	0.146	0.006	0.146
I_4	0.156	0.156	0.239	0.331	0.148	0.331
I_5	0.392	0.392	0.844	1.000	0.347	0.347
I_6	−0.081	−0.081	−0.189	−0.308	0.049	−0.070
Total	**−0.141**	**0.026**	**0.096**	**0.114**	**0.036**	**0.148**
E. ISTANBUL						
I_1	0.025	0.025	0.210	0.330	−0.088	0.091
I_2	−1.000	−1.000	−1.000	−1.000	−1.000	−0.469
I_3	−0.307	0.000	0.063	0.132	−0.006	0.132
I_4	−0.476	0.000	0.067	0.141	−0.007	0.141
I_5	−0.395	0.000	0.412	0.866	−0.041	−0.041
I_6	0.472	0.475	0.422	0.364	0.538	0.480
Total	**−0.280**	**−0.083**	**0.029**	**0.139**	**−0.101**	**0.056**

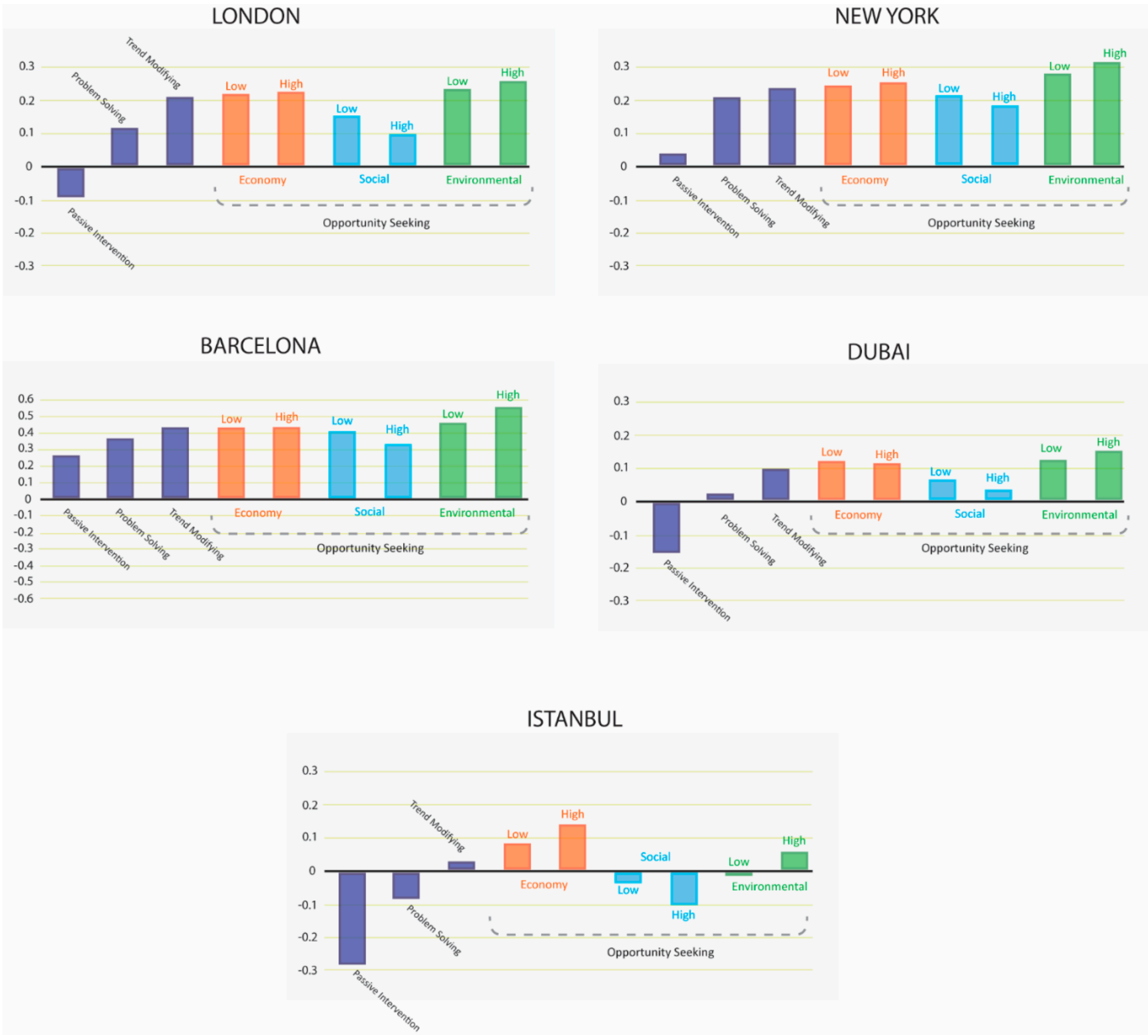

Figure 4. The result of the SMLC model (B) on the tested cities.

5. Discussion

The authors have formulated a generic low carbon model, SMLC, and applied it in 17 touristic cities. They have also constructed low carbon metrics for touristic cities that could be used by decision makers to realign development policies. By rotating the low carbon city scale around its axis, four zones were constructed: High carbon, neutral, low carbon, and sustainable. Zones were then dissected into six sectors representing key performance indicators. Scores were plotted and connected, leading to low carbon city metrics (Figure 5).

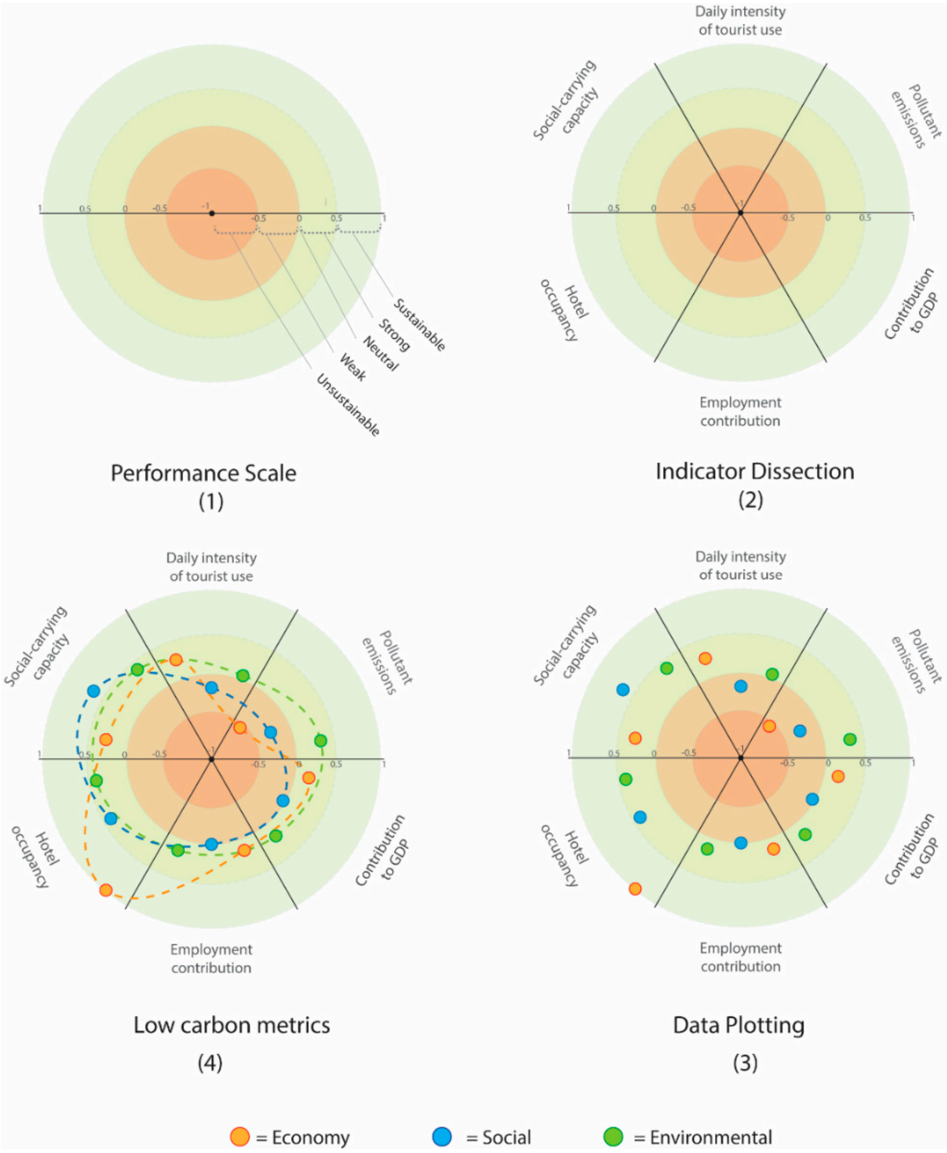

Figure 5. Low carbon metrics for touristic cities.

To operationalize SMLC, five touristic cities were selected for testing: London, New York, Barcelona, Dubai, and Istanbul. London, for instance, under the passive intervention strategy, is high carbon. However, under a problem-solving strategy, where emphasis should be placed on the economy, it turns out to be low carbon. The same holds good for the other two strategies: Trend modifying and opportunity seeking, where tourism and environment are priorities. Istanbul, on the other hand, is classed high carbon and neutral under the passive and problem-solving strategies, respectively. With the adoption of the economy and environment as drivers under trend modifying and opportunity seeking strategies, it becomes low carbon. When driven by environmental factors in opportunity seeking scenarios, New York, Barcelona, and Dubai become low carbon (Figure 6).

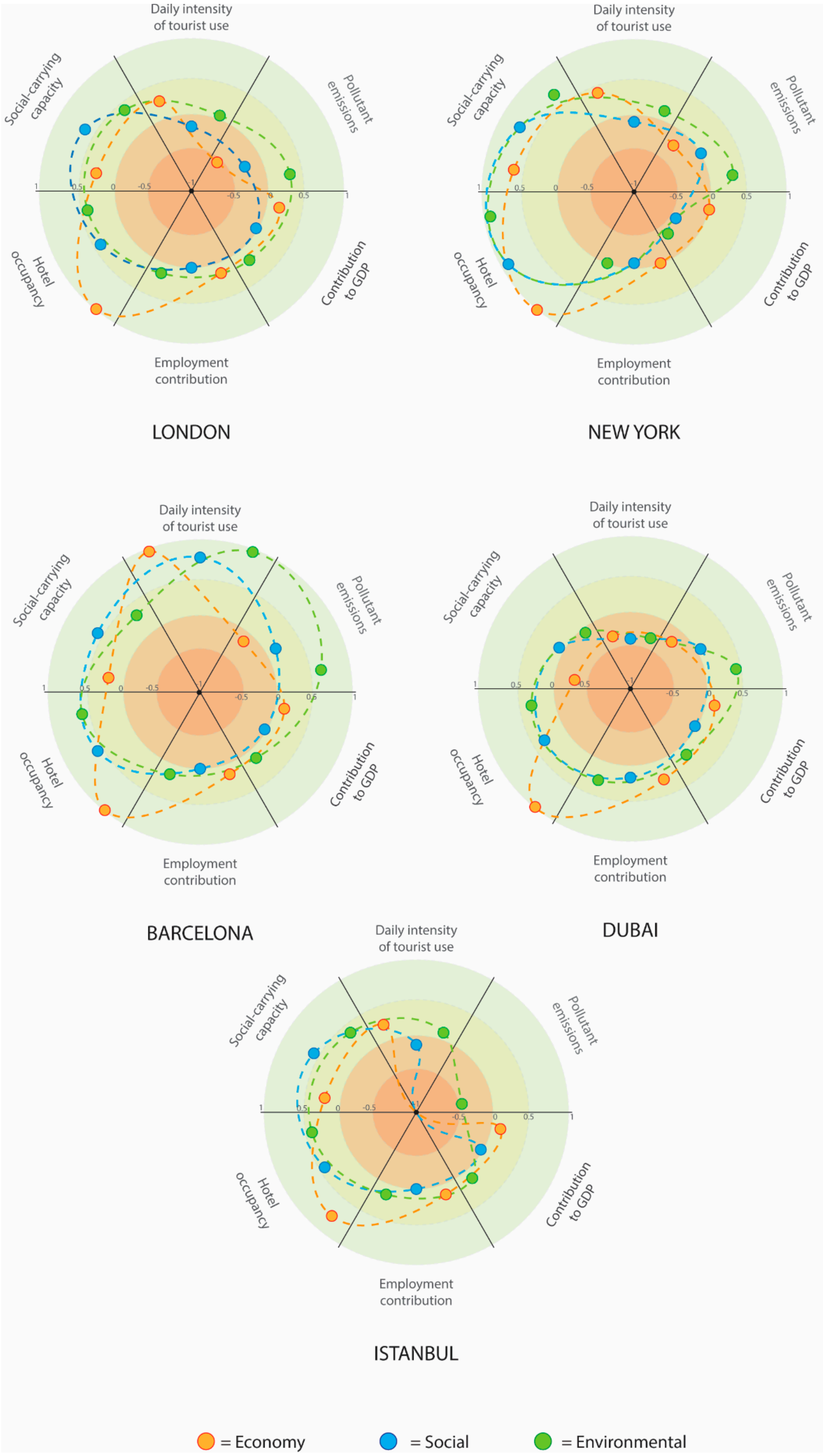

Figure 6. SMLC metric results.

Measured against key performance indicators in the SMLC model, touristic cities could foresee probable impacts, reconsider policies, and realign city plans to achieve low carbon targets. The policy implications could be economic, environmental, or social.

5.1. Economy

One of the main purposes of applying a low carbon model to touristic cities is to ensure that the long-term economic operations are viable and evenly handed to stakeholders. Benefits could take many forms, such as stable employment, minimum economy leakage, poverty alleviation, and the like. It is important that policies ensure economic returns accrue from tour operators, food producers, transport services, guides, etc. By recognizing the needs of multiple occupations, land use distribution in a low carbon touristic city can be clustered to maximize mobility.

Istanbul's transformation to a low carbon touristic city could be attained by accentuating commercial and touristic characteristics, developing the service sector, and persevering cultural and natural resources. The application of SMLC suggests that Istanbul could reach the benchmark by increasing tourism's contribution to GDP from 4.6% to 10.4% and employment's contribution from 2.1% to 9.9%. It is imperative that Istanbul expands touristic activities all year round to attract 63 million visitors by 2023. Moreover, the city's focus on international visitors has to tap MICE (meetings, incentives, conferences, and exhibitions), a popular and sustainable development initiative [39].

5.2. Social

The social carrying capacity indicator of the SMLC model attempts to measure sustainable tourism development from a social perspective by preserving traditions, the socio-cultural authenticity of local communities, living heritage, and respecting inter-cultural understanding. To seek a widespread and fair distribution of socio-economic benefits from tourism throughout the recipient community, the most important agenda should include jobs and services to the poor. It is imperative to raise public awareness, involve communities in the planning process, and disseminate information on city development. It means that decisions can be made about tourism development at the lowest level of governance. Thus, stakeholders should be able to address the specific position of indigenous and traditional communities in socio-economic development.

In Dubai, for example, the ratio of tourists to locals slightly exceeds the benchmark. In 2016, Dubai accommodated around 10 million visitors, a figure that is expected to reach 20 million by 2020 To retain Dubai's local identity, SLCM suggests that the ratio of visitors should be increased by at least 2.7%.

5.3. Environmental

Within a low carbon city concept, the natural environment deals with issues, such as conservation, biodiversity, over-exploitation, and pollution. It is also essential to maintain the aesthetic quality and appearance of the environment because of its long-term impact on tourism. Policies and controls may seek to minimize physical degradation caused by construction and waste disposal. Environmental policies should address the scale and intensity of development. The key is having policy and instruments in place at a local level that influence the location and nature of new development. The attention of development should not only be paid to the building of touristic facilities, but also to supporting infrastructures, such as airports, roads, harbors, green public transports, pedestrians, cycle friendly environments, etc. London is a case example. Currently, London produces 4.67 metric tons of carbon per capita. The city intends to reduce carbon emissions by 60%, to 2.80 metric tons per capita by 2025. In fact, under the opportunity seeking strategy, the SMLC model suggests an additional 50% reduction of carbon emissions for the city of London to become sustainable. Further, the Ultra-Low Emission Zones (ULEZ) initiative would play a key role in lowering London's carbon emissions to respond to sustainable development goals (tfl.gov.uk). In fact, the city has established a specific strategy to create green financing and a new clean tech hub to promote inclusive and sustainable economic growth [40].

6. Conclusions

This research has formulated a strategy based on a low carbon city model, SMLC to afford a preview of current and future trajectories. Being generic and flexible, the SMLC model features simplified performance based on low carbon metrics that have been applied to 17 touristic cities. Five low and high carbon cities were used to test SMLC, including London, New York, Barcelona, Dubai, and Istanbul, under four strategies of passive intervention, problem-solving, trend modifying, and opportunity seeking. The results show that these cities can be promoted to be sustainable touristic cities. The limitation of the model arises from the limited number of KPIs that were used. However, the authors think that the applicability of the model outweighs the model's limitations. It can be improved by adding spatial and graphical analysis. The authors hope that this approach enriches knowledge on policy-making and supports the discussion to set out or amend sustainable city targets. SMLC is a basic model that could be further refined and tested to increase its reliability, bridge the gap between theoretical and practical studies, and contribute to low carbon innovation.

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Conflicts of Interest: The authors declare no conflicts of interest.

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