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HOW TO IDENTIFY CITIES ON THE PATH TOWARDS REAL SUSTAINABILITY?

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Abstract: Despite rising awareness concerning climate change, global anthropic impacts on the environment are forecasted to increase overcoming years, exceeding our planet's ecological limits. The accelerating pace of climate degradation calls for a quick and efficient response from our societies, should we have a chance to limit the impacts of global warming. Being main nodes of over-consumption and pollution, thus having a high potential for footprint reduction, cities are crucial actors for climate mitigation. Hence, to successfully achieve a transition towards real sustainability, knowledge transfer needs to happen from the cities that are aiming towards life-respecting planetary boundaries to other urban regions worldwide. Although gaining momentum in the literature, a life respecting Earth's Carrying Capacity (ECC) is not yet explicitly nor widely set as the ultimate goal for cities wanting to realistically face climate change. This article's purpose is to reflect on the identification of cities aiming for ECC and points out the various obstacles to this goal. A misrepresentation of cities' impact, both induced by misused sustainability terms and incomplete assessment methodology, is found to be hindering cities from reducing their footprint with the efforts needed to adequately face climate change. To that extent, it is crucial that ECC becomes a wider used target for cities, and that compliant assessment methods along with more holistic indicators are used to evaluate and monitor their progress. Finally, other technical issues regarding the incompleteness of standards, accessibility, and representativeness of qualitative data must be addressed.

1 INTRODUCTION

Accounting for 80% of global greenhouse gas (GHG) emissions and 75% of the planet's material resources, cities' overconsumption is a crucial point regarding the environmental crisis (Ortega-Montoya and Johari 2020; Swilling et al. 2018; Ghaemi and Smith 2020). Already home to half of the world's population, this urbanizing trend is projected to increase to 70% by 2050, according to the latest report by the United Nations Organization (UNO) (United Nations, Department of Economic and Social Affairs, and Population Division 2019). Concentrating important monetary, material and energetic flows, cities have a great potential for resource conservation and could be catalysts to a global sustainable transition (Hachaichi and Baouni 2020; J. Moore, Kissinger, and Rees 2013). As a result, a growing interest has been given to cities regarding urban sustainability in the literature (Baabou et al. 2017; Swilling et al. 2018; Lombardi et al. 2017; Mirabella, Allacker, and Sala 2019). However, despite this rising awareness concerning climate change, ecological footprint, natural resource consumption and greenhouse gas (GHG) emissions, are all foreseen to increase in the years to come, exceeding our planet's limits (Spratt, Dunlop, and Taylor 2020; D. Moore et al. 2012; Swilling et al. 2018; Galli et al. 2020). The purpose of this article is to reflect on how to identify cities that have reduced their pressure on the environment and are aiming towards a life within our only planet's means. A first review of the discrepancies in meaning when talking about sustainability is performed and compared to what Earth's carrying capacity (ECC) really entails. ECC compliant sustainability indicators and accounting approaches are described, and the importance of their correspondence with cities' dynamics is put forward. Finally, the common gaps and biases encountered in a search for cities on the path towards real sustainability are listed. Real sustainability is defined as a recognition that human manufactured capital is not substitutable for natural ecological capital, commonly referred to as ecosystem services or biocapacity (Neumayer 2003).

2 VARIOUS DEFINITIONS AROUND SUSTAINABILITY

In a world where terms like "sustainability", "green growth", or "green cities" are flourishing, some must wonder how is it that scientists keep talking about global warming. Although the meaning of "sustainable development" was universally agreed upon in the Brundtland report in 1987, the term "sustainability" bears several meanings (J. Moore, Kissinger, and Rees 2013; Rees 1989; Hassan and Lee 2015; Eyong and Foy 2006). As an example, Metro Vancouver is often cited in the literature as a sustainable city, because of its engagement and actions towards environmental challenges (J. Moore, Kissinger, and Rees 2013). However, when looking at its global impact, it appears like most Canadian cities : rather unsustainable and typical of high-consuming cities (Isman et al. 2018). Indeed, when measured with an overarching indicator such as the ecological footprint, the city was found in a clear overshoot, at the point that if everyone on earth were to live alike Metro Vancouver's residents, almost four planets would be needed to supply resources and assimilate the waste and pollution of their lifestyles (J. Moore, Kissinger, and Rees 2013). This dependency on other regions for food and natural resources, exacerbated by the globalized context of our societies, highlights the pressure cities induce on territory outside their physical boundaries and their "lack of self-sufficiency" (Ortega-Montoya and Johari 2020; Kissinger, Rees, and Timmer 2011; Hassan and Lee 2015; Galli et al. 2020). Hence, for accuracy purposes not only shall one refer to these urban regions as "cities on the way to sustainability" rather than "sustainable cities", but also consider a more holistic approach when assessing urban environmental impact, in order to consider cities' widespread impact (Kissinger, Rees, and Timmer 2011; Galli et al. 2020; Baabou et al. 2017; J. Moore, Kissinger, and Rees 2013). This discrepancy between usual terms employed and actual status sheds light on the distortion that can happen regarding the perception people have on the overall environmental situation, and can further hinder decision-makers from acting according to the urgency of the matter (Hassan and Lee 2015; Mirabella and Allacker 2021). Indeed, "One Planet" is not a mere target for our societies, it is the context within which we evolve and must respect in order for future generations to be able to live and thrive (Galli et al. 2020). The Earth's Carrying Capacity (ECC) sets quantitative environmental limits, or planetary boundaries (PB), within which our societies can operate without causing irreversible degradation (Steffen et al. 2015). These environmental thresholds could be a more accurate objective for policy-makers rather than mere sustainability, because not only do they give quantitative objectives, but they can also be used for evaluating sustainability indicators of various materiality (Li et al. 2020; Świąder et al. 2018; Swilling et al. 2018; Hachaichi and Baouni 2020).

3 HOW TO ASSESS EARTH CARRYING CAPACITY AT CITY SCALE?

To comply with the definition of ECC, the identification of best performing cities relies on several aspects. The indicators and metrics measured shall be comparable with planetary boundaries and the analysis must be holistic and comprehensive.

3.1 ECC Compatible Sustainability Indicators

Cities are complex systems for which various challenges need to be considered in order to fully understand their dynamics and correctly assess their impacts (Mirabella, Allacker, and Sala 2019; J. Moore 2013). As of today, no single indicator can evaluate environmental urban impacts in their entirety although several proxies can be measured. Among the most used at the city scale are several footprints such as material, ecological, carbon or water (Mirabella, Allacker, and Sala 2019; Bringezu 2015). They can be described as ECC compliant because planetary thresholds have been scientifically evaluated for their corresponding metrics.

3.1.1 Material Footprint

Natural resource consumption is generally evaluated using Domestic Material Consumption (DMC) which accounts for the annual quantity of raw material a territory extracts and uses domestically or physically imports and is expressed in tonnes per capita per annum (Swilling et al. 2018). A DMC range of 6 – 8 tonnes has been proposed as an indicative threshold for staying within planetary boundaries, given current population, and associated averaged material standard of living, i.e., a fair material share. This could therefore serve as a target for economic decoupling efforts (Swilling et al. 2018; UNEP 2011).

However, because it omits the upstream impacts of resource consumption - which represents 80-90 % of the material footprint - and the unused extraction, this indicator fails at representing the real impact of a territory's consumption (J. Moore 2013). Hence, another indicator referred to as the Total Material Consumption (TMC) has been proposed, as it encompasses these lacking aspects and allows for a better guidance as it deconstructs material footprint into three different flows (Swilling et al. 2018; Bringezu 2015). The corresponding thresholds have been set for biotic, abiotic and Raw Material Consumption (RMC) respectively to 2, 6-12 and 3-6 tonnes per person per year (Swilling et al. 2018; Bringezu 2015). This corridor for sustainability would allow a better use of natural resources and could also serve as a basis for reducing different bundles of environmental pressure induced by our societies (Bringezu 2015; Sala et al. 2020).

3.1.2 Ecological Footprint

The ecological footprint (EF) accounts for the human pressure a specific population induces on its natural capital and expresses it in terms of global hectares of productive land necessary to produce the resources needed for consumption and assimilates the generated wastes (Świąder et al. 2018; Kissinger and Rees 2010). It either compares it to the biocapacity (BC) of the same supportive ecosystem (the bioproductivity of the land), or to the Fair Earth Share. The latter is a dynamic indicator evaluated by dividing the global biocapacity of the planet by the total number of its inhabitants. Using the data for 2019, the Fair Earth Share was evaluated at 1.6 gha/cap/year, for a world's total biocapacity of 12.2 billion hectares, to be shared by 7.7 billion people (Global Footprint Network 2019). This reflects the fact that environment is a common good, hence everyone shall be legitimate to pretend to an equal share of it (J. Moore and Rees 2013). Although, one should bear in mind that as population increases and available biocapacity goes down, due to climate warming's side effects, this Fair Earth Share is likely to shrink over the coming years (United Nations, Department of Economic and Social Affairs, and Population Division 2019; D. Moore et al. 2012)

3.1.3 Carbon Footprint

The carbon footprint (CF) is a subpart of the ecological footprint and represents the quantity of greenhouse gas (GHG) emissions emitted directly or indirectly by a particular entity, and is generally expressed in terms of tonnes of CO_2e (Lombardi et al. 2017). An upper global limit of 387 gigatons of CO_2e has been set, referred to as the carbon budget. It represents the cumulative amount of emission that our societies must not exceed in order to respect Paris Agreements and remain within a temperature elevation of 1.5°C (C40 Cities and ARUP 2016).In a scenario where our societies do not rely on carbon capture technologies, the equivalent per capita target would be of 2.5 tCO_2e in 2030 and gradually decrease to 0.7 tCO_2e by 2050 (Institute for Global Environment Strategies and Aalto University 2019)

3.1.4 Water Footprint

The water footprint (WF) is the amount of water used by a territory for its activities and considers the indirect flows through either a lens of production or consumption (Aldaya 2012). The WF comprises three main categories of blue, grey and green water according to the source of the flow considered, respectively groundwater and surface water, evapotranspiration from soil or assimilated with waste flows (Paterson et al. 2015; Aldaya 2012). Analogous to EF, the WF threshold is either expressed in terms of local attributes (here water availability), or in terms of planetary boundaries. The latter corresponds to the global amount of freshwater our societies can use while still allowing to maintain the natural environmental flow in all river basins. It has been set at 2,800 km^3/year, or for a global population of 7.7 billion people, a limit of 363.6 m^3/cap/year (Gleeson et al. 2020; Li et al. 2020).

3.1.5 Anthropic Pressure

It is worth mentioning that although planetary boundaries have been set for these sustainability indicators, their value is not constant over time and are particularly sensitive to parameters like population, population density or economic globalization and GDP, as represented in Figure 1 (Ortega-Montoya and Johari 2020; Moran et al. 2018; Ghaemi and Smith 2020). As a result, the identification of cities on the way towards ECC must be done through absolute reductions of their overall pressure on the ecosystem. Monitoring reductions based on normalized indicators at the urban scale (i.e., CO_2e per capita) would dismiss the population as a driver for environmental degradation and would fail to reflect a city's situation in its integrality.

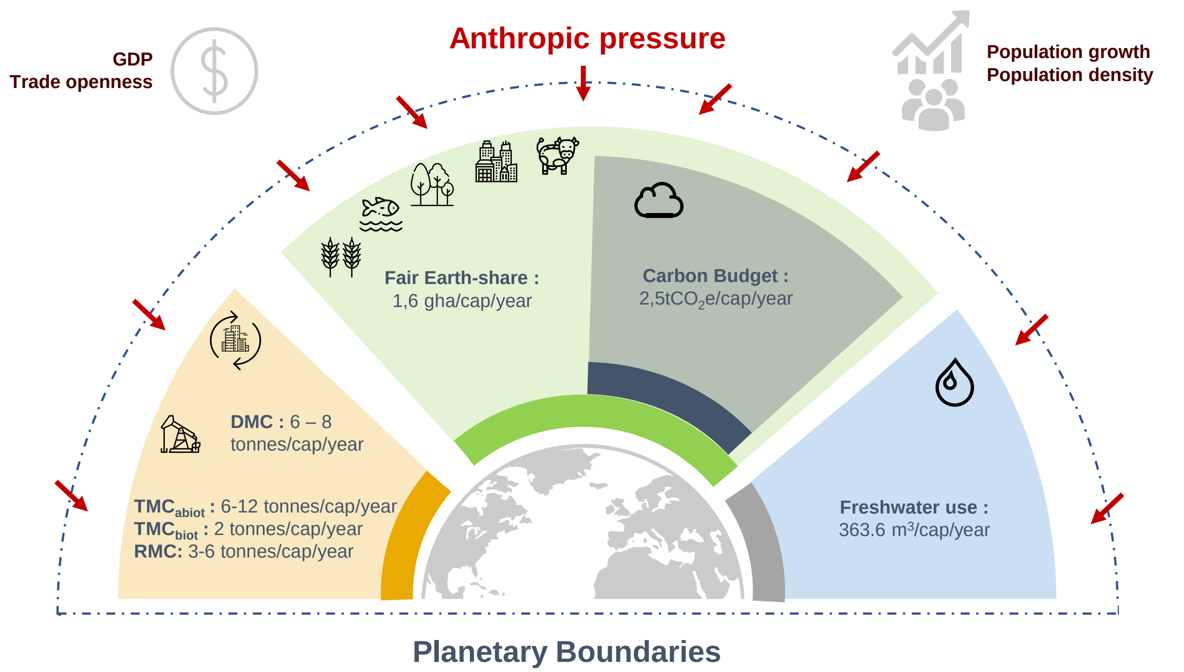

Figure 1: Scheme for some of the planetary boundaries per capita and anthropic pressure factors

3.2 Boundaries and Accounting Approaches

To ensure the comprehensiveness and accuracy of sustainability assessments at the urban scale, the first challenge lies in the accounting method. The approach chosen determines whether impacts are attributed according to a consumption-based (CB), production-based (PB) or territorial (TE) point of view. Depending on the method chosen, the responsibility is then either placed on the consumer, the producer or merely where the impacts physically occur, as represented in the Figure 2 (Mirabella and Allacker 2021; Lombardi et al. 2017).

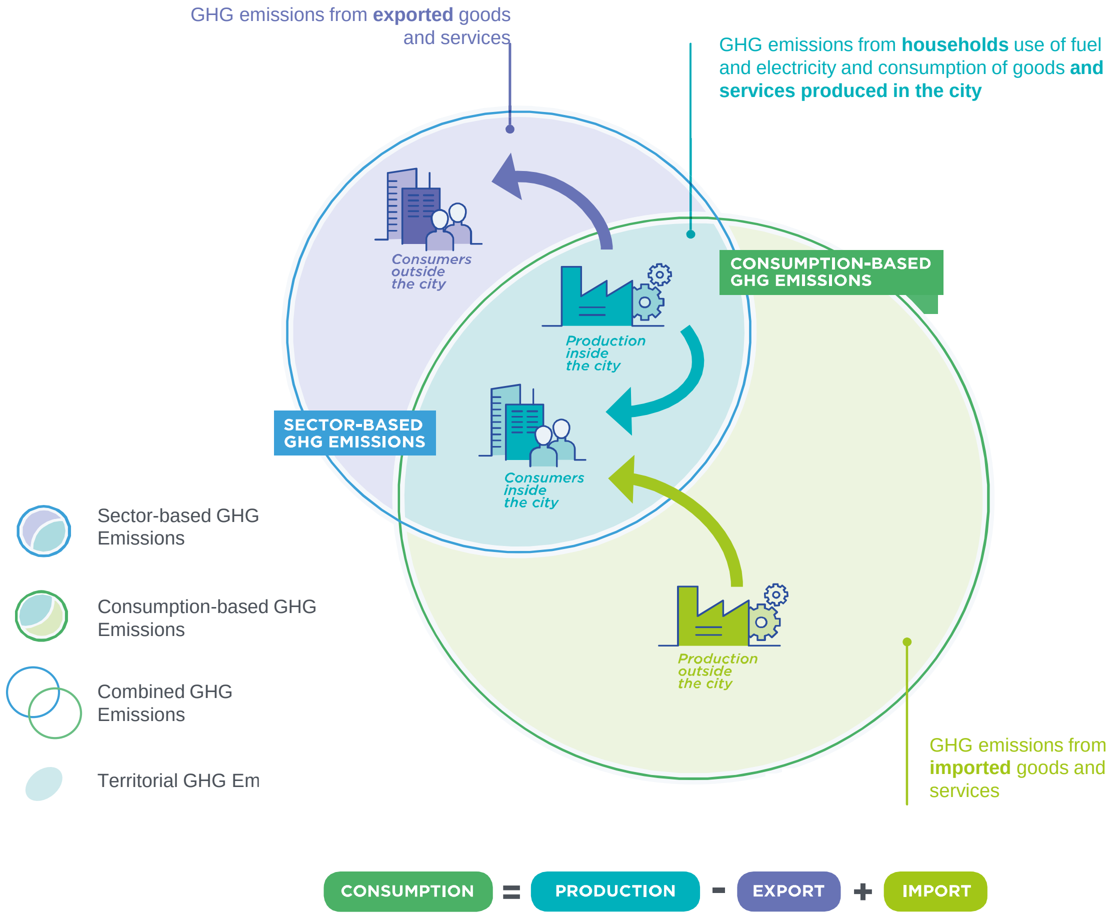

Figure 2: Scheme of different accounting approaches (Source: adapted from C40 Cities 2017)

Hence, for a sustainability assessment to represent the pressure adequately that a certain city induces on its ecosystem, it must reflect the city's dynamics (Mirabella and Allacker 2021; Balouktsi 2020; Swilling et al. 2018; Kissinger and Rees 2010). As connectivity of urban regions develops with the rest of the world, it spreads ecological pressure to further territories (Ortega-Montoya and Johari 2020; Mirabella and Allacker 2021; Li et al. 2020). As a result, to reflect the city's economic structure, consumption-based approach ould be preferred for high-consuming cities (typically based on services) and a production-based approach for low-consuming cities (generally based on manufacturing) (Wiedmann et al. 2020; C40 Cities 2017; Moran et al. 2018). This profiling helps prevent any "burden-shifting" from high-consuming cities, whose embodied emissions and impacts are bigger than direct ones, to low consuming ones (Moran et al. 2018; Wiedmann et al. 2020; Ghaemi and Smith 2020; Ortega-Montoya and Johari 2020). Apart from a fairer and more equitable attribution of impacts, categorizing the urban clusters could help develop more efficient transfer knowledge among cities facing the same issues and limit a "front runner paradox effect" (Balouktsi 2020; Van der Heijden 2018; Noiva, Fernández, and Wescoat 2016). The latter describes the lack of adequacy that can occur when knowledge transfer is done from a small group of seemingly leading cities to the urban majority where solutions do not resonate with their realities and main issues, making the whole process inefficient (Van der Heijden 2018; Hassan and Lee 2015). Having in mind all these aspects prevents misrepresentation and allows targeting active cities on the way towards ECC with more accuracy. However, there are other practical obstacles that stand in the way of identifying these leading urban regions and that must also be acknowledged.

4 OBSTACLES FOR ECC ASSESSMENT AT URBAN SCALE

When trying to pinpoint leading cities transitioning towards a life respecting our only planet's means, several gaps and biases are encountered, that can be separated among four main categories: definitions and materiality, scopes and methodology, urban accounting standards, and data at the urban scale.

4.1 Definitions and Materiality

As described in Section 2, there is a significant discrepancy concerning frequently used sustainability terms and actual situations regarding environmental impact assessment. As a result, the misemployed words can distort reality to the point of being in antagonism with it. This ambiguity in definition can make it difficult for urban decision-makers to make the right decision in designing policies that could reduce cities' environmental impact according to the urgency of the matter (Hassan and Lee 2015). This is corroborated by the fact that nowadays, despite the critical situation regarding climate change, only a few cities really monitor their environmental impact against ECC, or in a planetary boundary perspective (J. Moore, Ouellet-Plamondon, et al. 2021; Galli et al. 2020). Moreover, although carrying capacity assessment promotes a holistic approach to assess the environmental impact, the most used indicator at urban scale remains about GHG emissions quantification despite its narrow focus (Kalbar et al. 2017). Although an important driver of global change, affecting biodiversity, water availability, and some natural resources, particularly those related to food crops, a singular focus on GHG emissions is less comprehensive than other indicators like ecological footprint., It does not account for direct drivers of crucial aspects such as loss of biodiversity, due in large part to land use change, water shortages or depletion of natural resources (Kalbar et al. 2017; Mirabella, Allacker, and Sala 2019). This lack of completeness is problematic because in the case where an absolute reduction in GHG emissions is achieved by a trade-off in another kind of ecological capital, a carbon footprint assessment would fail to capture it and only present the situation as an improvement (Yu et al. 2019; Merino-Saum et al. 2020). For example, converting to biofuels as a way to reduce carbon intensity could increase timber harvest from forests with a negative impact on biodiversity. Not only do those parameters make it difficult the identification of leading cities aiming for a life within ECC, but it also unveils a lack of comprehensiveness concerning the scopes and boundaries considered.

4.2 Scopes and Methodology

Selecting cities on the basis of a global and absolute reduction (as suggested in section 0) implies comparing the same urban system's footprint for various years. However, both these temporal and physical scopes are limited in some ways. Indeed, if we consider urban ecological footprint assessment for instance, most of the evaluation worldwide have been performed for a single year, and do not specify the boundaries considered, which hinders comparability for evaluation and monitoring of improvements (J. Moore, Ouellet-Plamondon, et al. 2021). Hence, although EF is considered an overarching indicator, the lack of urban longitudinal studies prevent its broader use as a selection criteria for identifying cities going toward ECC (Galli et al. 2020; J. Moore, Ouellet-Plamondon, et al. 2021). Another bias that affects the identification of leading urban regions in terms of impact reduction is the lack of consistency among cities' typologies and the accounting methods used to evaluate their sustainability. Indeed, most of the studies performed are on high-consuming cities and yet, there is a clear lack of comprehensive consumption-based assessment (Wiedmann et al. 2020; Moran et al. 2018; Mirabella and Allacker 2021). This gap is partly explained by the inconsistency in urban accounting standards (Lombardi et al. 2017; Wiedmann et al. 2020).

4.3 Urban Accounting Standards

To facilitate interurban comparison on sustainability performance, international accounting standards have been designed. However, some inconsistencies have been pointed out for different materiality assessment. For example, standards for ecological footprint or material footprint assessment at urban scales are directly adapted from their national versions, respectively Global Footprint Network or Eurostat, using a top down approach (Świąder et al. 2020; Baabou et al. 2017; Voskamp et al. 2017). While it allows for a comparison between different cities, it also hinders the accuracy of their evaluation. For a more precise assessment, a bottom up approach can be used, however, it can hinder comparison, as various approximations and adaptations might be done differently from a study to another (Voskamp et al. 2017; Wang et al. 2020; Świąder et al. 2020)). As a result, a choice between accuracy and comparability is to be made. For water and carbon footprints, although international urban standards already exist, shortcomings in their accounting protocols have been expressed (Lombardi et al. 2017; Mirabella and Allacker 2021; Aldaya 2012). As highlighted in section 4.2, there is a lack of comprehensive consumption-based assessment at the urban scale, despite the fact that most urban clusters have significantly large consumption embodied emissions, on par with direct ones (Moran et al. 2018). Indeed, for the main international standards concerning carbon footprint, the report of indirect emissions is both incomplete and facultative for cities, which can partly explain inadequacy in assessment (Lombardi et al. 2017; Mirabella and Allacker 2021; Chen et al. 2019). This lack of comprehensive accounting results in misrepresentation of cities' real impacts., Only considering direct emissions can lead to under-reporting by up to three times a city's real impact, and indirectly promotes burden shifting from high-consuming urban clusters to low consuming ones (Ortega-Montoya and Johari 2020; Mirabella and Allacker 2021). Life cycle analysis (LCA) methods, that encompass embodied emissions, are gaining momentum in the urban academic literature and several researchers request that they further complement actual standards to solve this issue of unfairness and incompleteness (Albertí et al. 2017; Mirabella, Allacker, and Sala 2019; Ghaemi and Smith 2020). However, LCA methods are data-intensive approaches that can be hard to use in regions where qualitative data are hardly accessible (Ghaemi and Smith 2020).

4.4 Data at Urban Scale

When listing the limitations and gaps of one's research in the domain of urban sustainability, the lack of accessible, comprehensive, and qualitative data is typically mentioned (Khalil and Al-Ahwal 2020; Ghaemi and Smith 2020; Chen et al. 2019). Either they lack transparency, have a weak precision or are merely unavailable, which directly impacts the identification of cities going towards ECC (J. Moore, Ouellet-Plamondon, et al. 2021). International comprehensive urban databases for sustainability assessment are lacking water, material, and ecological footprint, which limits their use in the search for leading cities (J. Moore, Ouellet-Plamondon, et al. 2021). For carbon footprint, although the Carbon Disclosure Project (CDP) database helps with gathering information on cities' emissions around the globe, the platform is self-reported by cities and data are not further verified, which brings uncertainty on their quality (Nangini et al. 2019). Reporting qualitative and comprehensive data for urban sustainability requires dedicated infrastructure, staff and is time-consuming, requiring a subsequent budget. These kinds of constraints are one of the reasons why low-consuming cities are generally poorly represented in existing databases (Hachaichi and Baouni 2020; Dietz 2018). This regionality in qualitative data accessibility further prevent the unbiased identification of cities going towards ECC and sheds light on the importance of assessing an intentionality parameter.

5 CONCLUSION

Identifying cities on the way towards real sustainability, that is, pursuing a life respecting our only planet's means, remains a difficult task. Indeed, actual main urban sustainability assessment methods, approaches and standards lack the completeness and accuracy needed for this selection (Wiedmann et al. 2020; Mirabella and Allacker 2021; Lombardi et al. 2017; Moran et al. 2018). Holistic indicators and coherent attributive methodologies need to be promoted and integrated to international urban standards in order to adequately evaluate urban environmental impact and responsibly face the climate crisis (Kissinger and Rees 2010; Mirabella and Allacker 2021). This prevention of burden shifting and trade-off between different aspects of environmental degradation also needs to be complemented with a more inclusive representation of cities in databases (Moran et al. 2018). The unequal representation of urban regions, and more specifically of low-consuming cities, hinders their identification as ones aiming at an ECC goal. To conclude, ECC must be put forward as the absolute goal for every city wanting to reduce their impact and be the subject of major knowledge transfer among urban regions. To ensure the efficiency of this interurban capacity building, further research must be done on relevant parameters to group cities with comparable contexts and facing similar challenges. Generalizing of an only solution to various cities is an irrational belief regarding a successful transition to a one planet paradigm. Considering the challenge foreseen from rapidly growing cities in the global south, it is crucial to get more information on these low-consuming cities' best practices in order to find appropriate solutions, rather than blindly keeping on applying inadequate solutions from high-consuming, western contexts (Hassan and Lee 2015; Nagendra et al. 2018).

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