



Article

How to Measure Sustainable Housing: A Proposal for an Indicator-Based Assessment Tool

Jakub Adamec ¹, Svatava Janoušková ^{2,3} and Tomáš Hák ^{1,3,*}¹ Faculty of Humanities, Charles University, 18200 Prague, Czech Republic; jakub.adamec@outlook.cz² Faculty of Science, Charles University, 18200 Prague, Czech Republic; svatava.janouskova@natur.cuni.cz³ Environment Centre, Charles University, 18200 Prague, Czech Republic

* Correspondence: tomas.hak@czp.cuni.cz

Abstract: Housing drives urban development and has a significant potential for contributing to sustainability. However, ample sustainability indicator sets fail to include relevant indicators of sustainable housing—assessment seems to be an underdeveloped topic. We chose the United Nations Geneva Charter on Sustainable Housing as a conceptual foundation for the proposed assessment tool. It addresses recent challenges by four defining principles and related rationales, thus forming a theoretical basis of sustainable housing. We applied both theoretical research (desk-top analysis) and qualitative research (an expert panel) to develop a comprehensive framework for sustainable housing and complemented it with relevant indicators. The proposed housing sustainability assessment tool (HSAT) explicitly advocates a holistic approach that seeks to balance the environmental, social, economic and institutional dimensions of sustainability; simultaneously, it includes an integrated concept of the building–community–locality. Hence, this article does not seek to redefine the sustainable housing definition or concept but to contribute to the development of a highly relevant indicator-based system for its assessment. This will ensure that correct and unambiguous messages are sent not only to policymakers but also investors, urban planners and finally also the citizens—the housing clients.

Keywords: sustainable development; sustainable housing; UN Geneva Charter; indicators; an assessment tool



Citation: Adamec, J.; Janoušková, S.; Hák, T. How to Measure Sustainable Housing: A Proposal for an Indicator-Based Assessment Tool. *Sustainability* **2021**, *13*, 1152. <https://doi.org/10.3390/su13031152>

Academic Editor: Manuel Duarte Pinheiro
Received: 23 December 2020
Accepted: 20 January 2021
Published: 22 January 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Having satisfactory accommodation is a major element of people's material needs, and therefore, housing is one of the basic conditions determining the quality of life [1,2]. Although the basic needs of accommodation, such as having a shelter from weather conditions, space for privacy and personal security, a place to raise children and to rest, have remained the same over time, the views on what satisfactory accommodation is have changed rapidly [1]. This is why the provision of adequate and affordable housing remains a key priority for governments throughout the world [3]. Adequate housing should provide adequate privacy, adequate space, physical accessibility, personal security, the security of tenure, adequate lighting, heating and ventilation, basic infrastructure such as water supply, sanitation and waste management facilities, suitable environmental quality and health-related factors, and an adequate and accessible location for work and basic facilities; all the foregoing should be available at an affordable cost [4].

However, meeting all people's demands for quality adequate housing must, of course, affect both natural and social environments. Housing construction and operations consume large amounts of natural resources while producing waste and pollution [5,6]. Poor conditions in social neighborhoods (i.e., characteristics of the social relationships among its residents) may negatively affect personal as well as community life [1]. Housing must, therefore, meet not only the criterion of adequacy but also social and environmental sustainability [7]—otherwise, the overall impacts of even adequate housing may negatively

affect human health and life satisfaction. In other words, sustainable housing must address the cultural, economic, environmental and social facets of housing in an integrated fashion [6,8].

Due to growing population and personal demands on housing quality, housing has become one of the most important public policies shaping sustainability [5,9,10]. Therefore, all major international sustainability initiatives refer to housing or settlement strategies. However, indicator sets derived from them often fail to include indicators of sustainable housing; housing is an underdeveloped topic in terms of indicator assessment [11]. Furthermore, a glimpse at the Internet confirms that while sustainable housing seems to be an already established research theme (Google Scholar shows over 20,000 references for this), only 26 records match the keyword “sustainable housing assessment”, and 38 records show papers comprising “sustainable housing indicators” (within them only a handful deal with a comprehensive indicator-based system). This is just an approximate indication, but it corresponds well with the work of some authors who have concluded that there has been no single method or tool that truly accommodates all the often-competing parameters in the building design or construction processes [12].

The principal difficulty for measuring sustainable housing is defining its concept and its objectives in a meaningful and realistic way [6]. Therefore, in the theoretical part of this article, we show the long and complex way of doing this. Another problem is finding appropriate indicators to measure all sustainable housing aspects included in its definition [11]. We analyzed various approaches to assessments of sustainable housing, and based on the desk-based analysis of these assessments and methods of qualitative research (expert panel), we propose an indicator-based assessment tool (a comprehensive and balanced indicator set) for sustainable housing.

As a conceptual framework for the housing sustainability assessment, we applied the approach and definition of sustainable housing according to the UN Geneva Charter on Sustainable Housing [3]. The Charter defines four core principles and related rationales addressing sustainable housing. We take for granted that this format has laid a solid policy and conceptual framework providing a groundwork for thorough expert and scientific follow-up on their operationalization by relevant indicators. Assigning indicators to particular rationales needs conceptualization and operationalization of this framework.

This article does not seek to redefine the sustainable housing definition/concept already endorsed by the international community in the format of the UN Geneva Charter, but to contribute to the development of a highly relevant comprehensive indicator-based system for its assessment that has not been put in place yet. Such a system is represented by the proposed housing sustainability assessment tool (HSAT) that comprises important aspects of the UN Geneva Charter concept, the United Nations sustainable development strategy and broad views of the sustainable housing assessment. Its use would ensure that correct and unambiguous messages are sent to policymakers, investors, and urban planners in order to contribute to both the further conceptual work and extensive empirical and practical developments (e.g., conceptual refinement, indicator testing, pilot assessments). The next step would logically be an exploration of data availability, country and/or local-specific relevance, and financial demands or institutional capacities for practical applications. Finally, we offer some suggestions for sustainable housing experts and indicator developers and providers.

2. Sustainable Housing Concept

The term “sustainable development” was coined by the International Union for Conservation of Nature in the 1980 World Conservation Strategy [13]. Our Common Future (Brundtland Report) [14] then gave further direction to comprehensive global solutions and defined the concept of sustainable development as a development “which meets the needs of the present generation without compromising the ability of future generations to meet their own needs”. During the early stages, the institutional dimension was discussed—alongside environmental, economic and social ones—in terms of integrating the

environment into other policies but was hardly considered as a dimension of sustainability in its own right. It has been recognized that institutional capacity must be incorporated into policy design from the very beginning and on an equal footing if a bias of the results violating the basic concept of sustainable development is to be avoided [15]. The institutional dimension of sustainable development had already been touched upon in 1995 when the UN Commission for Sustainable Development decided to develop indicators to assess the progress of the implementation of Agenda 21 [16]. The indicator system explicitly took account of the role of institutions, but the indicators focused only on the impacts of organizations and thereby neglected important institutional aspects that predetermine activities and policies, as well as their effectiveness. The importance of a broader understanding of institutions was then emphasized by the World Bank [17] as a need to transform institutions in order to achieve sustainable development in a dynamic world [18].

Since the early 1990s, the term “sustainability” has been widely used, and several authors state that it has become one of the most overused, abused, and misused terms in society, as well as in development literature [19–21]. We hear about sustainable cities, a sustainable economy, a sustainable society, sustainable transport, and sustainable housing, but we rarely know what these concepts really mean. Attempts have been made to operationalize various terms related to sustainability, including sustainable housing, for three decades. However, as Choguill [19] pointed out, operationalizing sustainability in housing is extremely difficult. Similarly, sustainable city and smart city concepts have undergone a long process of conceptualization and, most of all, an unfinished operationalization. Indicators for both concepts are available, but in such an abundant and unsystematic way that city managers often do not understand which indicators to use [22]. Thus, it has been at least a partial achievement of scientists as well as professionals, politicians, and the interested public to agree upon a definition of the sustainable housing concept.

A straightforward way to define sustainable housing follows the Brundtland Commission’s definition. Thus, sustainable housing can be defined as “housing development that meets the housing needs and demands of the present generation without compromising the ability of future generations to meet their (housing) needs and demands” [7]. However, such a definition would face the same critique as above for its vagueness, ambiguity, and lack of consensus on what is to be sustained and what to be developed [23–25]. A review of relevant definitions of sustainable housing distinguishes several approaches to the sustainable housing conceptualization.

As in many other fields of human activities (e.g., transport, energetics), the concept of housing has developed over a long period of time, and even in a sustainability context, it may still be viewed as “housing for sustainable development” or “sustainable housing”. While housing meets many fundamental needs of people and is thus instrumental for (sustainable) development together with other economic and social needs, sustainable housing directly drives sustainable development by linking people of various incomes, age and tenure groups, building stable communities and meeting the needs of people in their personal and economic lives while respecting the ability of future generations to meet their needs. Previous approaches mostly stressed the role of housing as to achieve sustainability in terms of the housing consumption of resources (raw materials as well as land/space) in its construction, maintenance and use, on a larger scale. Sustainable housing was commonly defined as housing that has a minimal negative impact on the natural environment [23,26–28]. These negative impacts, in particular, included impacts on climate, air, water, and soil quality, noise, smell, non-renewable materials and biodiversity. In these definitions, the concept of sustainable housing took on a rather technical environmental meaning and focused especially on how to design and construct buildings, make them environmentally friendly and decide which approaches were to be used for spatial (sustainable land-use) planning in order to avoid land occupation, increased transport volume, and other harmful impacts [5,29–31]. More inclusive approaches described by Chiu [6,7] shift the primary concern of sustainable housing from environmental protection to people’s housing needs. Besides describing environmental quality as shaping good

housing conditions, the author includes the cultural aspects of housing and living that she understands as the design of residential buildings based on current local, cultural and esthetic values as well as those of the past, enriching and sustaining the cultural identity of a place (the preservation of housing heritage).

The sustainable housing concept has adopted a holistic approach incorporating economic, environmental and social sustainability in a mutually reinforcing manner [5,32]. Some authors emphasize environmental aspects in the social context of sustainable housing and speak about environmental poverty, where households excluded from services such as education or employment are likely to have limited access to environmental goods and services [33]. Other authors link housing with economic aspects and deal with housing affordability [34–37]. According to these authors, housing should not only be affordable in terms of the balanced ratio between a household’s income and expenditure, but it should also meet other quality requirements such as good environmental quality of housing location, safety, and good access to jobs, transport and services. Golubchikov and Badyina [4] describe the same aspects of housing in their concept of adequate housing. In approaches linking the social, economic and environmental aspects of sustainable housing, authors do not only address the technical aspects of housing (sustainable buildings and spatial planning), but they draw attention to relations in the community and locality, e.g., harmonious social relations within the housing system, stability of the community, identification with and pride in the community, participation in collective groups and networks in the community, and safety and security [7,38,39].

As might be seen, sustainable housing is neither an absolute nor a constant concept; there is no single, fully consensual and changeless definition. However, there are some aids guiding countries seeking to promote sustainable housing—most significantly of all, the UN Geneva Charter on Sustainable Housing. This charter is a non-legally binding document endorsed by the United Nations Economic Commission for Europe in 2015 [3]. However, the Charter—like Sustainable Development Goals (SDGs) and other framework policy documents—defines the goal of sustainable housing in a general way: “to ensure access to decent, adequate, affordable and healthy housing for all”. To address the above challenges, the Charter defines four principles (key themes) and related rationales, thus forming a theoretical basis of sustainable housing: environmental protection, economic effectiveness, social inclusion and participation, and cultural adequacy. Each principle consists of several (4–12) rationales (objectives or ideas), 34 in total (see Table 1).

Table 1. The UN Geneva Charter’s structure—principles and rationales (an exemplary digest).

	Principles	Rationales
1	Environmental protection	1. Reducing the carbon footprint of buildings throughout their lifecycle 2. Improved environmental and energy performance of dwellings ... 10. Waste management treated as an integral part of sustainable housing strategies
2	Economic effectiveness	1. Secure and neutral tenure 2. Housing construction performed based on the use of building codes and standards ... 12. Spatial planning efficiently distributing economic activities; improving technical and social services; undertaking urban regeneration; providing affordable housing; and addressing urban sprawl
3	Social inclusion and participation	1. Increased availability of housing options, particularly affordable and social housing, through different instruments, including through promoting tenure neutrality 2. Research and exchange of knowledge on all aspects of sustainable housing ... 8. Effective, clear, and transparent governance at all levels

Table 1. Cont.

Principles	Rationales
4 Cultural adequacy	1. Emphasizing the development of public spaces for cultural and social activities 2. Housing takes into consideration the background and culture of inhabitants
	...
	4. Houses and neighborhoods designed and actively maintained in order to enhance the emotional wellbeing of people, including the involvement of local communities in this process

3. Approaches to Sustainable Housing Assessment

In the 1960s, an environmental impact assessment (EIA) started to be used to measure major community projects or buildings. EIAs support the decision-making process by measuring the environmental impacts of a particular project located in a particular site with particular conditions. In the 1970s, the first life cycle analysis (LCA) was developed [40] and later utilized to measure potential environmental impacts of building components or construction materials. However, despite many benefits (engaging with stakeholders and potential for dialog) [41], both the EIA focusing on large-scale projects and the LCA examining products' impacts in detail could not fulfill an increasing demand for a user-friendly and comprehensive building assessment system or sustainability assessment [42–44].

In the 1990s, the first national building environmental assessment (BEA) tools were developed focusing on “greenness” and the environmental impacts of buildings, including energy consumption and resource conservation or ozone depletion [45]. Major BEAs such as the Building Research Establishment Environmental Assessment Method (BREEAM), developed in the UK in 1993, the Leadership in Energy and Environmental Design (LEED), developed in the US in 1998, and the Comprehensive Assessment System for Built Environment Efficiency (CASBEE), developed in Japan in 2001, are market-driven certification or labeling tools used internationally by various stakeholders. Those certification tools differ, but in general, they guarantee a certain standard of a building and increase the market value of the property [46]. BEAs have been gradually modified according to building sustainability assessments (BSAs) as the perception of sustainability has shifted from environmental aspects towards a more comprehensive approach adding social and economic dimensions [8,47,48]. And accordingly, research results claimed that assessing an individual building or its components was not enough to address sustainability [49,50]. As a response, in the second half of the 2000s, major systems involved in BSAs such as CASBEE, BREEAM and LEED developed their first neighborhood sustainability assessments (NSAs) addressing aspects of local conditions and community [51].

Recently, sustainable housing assessments have advanced in two main directions: (i) the assessment level is becoming more specific; for example, LEED has separate tools to assess the sustainability of interiors, buildings, neighborhood developments and cities and communities [52]; (ii) assessment criteria are becoming broader including housing affordability [37], outdoor comfort, urban energy consumption [53] or attitudes and behavior of end-users [54]. This increasingly comprehensive approach to sustainability assessments can also be observed in technical methods such as the LCA. Finkbeiner et al. [55] introduced a life cycle sustainability assessment (LCSA) to measure the sustainability of a product combining life cycle analysis (LCA), life cycle costing (LCC) and social life cycle assessment (S-LCA), thus evaluating the environmental, economic and social impacts of a product. The recent research explores the potential of BSA and NSA tools in governance [10], housing policies enhancement and development [56] and a housing funding program's evaluation [57]. Despite the remarkable development of these tools, experts and scientists point out the necessity of applying comprehensive yet flexible assessment methods instead of applying mechanistic and technical sustainability models determined by market signals [58].

The above analysis of theoretical studies enabled us to consider all the important aspects of the Geneva Charter concept, the UN sustainable development strategy and the development of views of the sustainable housing assessment. We have combined them in an easy-to-interpret scheme for the visualization of a broad concept of sustainable housing linking sustainability dimensions (economic, environmental, institutional and social) with housing components (building, community, locality) into general sustainable housing architecture (Figure 1). At this point, a need for the rigorous application of conceptual and methodological approaches to assess these dimensions and components, operationalize and apply them in national and local housing policies is obvious.

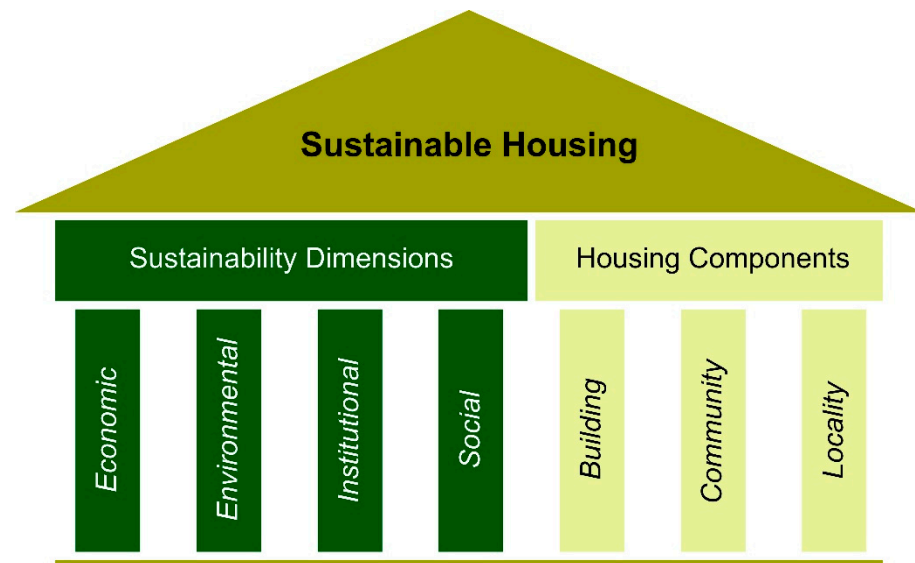


Figure 1. A general concept of sustainable housing.

4. Methodology: Housing Sustainability Assessment Tool (HSAT)

A general concept of sustainable housing—to a large extent based on the Geneva Charter—will remain just an “empty building” without further thorough (more specific) expert and scientific operationalization. Therefore, we argue that selecting appropriate phenomena (indicated facts) and related indicators from existing sets or formulating new ones within this concept is an urgent challenge. Experts should focus primarily on the identification of the “indicator-indicated fact” relation to ensure the indicators’ relevance. This will ensure that correct and clear messages are sent to policymakers [59].

To do this, the rationales of the Geneva Charter were analyzed in order to be split up into particular phenomena. Often, the Charter’s rationales comprise more than one objective, e.g., the rationale “improved environmental and energy performance of dwellings, which contribute to combating energy poverty, improving residents’ quality of life and reducing health problems” consists of five different phenomena: (1) environmental performance of dwellings, (2) energy performance of dwellings, (3) residents’ energy poverty, (4) residents’ quality of life, and (5) residents’ health problems. In our research, we analyzed all the Charter’s rationales using an expert panel method.

One expert analyzed the content of all 34 rationales, and by using comparative references from a literature review, he identified all particular phenomena for the housing sustainability assessment tool (HSAT). A primary reservoir of 107 particular phenomena was further analyzed by a 7-member expert panel: Two experts dealt with the conceptualization of sustainable development and quality of life, and also with their measurement at all levels (global, national, local); three experts dealt with the conceptualization and evaluation of sustainable housing at a national and international level; one expert with the sustainable building field and one expert with the analysis of sustainable development strategies and housing at a city level. First, each member of the panel analyzed the

107 phenomena separately; then, the results were systematically compared in a moderated discussion. During this phase, duplications and thematic overlaps among the particular phenomena—in the themes as, e.g., energy poverty, urban sprawl, neutral tenure, housing renovation, urban regeneration, infrastructure and services—were identified and removed.

Furthermore, justification of including such complex phenomena as, e.g., quality of life or people’s emotional wellbeing in the HSAT was discussed within the panel. These concepts are so complex that for any comprehensive tool to assess sustainable housing, it would be necessary to count hundreds, perhaps thousands, of indicators, and the tool would thus be of little use in practice. Finally, the expert panel identified 55 phenomena for a comprehensive assessment of sustainable housing. Thus, a derived conceptualization of sustainable housing was accomplished, and a particularized idea of sustainable housing was formed into a concept allowing further operations, including assessment (measurement).

The phenomena operationalization arises from an extensive literature review. Comparable methods were applied, for example, for the development of conceptual frameworks of urban resilience and urban sustainability [60]. The world-wide studies may stand for a virtual proxy panel of experts, and their findings may be broadly applied to the sustainable housing assessment. A collection of 2255 articles was established from the Web of Science based on relevant keywords accurately representing the theme of “sustainable housing assessment”, agreed on by experts (Table 2). To reduce the number of studies for the further in-depth analysis, the most relevant one hundred articles were selected—ten articles for each agreed keyword. It was done by applying a bibliometric analysis [61] systematically mapping (i) the cross-citation relationship within the articles’ collection and (ii) the overall citation rank of articles. Subsequently, the published research was analyzed in order to identify all appropriate potential indicators for the above phenomena. However, indicators were not found for all 55 phenomena, and thus, additional resources dealing with sustainability assessment were analyzed in order to cover the missing phenomena-related indicators. For this purpose, reports by the Organisation for Economic Co-operation and Development, United Nations, European statistical office, World Health Organization, the World Bank, the International Union of Tenants and the German Federal Ministry for the Environment were used (see an external data set [62]). This analysis resulted in a primary pool with over 750 indicators (described by metadata, including its occurrence frequency in the studies) that were subsequently evaluated by the expert panel.

Table 2. Keywords used for the selection of relevant publications for a literature review.

Keyword	Number of Publications	Year of First Publication
Sustainable housing tool	450	1997
Decision-making sustainable housing	250	1996
BREEAM	188	1999
LEED assessment	257	1999
DGNB	36	2009
SBTool	37	2010
Sustainable housing indicator	263	2002
Sustainable housing principle	292	1996
Sustainable urbanism	341	1994
Sustainable housing index	141	2004

In some cases, the analyzed documents provided a wider selection of possible indicators to assess the particular phenomenon, e.g., “energy performance of dwellings” may be assessed by indicators such as the annual energy consumption of a building per square meter, the annual non-renewable primary energy used for facility operations, the annual energy consumption of one resident building’s envelope performance, and overall energy efficiency. In such a case, the panel took into consideration the frequency of occurrence of the indicator and chose the most frequent one. In other cases, only one indicator was found and thus selected for the assessment, e.g., the phenomenon of “informal construc-

tion dwellers” is assessed by the indicator percentage of informal construction dwellers in a given district. Occasionally, no existing method(s) for the assessment of identified phenomena were found. It was mainly an assessment of the existence of the institutional base for sustainable housing implementation (e.g., the existence of specific standards, official procedures, management methods, economic regulations, housing policies and measures). In these instances, the panel complemented a suitable indicator for the particular phenomenon assessment in the format of a “yes-no” question (e.g., “Do building codes and standards which promote the harmonization of common practices, procedures, and products specifications to allow compatibility across state borders and support building safety exist?”).

There were different types of indicators related to the phenomena: the final HSAT consists of (i) individual indicators (e.g., annual water consumption per person), (ii) indices (e.g., weighted urban proliferation), and (iii) dashboards (a system of several individual—quantitative and/or qualitative—indicators for more complex concepts such as, e.g., green spaces).

A general structure of the phenomena assessment is shown in Figure 1 (above). All phenomena were broken down into four dimensions—social, environmental, economic and institutional. We applied an often used 4-pillar sustainability approach, which, although introduced a long time ago by the UN Commission on Sustainable Development, is still present in many indicator assessment methods manifesting a balance among different sustainability perspectives and objectives [63]. A key for this association was the indicator character, not a character of the phenomena, e.g., the phenomenon “risk of homes being lost” is labeled as an economic fact in the Geneva Charter, but because it is assessed by a social indicator, “the number of evictions per 1000 inhabitants” (its social dimension is underlined by the non-monetary unit used), the HSAT classifies it as a social one. At the same time, the expert panel assigned one for the three housing components—building, community, locality—to the phenomena. This final step, the indicator assignment to the phenomena, completed the sustainable housing concept’s operationalization.

5. Results

The final HSAT comprises in total 55 phenomena with associated assessment methods (available in a full version as an external data set see [62]). The assessment methods include different types of indicators—individual indicators, indices and dashboards for more complex phenomena. There are also qualitative indicators in the form of “yes–no” questions presented as individual indicators as well as parts of dashboards. A structure of the HSAT in terms of particular assessment methods is depicted in Figure 2.

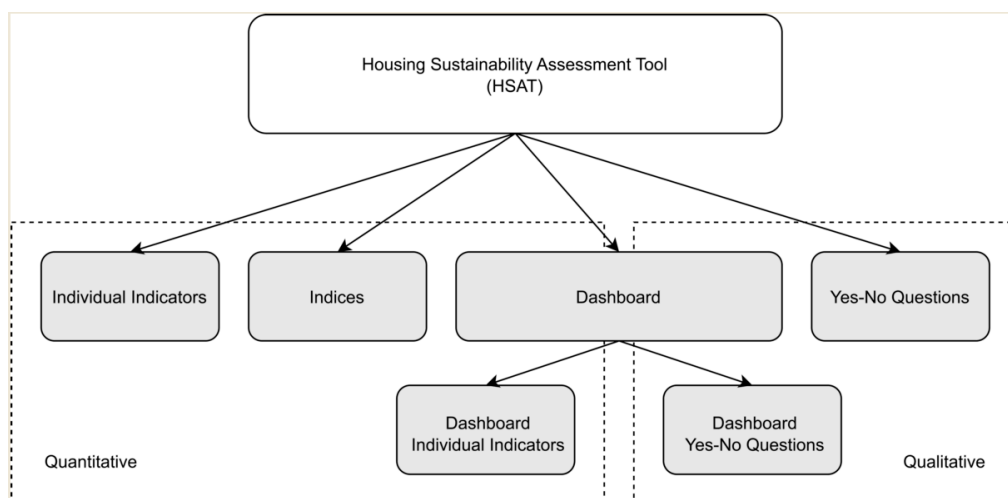


Figure 2. The housing sustainability assessment tool (HSAT) structure in terms of particular assessment methods (indicators).

With regard to sustainability dimensions (economic, environmental, institutional and social), they are all covered in the HSAT (see Figure 3): The social indicators are most represented (19 indicators), followed by environmental indicators (17 indicators) and institutional indicators (15 indicators); the economic dimension of sustainability is assessed by four indicators. This distribution is not unambiguously set since several indicators assess phenomena that overlap two sustainability dimensions. For example, the HSAT's indicator number of people affected by natural and human-made disasters' is associated with the social sustainability dimension since it measures the number of people. However, the same phenomenon is also important for economic analyses about the resources needed for disaster management (number of people converted into financial terms). Similarly, the HSAT's environmental indicator "the percentage of the cost of locally sourced materials from all materials used for construction" may also be understood in economic terms, since the use of local resources supports the local economy. Despite some ambiguity of the indicator categorization, the importance of this distribution is to demonstrate the comprehensiveness of the HSAT and the diversity of selected indicators.

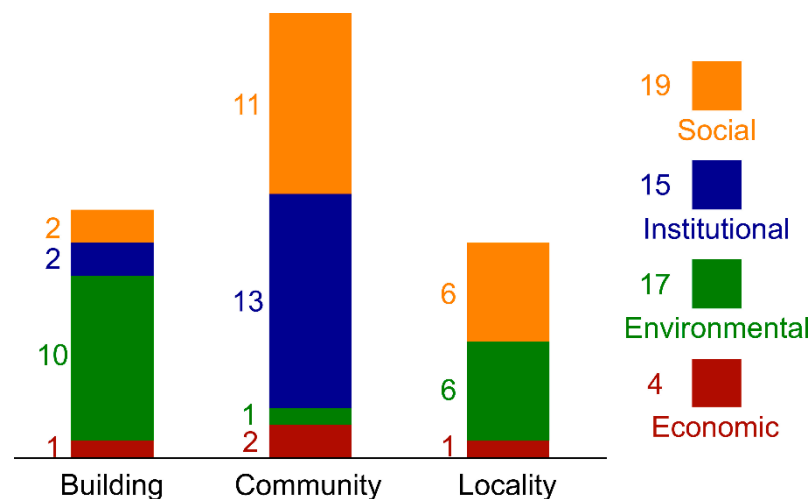


Figure 3. HSAT—distribution of indicators within sustainable housing components and sustainability dimensions.

A different situation may be found in the assessment of sustainable housing components. The indicators assessing the community are the most represented—they account for half of the HSAT indicators (27 out of 55). The other two components—locality and building—are almost equally represented there (13, and 15 indicators, resp.; see Figure 3). The boundaries between components are also indistinct there. It is worth looking again at the indicator "the number of people affected by natural and man-made disasters": The expert panel ascribed it to the community component since it assessed the number of affected people living in the community. However, this indicator also gives an account of the locality by referring to people living in a flood-prone area or an area affected by industrial accidents. The indicator thus provides important information about the risk of natural and human-made disasters in a certain place that may influence the decision to live or construct new houses there. Similarly, the expert panel associated the "housing affordability index" with a community component since it demonstrates the socioeconomic structure of the citizens, but it may also be associated with the locality component since it indicates the attractiveness of a place (clean air, greenery, and low noise level).

The most interesting results are generated by interlinking sustainability housing components and sustainability dimensions. Figure 3 shows that the building component is predominantly assessed by environmental indicators (about 2/3 of all indicators). In contrast, the community component is assessed by institutional indicators in more than half of the cases, while almost another half are the indicators of the social dimensions of sustain-

ability. The locality component is equally assessed by social and environmental indicators. These results may be expectable based on the thorough literature review; nevertheless, it is also interesting that the expert panel arrived at this point without any self-correction or steering towards a proportionate representation of particular dimensions in sustainable housing components considering a great number of phenomena and the selection of indicators.

We have already mentioned that the indicators' division, according to sustainability dimensions and sustainable housing components, is arbitrary (expert-based). Some indicators ideally could be associated with more dimensions and/or components because they often overlap two possible options. Still, this categorization serves as a justification of the developed HSAT framework being generally in line with current concepts of sustainable housing presented by the reviewed documents. This view has gradually shifted from an environmentally friendly building (i.e., the environmental dimension and building component) to a broader perspective also comprising the social and environmental characteristics/qualities of the locality surrounding the building, and the social relationships in the community as well as institutional support of the housing development. The proposed HSAT captures this shift by means of the phenomena and associated indicators and thus contributes to the conceptualization and operationalization of the dynamic, sustainable housing concept. Such operationalization is instrumental for any further use of the concept for sustainable housing assessment at an international, national and, in particular, local level. For effective (local) implementation, different approaches can be used, including simplification or reduction of HSAT guaranteeing clarity and activism [64].

6. Discussion and Conclusions

Our research aimed to develop an indicator-based assessment tool (a comprehensive and balanced indicator set) for sustainable housing built on the analysis of the UN Geneva Charter, the UN sustainable development strategy, and the sustainable housing assessment approaches. We applied qualitative methods, in particular the content analysis of available studies about sustainable housing assessment and the expert panel. These methods are often used for the conceptualization and operationalization of concepts as well as for the development of assessment methods at all levels (national, supranational, global) [65,66]. The nature of qualitative methods affects the results' objectivity—this research shows how a particular group of experts understands/views and interprets some concept (sustainable housing). Therefore, many complex concepts, which are not founded on natural sciences, may not have a unanimous definition.

Our research approach is grounded on a wide knowledge base of relevant sources and abundant experience of the panel members regarding sustainability assessment at all pertinent levels—from local and national to international and global. The HSAT is one of the potential instruments for the conceptualization and operationalization of the given concept and a possible method of sustainable housing assessment. Its comprehensiveness reflects the key sustainable housing needs and sustainable development aspects and thus bridges narrow approaches (focused particularly on building, energy, environment, etc.) and brings one more piece into the sustainable housing assessment.

Despite all the limitations and necessary imperfections of the presented research, we believe that this work will contribute to a better understanding and primary employment of the sustainable housing concept in practice. As in long discussions on sustainable development and its assessment (currently the Sustainable Development Goals framework), we anticipate a lively discussion on the HSAT, based on the growing international interest in sustainable housing displayed by major initiatives such as Housing 2030, supported by UNECE, UN-Habitat and Housing Europe. Like individual countries, or even cities, which select their specific sustainability phenomena (themes, problems, etc.) and the most relevant indicators for their analyses, assessments and subsequent measures, we anticipate further research, testing and adaptations of the proposed HSAT to country- or/and site-specifics in order to obtain rigorous data and information on sustainable housing facts.

The world at present is a rapidly changing and urbanizing place to live in. This has been reflected, *inter alia*, by the UN Agenda 2030 (SDGs) that calls for making cities and settlements inclusive, safe, resilient and sustainable. Therefore, the great importance of HSAT may be at a city level because the current imperative calls for sustainable housing in sustainable cities. Paradoxically, the concept of sustainable cities—a more complex concept than sustainable housing both in its subject matter as well as its geography—is by far more elaborate. Sustainable, green, healthy, resilient, smart and recently also smart-sustainable cities have been politically as well as conceptually supported and intensively developed methodologically. Sustainable cities, Local Agenda 21 and other concepts and related methods have been in place for several decades. Every mayor has some knowledge of, and also often some analytical justification of strong (sustainable) and weak (unsustainable) facets of his town or city. Usually, it is easier to identify unsustainable conditions or trends—they may be a socially excluded locality, an ecologically deteriorated site, an economically weak district—than to calculate sustainability limits “overshooting”. However, still, there are many indicators-based systems providing sound information on urban phenomena that may be used to track trends or benchmarks in different cities.

Housing today acts not only to sustain particular aspects of life (provide shelter or protect the environment) but should also play a crucial role in achieving sustainable development. It is absolutely wrong to assume that adequate housing is seen as a social and economic burden in developing countries while industrialized countries automatically apply high standards in this field. Even the richest countries must combat the negative trends of rapid housing developments creating a high carbon footprint, air pollution, land take and related environmental degradation, social isolation, noise, overall stress and further negative impacts. Since housing plays a key role in the quality of human life, the provision of adequate housing has become a key priority for all governments. However, the sustainability paradigm places high demands on housing adequacy: environmental protection, economic effectiveness, social and cultural development, and institutional support. Thus, sustainable housing requires a new (holistic) approach to synergistically address these issues.

HSAT provides a comprehensive tool to assess housing sustainability and to design sustainable housing policies and practical measures. It explicitly advocates a holistic approach seeking to balance the environmental, social, economic and institutional dimensions of sustainable housing. Thus, it helps overcome the traditional view of urban sustainability as green development; it also exceeds the scope of assessments and solutions from building to the integrated concept of the building—community—locality. To make the HSAT more practical, the next step will be its transformation into a user-friendly application tailored for urban planners, city officials, and investors. A simplified version of such an application, easily accessible, may also provide important information on the quality of housing to the broad public and raise awareness about this vital issue.

Author Contributions: Conceptualization, J.A., S.J.; methodology, J.A.; data processing, J.A., S.J.; formal analysis, J.A., S.J., T.H.; writing—original draft preparation, J.A.; writing—review and editing, S.J., T.H.; visualization, J.A. All authors have read and agreed to the published version of the manuscript.

Funding: This work was financially supported by the Specific Academic Research of Charles University (SVV) Výzkum sociálních a environmentálních inovací (VS 260 471) and by the Charles University Research Program Progres Q16.

Data Availability Statement: An external data set; Mendeley Data, 2020; Available online: <https://data.mendeley.com/datasets/8kvs86k6c4/1>.

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

References

- Balestra, C.; Sultan, J. *OECD Statistics Working Papers. "Home Sweet Home: The Determinants of Residential Satisfaction and Its Relation with Well-Being"*; OECD Publishing: Paris, France, 2013.
- Streimikiene, D. Quality of life and housing. *Int. J. Inf. Educ. Technol.* **2015**, *5*, 140. [\[CrossRef\]](#)
- United Nations Economic Commission for Europe. *The Geneva United Nations Charter on Sustainable Housing: Ensure Access to Decent, Adequate, Affordable and Healthy Housing for All*; UNECE information service (E/ECE/1478/Rev.1); United Nations Economic Commission for Europe: Geneva, Switzerland, 2015.
- Golubchikov, O.; Badyina, A. *Sustainable Housing for Sustainable Cities. A Policy Framework for Developing Countries*; UN-HABITAT: Nairobi, Kenya, 2012; ISBN 9789211324884.
- Winston, N. Urban Regeneration for Sustainable Development: The Role of Sustainable Housing? *Eur. Plan. Stud.* **2009**, *17*, 1781–1796. [\[CrossRef\]](#)
- Chiu, R.L.H. Social sustainability, sustainable development and housing development. In *The Experience of Hong Kong*; Routledge: Hoboken, NJ, USA, 2003; pp. 221–239. [\[CrossRef\]](#)
- Chiu, R.L.H. Socio-cultural sustainability of housing: A conceptual exploration. *Hous. Theory Soc.* **2004**, *21*, 65–76. [\[CrossRef\]](#)
- Andrade, J.; Bragança, L. Sustainability assessment of dwellings—A comparison of methodologies. *Civ. Eng. Environ. Syst.* **2016**, *33*, 125–146. [\[CrossRef\]](#)
- Priemus, H.; Heuvelhof, E.T. The Long Way to Sustainable Housing Areas. *Environ. Plan. B Plan. Des.* **2005**, *32*, 1–3. [\[CrossRef\]](#)
- Doyon, A.; Moore, T. The Role of Mandatory and Voluntary Approaches for a Sustainable Housing Transition: Evidence from Vancouver and Melbourne. *Urban Policy Res.* **2020**, *38*, 213–229. [\[CrossRef\]](#)
- Winston, N.; Pareja Eastaway, M. Sustainable Housing in the Urban Context: International Sustainable Development Indicator Sets and Housing. *Soc. Indic. Res.* **2008**, *87*, 211–221. [\[CrossRef\]](#)
- Chen, B.; Pitts, A.; Ward, I. Indicator for Sustainable Housing Design: From EcoHomes to the Code for Sustainable Homes. In Proceedings of the PLEA 2008—25th Conference on Passive and Low Energy Architecture Dublin, Dublin, Ireland, 22–24 October 2008.
- International Union for Conservation of Nature and Natural Resources; United Nations Environment Programme; World Wildlife Fund; Food and Agriculture Organization of the United Nations; Unesco. *World Conservation Strategy: Living Resource Conservation for Sustainable Development*; IUCN: Gland, Switzerland, 1980.
- World Commission on Environment and Development. *Our Common Future*; Oxford University Press: Oxford, UK, 1987; ISBN 9780192820808.
- Spangenberg, J.H. Institutional sustainability indicators: An analysis of the institutions in Agenda 21 and a draft set of indicators for monitoring their effectivity. *Sust. Dev.* **2002**, *10*, 103–115. [\[CrossRef\]](#)
- United Nations. *Indicators of Sustainable Development. Framework and Methodologies*; UN Division for Sustainable Development, Department of Policy Co-ordination and Sustainable Development, United Nations: New York, NY, USA, 1996.
- World Bank. *World Development Report 2003. Sustainable Development in a Dynamic World—Transforming Institutions, Growth, and Quality of Life*; World Bank: Washington, DC, USA, 2003.
- Pfahl, S. Institutional sustainability. *IJSD* **2005**, *8*, 80–96. [\[CrossRef\]](#)
- Choguill, C.L. The search for policies to support sustainable housing. *Habitat Int.* **2007**, *31*, 143–149. [\[CrossRef\]](#)
- Károly, K. Rise and Fall of the Concept Sustainability. *JES* **2011**, *1*, 1–13. [\[CrossRef\]](#)
- James, P. *Urban Sustainability in Theory and Practice. Circles of Sustainability*; Routledge: Hoboken, NJ, USA, 2014; ISBN 9781317658368.
- Huovila, A.; Bosch, P.; Airaksinen, M. Comparative analysis of standardized indicators for Smart sustainable cities: What indicators and standards to use and when? *Cities* **2019**, *89*, 141–153. [\[CrossRef\]](#)
- Priemus, H. How to make housing sustainable? The Dutch experience. *Environ. Plan. B: Plan. Des.* **2005**, *32*, 5–19. [\[CrossRef\]](#)
- Jabareen, Y. A new conceptual framework for sustainable development. *Environ. Dev. Sustain.* **2008**, *10*, 179–192. [\[CrossRef\]](#)
- Pesqueux, Y. Sustainable development: A vague and ambiguous “theory”. *Soc. Bus. Rev.* **2009**, *4*, 231–245. [\[CrossRef\]](#)
- Zhu, Y.; Lin, B. Sustainable housing and urban construction in China. *Energy Build.* **2004**, *36*, 1287–1297. [\[CrossRef\]](#)
- Buys, L.; Barnett, K.; Miller, E.; Bailey, C. Smart housing and social sustainability: Learning from the residents of Queensland’s Research House. *Aust. J. Emerg. Technol. Soc.* **2005**, *3*, 43–57.
- Seyfang, G. Community action for sustainable housing: Building a low-carbon future. *Energy Policy* **2010**, *38*, 7624–7633. [\[CrossRef\]](#)
- Morgan, J.; Talbot, R. Sustainable social housing for no extra cost? In *Achieving Sustainable Urban Form*; Burton, E., Jenks, M., Williams, K., Eds.; Routledge: New York, NY, USA, 2001.
- Pickvance, C. The construction of UK sustainable housing policy and the role of pressure groups. *Local Environ.* **2009**, *14*, 329–345. [\[CrossRef\]](#)
- Castellani, V.; Sala, S. Sustainability Indicators Integrating Consumption Patterns in Strategic Environmental Assessment for Urban Planning. *Sustainability* **2013**, *5*, 3426–3446. [\[CrossRef\]](#)
- Turcotte, D. Developing Sustainable Housing: Moving beyond Green. Available online: www.plannersnetwork.org/2007/07/developing-sustainable-housing-moving-beyond-green (accessed on 30 September 2020).

33. Bhatti, M.; Dixon, A. Introduction to special focus: Housing, environment and sustainability. *Hous. Stud.* **2003**, *18*, 501–504. [[CrossRef](#)]
34. Fisher, L.M.; Pollakowski, H.O.; Zabel, J. Amenity-Based Housing Affordability Indexes. *Real Estate Econ.* **2009**, *37*, 705–746. [[CrossRef](#)]
35. Pullen, S.; Arman, M.; Zillante, G.; Zuo, J.; Chileshe, N.; Wilson, L. Developing an Assessment Framework for Affordable and Sustainable Housing. *AJCEB* **2010**, *10*, 48. [[CrossRef](#)]
36. Mulliner, E.; Maliene, V. An Analysis of Professional Perceptions of Criteria Contributing to Sustainable Housing Affordability. *Sustainability* **2015**, *7*, 248–270. [[CrossRef](#)]
37. Mulliner, E.; Malys, N.; Maliene, V. Comparative analysis of MCDM methods for the assessment of sustainable housing affordability. *Omega* **2016**, *59*, 146–156. [[CrossRef](#)]
38. Uzzell, D.; Pol, E.; Badenas, D. Place Identification, Social Cohesion, and Environmental Sustainability. *Environ. Behav.* **2002**, *34*, 26–53. [[CrossRef](#)]
39. Dempsey, N.; Bramley, G.; Power, S.; Brown, C. The social dimension of sustainable development: Defining urban social sustainability. *Sust. Dev.* **2011**, *19*, 289–300. [[CrossRef](#)]
40. Guinée, J.B.; Heijungs, R.; Huppes, G.; Zamagni, A.; Masoni, P.; Buonamici, R.; Ekvall, T.; Rydberg, T. Life cycle assessment: Past, present, and future. *Environ. Sci. Technol.* **2011**, *45*, 90–96. [[CrossRef](#)]
41. Sheate, W.R.; Partidário, M.R. Strategic approaches and assessment techniques—Potential for knowledge brokerage towards sustainability. *Environ. Impact Assess. Rev.* **2010**, *30*, 278–288. [[CrossRef](#)]
42. Gasparatos, A.; El-Haram, M.; Horner, M. A critical review of reductionist approaches for assessing the progress towards sustainability. *Environ. Impact Assess. Rev.* **2008**, *28*, 286–311. [[CrossRef](#)]
43. Morgan, R.K. Environmental impact assessment: The state of the art. *Impact Assess. Proj. Apprais.* **2012**, *30*, 5–14. [[CrossRef](#)]
44. Meex, E.; Hollberg, A.; Knapen, E.; Hildebrand, L.; Verbeeck, G. Requirements for applying LCA-based environmental impact assessment tools in the early stages of building design. *Build. Environ.* **2018**, *133*, 228–236. [[CrossRef](#)]
45. Crawley, D.; Aho, I. Building environmental assessment methods: Applications and development trends. *Build. Res. Inf.* **1999**, *27*, 300–308. [[CrossRef](#)]
46. Mattoni, B.; Guattari, C.; Evangelisti, L.; Bisegna, F.; Gori, P.; Asdrubali, F. Critical review and methodological approach to evaluate the differences among international green building rating tools. *Renew. Sustain. Energy Rev.* **2018**, *82*, 950–960. [[CrossRef](#)]
47. Sev, A. A comparative analysis of building environmental assessment tools and suggestions for regional adaptations. *Civ. Eng. Environ. Syst.* **2011**, *28*, 231–245. [[CrossRef](#)]
48. Lee, W.L. A comprehensive review of metrics of building environmental assessment schemes. *Energy Build.* **2013**, *62*, 403–413. [[CrossRef](#)]
49. Haapio, A. Towards sustainable urban communities. *Environ. Impact Assess. Rev.* **2012**, *32*, 165–169. [[CrossRef](#)]
50. Ameen, R.F.M.; Mourshed, M.; Li, H. A critical review of environmental assessment tools for sustainable urban design. *Environ. Impact Assess. Rev.* **2015**, *55*, 110–125. [[CrossRef](#)]
51. Sharifi, A.; Murayama, A. Neighborhood sustainability assessment in action: Cross-evaluation of three assessment systems and their cases from the US, the UK, and Japan. *Build. Environ.* **2014**, *72*, 243–258. [[CrossRef](#)]
52. U.S. Green Building Council. LEED Rating System | U.S. Green Building Council. Available online: www.usgbc.org/leed (accessed on 15 July 2020).
53. Reith, A.; Orova, M. Do green neighbourhood ratings cover sustainability? *Ecol. Indic.* **2015**, *48*, 660–672. [[CrossRef](#)]
54. Zuo, J.; Zhao, Z.-Y. Green building research—current status and future agenda: A review. *Renew. Sustain. Energy Rev.* **2014**, *30*, 271–281. [[CrossRef](#)]
55. Finkbeiner, M.; Schau, E.M.; Lehmann, A.; Traverso, M. Towards Life Cycle Sustainability Assessment. *Sustainability* **2010**, *2*, 3309–3322. [[CrossRef](#)]
56. Adabre, M.A.; Chan, A.P. Critical success factors (CSFs) for sustainable affordable housing. *Build. Environ.* **2019**, *156*, 203–214. [[CrossRef](#)]
57. Saldaña-Márquez, H.; Gómez-Soberón, J.M.; Arredondo-Rea, S.P.; Gámez-García, D.C.; Corral-Higuera, R. Sustainable social housing: The comparison of the Mexican funding program for housing solutions and building sustainability rating systems. *Build. Environ.* **2018**, *133*, 103–122. [[CrossRef](#)]
58. Schweber, L. The effect of BREEAM on clients and construction professionals. *Build. Res. Inf.* **2013**, *41*, 129–145. [[CrossRef](#)]
59. Hák, T.; Janoušková, S.; Moldan, B. Sustainable Development Goals: A need for relevant indicators. *Ecol. Indic.* **2016**, *60*, 565–573. [[CrossRef](#)]
60. Fu, Y.; Zhang, X. Trajectory of urban sustainability concepts: A 35-year bibliometric analysis. *Cities* **2017**, *60*, 113–123. [[CrossRef](#)]
61. Knutas, A.; Hajikhani, A.; Salminen, J.; Ikonen, J.; Porras, J. Cloud-based bibliometric analysis service for systematic mapping studies. In Proceedings of the 16th International Conference on Computer Systems and Technologies, Dublin, Ireland, 25–26 June 2015; pp. 184–191. [[CrossRef](#)]
62. Adamec, J. Housing Sustainability Assessment Tool (HSAT): An Indicator Set; Mendeley Data, 2020 (V1). Available online: <https://data.mendeley.com/datasets/8kvs86k6c4/1> (accessed on 20 December 2020).
63. United Nations Department of Economic and Social Affairs. *Indicators of Sustainable Development. Guidelines and Methodologies*, 2nd ed.; United Nations Publications: New York, NY, USA, 2001; ISBN 9211045061.

-
64. Klopp, J.M.; Petretta, D.L. The urban sustainable development goal: Indicators, complexity and the politics of measuring cities. *Cities* **2017**, *63*, 92–97. [[CrossRef](#)]
 65. Alyami, S.H.; Rezgui, Y. Sustainable building assessment tool development approach. *Sustain. Cities Soc.* **2012**, *5*, 52–62. [[CrossRef](#)]
 66. Gan, X.; Fernandez, I.C.; Guo, J.; Wilson, M.; Zhao, Y.; Zhou, B.; Wu, J. When to use what: Methods for weighting and aggregating sustainability indicators. *Ecol. Indic.* **2017**, *81*, 491–502. [[CrossRef](#)]