Examining Distinctive Indicator Scopes Measuring Well-Being in Sustainable Development Assessment

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Abstract

The significance of acknowledging well-being (WB) has increased in local sustainable development (SD) assessment. Meanwhile, scholars and practitioners have paid growing attention to using subjective indicators which rely on a person’s subjective evaluation to measure SD subjects, due to the frequent critique. The predominant use of objective indicators to assess SD frequently overlooks capturing individual’s and community’s WB. Nevertheless, the scopes and functions of subjective indicators remain underexamined in the SD assessment context. Therefore, this study discusses the distinctive characteristics of subjective sustainable development indicators (SDIs), contrasting with objective SDIs, complemented by examining WB indicators. To this end, an analysis of the literature on indicator-based assessment of SD and WB at the community and local level was conducted. The findings highlighted that the three distinctive approaches of SDIs could optimally capture and address associated WB: the objective SDIs could most sufficiently capture and address material WB capture, which turned, however, the shortcoming that overlooks other dimensions of WB. In contrast, the expert-led subjective SDIs could optimally capture and address community’s social WB, whereby the outcomes reflected social norms and preferences recognised by a community and sustainability theories. Likewise, the citizen-based subjective SDIs distinctly measured individual’s life satisfaction levels, whereby the outcomes explicitly presented individual’s subjective WB while addressing local needs and values. This study finally suggests that the complementary use of the respective SDIs contributes to a thorough local-level SD assessment, by optimally addressing associated WB, which ultimately helps meet the current and future generations’ WB in achieving local SD.

Keywords: indicator-based assessment, social well-being, subjective indicators, subjective well-being, sustainable development indicators

1. Introduction

Using appropriate indicators in assessing sustainable development (SD) at the local level has been recognised as important by practitioners and scholars across disciplines. The concept of SD includes considerable practical wisdom and ‘normative choice about what we value and how much we value it (Beemsterboer & Kemp, 2016).’ The first explicit encouragement regarding practicing assessment of SD at the local level was articulated in Local Agenda 21, adopted by the United Nations (UNs) World Conference on the Environment and Development in 1992. Following that, the UNs initiative, the Sustainable Development Goals (SDGs) adopted in 2015, has emphasised using adequate indicators to measure the SD progress at all levels to facilitate evidence-based decision-making while articulating meeting WB (Allen et al., 2017). Indicator-based assessment is one of the most broadly used approaches to SD assessment in academic research and practices (Hezri & Dovers 2006; Munda, 2013). However, the predominant use of indicators primarily relying on objective measurements in assessing SD has attracted critiques from scholars and practitioners; for instance, using Gross Domestic Product (GDP) to measure SD progress often overlook capturing factors that influence on citizen’s WB, due to its narrow economic scope and neglecting subjective assessment (Stiglitz, Sen, & Fitoussi, 2009). Accordingly, several alternative indicators have been developed to overcome the shortcoming; although often for international- or national-level assessments. For instance, the Index of Sustainable Economic Welfare calculates the cost of environmental degradation and
defense expenditure in addition to economic growth figure, although it does not consider social WB or human health unless they affect economic factors (Villamagna & Gieseke, 2014). Likewise, the Genuine Progress Indicator calculates the costs of the negative effects of economic activities and social costs overlooked by GDP, such as unpaid household labour (D’Acci, 2011; Sirgy, 2011). Yet, the scopes of these alternatives rely largely on objective measures, thus cannot fill ‘a gap between what could be measured and what occurred in a society (Stiglitz et al., 2009).

Given that indicators, relying on objective measurements are inaccurate to capture the subjective dimensions of SD, which are often intertwined with WB (Fasolo Galetto, & Turina, 2013; Jordan et al., 2010), indicators relying on subjective measurements (i.e., subjective indicators) play a crucial role. Prior to the analysis, this study distinguishes objective and subjective indicators from quantitative and qualitative indicators. Eurostat (2014) suggests that quantitative and qualitative indicators can be defined, focusing on ‘how’ to measure subjects and collect and present data, whereas objective and subjective indicators refer to ‘what’ is measured, considering the objective and subjective nature. Although objective and subjective indicators can measure both types of subjects, the information delivered explicitly reflect the characteristics of respective indicators; for instance, criminal rate (objective) and people’s fear of crime (subjective). Given that this study’s focus is on examining WB, which is understood as measurement subjects, the term objective and subjective indicators is referred to.

While subjective indicators have been well examined in the WB study (e.g., Bleys, 2012; D’Acci, 2011), studies examining their scopes and functions in SD assessment are scarce (e.g., Craheix et al., 2015; Singh, Murty, Gupta, & Dikshit, 2012). Accordingly, this study specifies varying approaches of sustainable development indicators (SDIs) and discusses the distinctive scopes and functions of subjective SDIs (i.e., expert-led and citizen-based) and objective SDIs, complemented by identifying and examining the characteristics of differentiated WB and the related indicators. To this end, analysis on the literature of indicator-based assessment of SD and WB is conducted. Here, this study poses the following research questions: ‘What is the conceptual limitation of using objective indicators in assessing SD, and what roles and functions do subjective SDIs instead play?’; ‘What does the incorporation of measuring WB in SDIs influence on local-level SD assessment?’ As a reminder of the paper, Section 2 introduces this study’s method. Section 3 elaborates the concepts of SD, WB, and basic human needs as the overarching subjects to be measured by indicators, while discussing the theoretical grounding of the major scopes of the overall SDIs. Section 4 examines major indicators employed in state-of-the-art practices of SD and WB assessment to explore the extent to which the conceptual and theoretical findings are identified and further specifies the respective SDIs scopes. Finally, Section 5 discusses the distinctive scopes and functions of the objective and subjective SDIs while providing the overview and implications for further study and practice.

2. Materials and Method

This study conducted the literature search, using the Web of Science database, considering that the size and breadth of its scientific citation index identify a reliably diverse and unbiased selection of articles, journals, and publishers (Cohen, 2017). The initial starting point was 2001 when sustainability science was broadly accepted as an academic discipline (Barrington-Leigh & Escande, 2016; Cohen, 2017) and WB began increasingly recognised (Barrington-Leigh & Escande, 2016) by scholars. To elicit the most relevant articles, it used the following search terms within the categories of ‘environmental studies’ and ‘environmental sciences’:

‘(qualitative indicators OR human well-being) AND sustainability’ & ‘(indicators AND indices) AND (human well-being OR sustainability)’

Seeing that the search terms ‘sustainable development’ and ‘subjective indicators’ provided fewer results than ‘sustainability’ and ‘qualitative indicators’, the latter terms were chosen for the literature search. Additionally, this study established the following eligibility criteria to ensure the article’s relevance to the analysis: 1) The articles studying indicator-based SD assessments at the local and community level, which discussed the concept of SD and indicator scopes; and employed a set of indicators incorporating either or both objective and subjective indicators. 2) The articles studying indicator-based assessment of WB at the local or community level, which discussed the concept of WB in relation to SD and indicator scopes; and employed a set of indicators incorporating either or both objective and subjective indicators. 3) The articles were peer-reviewed, written in English, and available in either an open-access or a hybrid journal. Based on the criteria, it scanned the titles and abstracts of the numerous articles, resulting from the first search (n=3,045) to produce an initial body of papers (n=236). Further, screening of full texts was conducted, whereby the following studies were excluded: those aimed to develop methodologies of indicator measurements, re-calculated existing indicator variables, and employed only one specific type of indicators (e.g., environmental indicators). Consequently, the final number of eligible articles was derived (n=85) (see Figure 1).
Regarding the indicator-based assessment of SDGs, several studies obtained from the literature search discuss how existing indicator systems can adequately measure and monitor SDG targets and goals, and how they (partially) contribute to the achievement (e.g., Doyle & Perez-Alaniz, 2017; Mayer, Haas, & Wiedenhofer, 2017; Schaubroeck & Rugani, 2017). However, none of those articles examine the SDG indicator system per se, thus the discussion is out of this study’s scope.

![Flowchart](image)

**Figure 1. A flowchart representing the literature selection process**

3. Conceptual and Theoretical Findings: Conceptual and Theoretical Understanding of Sustainable Development Indicators

3.1 Theoretical Background and Different Scopes of Sustainable Development Indicators

Table 1 presents the most common theoretical backgrounds for SDIs. Developing SDIs begins with raw data, which are non-valuated values, derived from a survey, and these values convert into a single indicator with a specific purpose. Further, single indicators are either grouped to form composite indicators or synthesised to create aggregate indicators or an index, which can be further gathered to form indices; index and indices entail the most elaborated information system, thus the most holistic measurement perspective (de Jonge et al., 2012; Latruffe et al., 2016). Meanwhile, the practicability and the reliability of SDIs must be validated by eligible criteria. Although the SMART principle -specific, measurable, attainable, realistic, and time-related- is widely referred to as a fundamental standard to ensure the practicability and reliability of SDIs, various studies suggest other essential criteria, such as policy relevance, data availability, ease of interpretation, analytical soundness, sensitivity to stress, and representativeness of objectives (Blancas, Lozano-Oyola, González, Guerrero, & Caballero, 2011; Gallego-Álvarez et al., 2015; Haider et al., 2018; Li, Zhang, Yuan, Liu, & Fan, 2012; Wei, Zhao, Xu, & Yu, 2007; Zhen & Routray, 2003).
Table 1. An overview of the theoretical grounding for the development of sustainable development indicators

| Theoretical Grounding of Sustainable Development Indicators |
|-------------------------------------------------------------|
| Raw data ↓                                                  |
| Construction Order ↓                                         |
| Indicator (scientifically converted) ↓                        |
| ↓(grouped)                                                  |
| Composite Indicators                                         |
| Selection Criteria                                           |
| Specific, SMART criteria, Attainable, Other essential criteria |
| Measurable, Realistic, Data availability                     |
| Understandability, Analytical soundness, Stress sensitive    |
| Aggregate Indicators                                         |
| Policy relevance, Analytical soundness                       |
| Policy relevance, Understandability                          |
| Data availability, Analytical soundness, Stress sensitive    |
| Analytical soundness, Stress sensitive, Representativity     |

The findings also highlight the two major scalings which the overall SDIs employ in the measurements (see Table 2). First, pillar-based scaling — also known as the Triple Bottom Line (Alfaro-Navarro et al., 2017; Sureeyatanapas, Yang, & Bamford, 2015) — defines the measurement categories based on the three pillars of SD, to which measurement subjects are determined and indicators are developed, while some may add other pillars, such as an institutional pillar (e.g., Antwi et al., 2017; Haider et al., 2018; Schneider et al., 2015). The examples of the scaling are seen in the existing indicator systems. The Ecological Footprint measures environmental subjects by calculating ecological productivity for a given population, including resource production and pollutant absorption (Phillis, Grigoroudis, & Kouikoglou, 2011). Economic measurements primarily assess subjects, such as economic inequity (e.g., unemployment rate), income distribution, public debt, and stock and flow of goods and services (King et al., 2014; Strezov, Evans, & Evans, 2017); an example is the Sustainable Society Index, which collectively calculates economic variables (c.f., Gallego-Álvarez et al., 2015). Finally, the set of composite indicators to monitor national SD performances, developed by the United Nations Commission for Sustainable Development measures subjects in the social pillar, such as equality, conditions of health, education, housing, and population (Singh et al., 2012). Given that SDIs generally integrate variables in different pillars, equal weighting of which facilitates the tangible analysis of SD impacts on different systems and feasible measurements of the intricacies of SD (Bleys, 2012; Estoque & Murayama, 2014), although its shortfall is to oversimplify the complexity of the goals (Cohen, 2017). Second, spatiotemporal scaling helps identify and measure trade-offs occurring within and across spatiotemporal boundaries in the SD process (Adams, Pressey, & Stoeckl, 2014; Kammerbauer et al., 2001). Spatial scaling defines a geographical or juristic boundary, within and across which measurements can be made. It ensures the relevance of SDIs to the context and an appropriate understanding of its condition (Blancas et al., 2011; de Jonge et al., 2012), thus enables the measurements to capture context-specific (basic) needs, which influence on intra-generational equity upon meeting a certain level (Reig-Martínez, 2013; Wang et al., 2018). Meanwhile, temporal scaling allows for evaluating the past development and predicting the future achievement of long-term SD; assessing time relationship is particularly crucial when it comes to capturing socioeconomic changes over time while maximising current and future WB, which can enhance the inter-generational equity (Kaklauskas et al., 2018; Morse, Vogiatzakis, & Griffiths, 2011; Ottaviani, 2018; Villamagna & Giesecke, 2014). However, insufficient incorporation of this scaling in indicator systems jeopardises the data reliability and usability of SDIs (Koop & van Leeuwen, 2015).

Furthermore, a single SDI relies on either objective or subjective measurements based on different valuation methods and thus produces contrasting (outcome) data (see Table 2) (Bhuiyan, Siwar, & Ismail, 2016; Fasolo et al., 2013; Ottaviani, 2018; Peano, Tecoco, Dansero, Girgenti, & Sottile, 2015; Singh et al., 2012). Objective SDIs gauge physical conditions of dynamic systems by quantifying the complexities; and are incorporated in numerous frameworks measuring SD (e.g., the indicators for Planetary Boundaries) and most SD goals, including SDGs which involve a large number of quantifiable targets (Doyle & Perez-Alaniz, 2017; O’Neill, 2012; Singh et al.,
Valuation of objective SDIs refers to available statistic data or variables from existing quantitative models, and the data derived from this method can reflect normative values or scales which represent pre-defined science or policy references (Blancas et al., 2011; Craheix et al., 2015; Herrera, Gerster-Bentaya, & Knierim, 2016; Ottaviani, 2018). This is particularly effective for measuring inputs and flows and outputs within a given system (e.g., a condition of material wealth). However, objective SDIs may be subject to data restriction in the case that publicly available data are sparse (Koop & van Leeuwen, 2015). Hence, an alternative approach to overcome the flaw is needed.

Meanwhile, subjective SDIs support a systematic understanding of the environment and society through measuring subjects that reflect the subjectivity, ambiguity, and context-dependency of SD (Craheix et al., 2015; Reed, Fraser, & Dougill, 2006; Singh et al., 2012). Valuations of subjective SDIs are identified two-fold. First, an exogenous approach utilises expert opinion and knowledge as a reliable source of scientific and technical information for (qualitatively) weighting variables. (Craheix et al., 2015; Talukder, Hipel, & van Loon, 2017). It facilitates communication among stakeholders, fosters in-depth knowledge exchange, and promotes interactive learning across domains, incorporating empirical and interpretative perspectives (Schneider et al., 2015). Accordingly, it helps detect which SD fields are most important for the present and future visions based on the social preferences regarding SD revealed to the given context (Gómez-Limón & Sanchez-Fernandez, 2010; Schneider et al., 2015), although the selection of experts often leads to bias which considers merely specific aspects of SD (Craheix et al., 2015; Pinar, Cruciani, Giove, & Sostero, 2014). Studies also suggest that the outcome data derived from this method can ground on either normative or relative values or importance - which is assigned when there are either no standard (referenceable) values are available or subjective information are needed (Craheix et al., 2015; Ottaviani, 2018). Second, personal evaluation incorporating self-perception utilises individuals’ attitudes, levels of satisfaction, and behavioural intentions for weighting variables (Choi & Sirakaya, 2005; Diener & Sue, 1997; Moser, 2009), and the outcome data derived from this method ground on relative values. It enables optimal measurements of substantially intangible subjects, such as quality of life or life satisfaction (e.g., Bleys, 2012; King et al., 2014). Additionally, direct inputs from local individuals mirror local concerns and knowledge of the local system, which enhances the local relevance of SDIs (Graymore, 2014). However, gathering the valuation source (e.g., individuals) often faces temporal and geographical constraints, which thus diminishes the spatiotemporal availability and reliability of the data (Craheix et al., 2015; Kammerbauer et al., 2001). The findings also imply that the subjective SDIs identified can be particularly suitable to a community- and local-level SD assessment, assuming that referring to relative values can address subjective values based on the local realities (e.g., individuals’ life satisfaction and community’s social preference) in assessment outcomes, while referring to normative values helps associate global SD issues (e.g., CO2 emission amount as a contributor of the climate change) with local practices.

Table 2. An overview of the major scopes common to overall sustainable development indicators

| Scaling                  | Theoretical Scopes of Sustainable Development Indicators | Measurement | Valuation method                  | Underlying value                  |
|--------------------------|----------------------------------------------------------|-------------|-----------------------------------|-----------------------------------|
|                         | Environmental dimension                                  | Objective   | Quantification (Quantitative weighting) | Normative value/scale             |
|                         | Economic dimension                                       | Subjective  | Exogenous approach (Expert judgment and knowledge) | Relative value/importance         |
|                         | Social dimension                                         |             | Personal judgement and self-perception |                                   |
|                         | Other dimensions                                         |             |                                    |                                   |
|                         | Spatiotemporal scaling                                   |             |                                    |                                   |
| Spatial boundary         |                                                          |             |                                    |                                   |
| Temporal boundary        |                                                          |             |                                    |                                   |
Given the conceptual and theoretical groundings, it is assumed that the objective and the two subjective SDIs identified tend to measure subjects representing associated basic human needs which attribute to corresponding WB (i.e., objective material and social WB and subjective WB), and thus respective SDIs could optimally capture and address the most relevant WB in the outcomes. The next section examines the assumption by exploring empirical materials and further specifies the respective SDI scopes.

3.2 The Overarching, Conceptual Subjects to Be Measured: Sustainable Development, Well-Being, and Basic Human Needs

The concept of SD aims to realise poverty alleviation, environmental protection, and social equitability alongside economic growth while acknowledging the need to improve well-being (WB) of the present generation in a way that contributes to the future generations (Kammerbauer et al., 2001; Mebratu, 1998; UNECE, 2008). In the context, the present generation pursues meet their basic human needs without precluding the future generations from enjoying the same benefits (Hopwood, Mellor, & O’Brien, 2005; Ness, Urbel-Piirsalu, Anderberg, & Olsson, 2007), whereby human need fulfillment is maintained over time (Munda, 2013; Nissi & Sarra, 2018). Likewise, WB is also attained by fulfilling basic human needs (Schaubroeck & Rugani, 2017). Kjell (2011) argues that a profound understanding of WB has evolved through studying and defining SD, outlining how WB positions in SD. Similarly, Moser (2009) suggests that SD must not only acknowledge the dependency of the human society on the environment but recognise and enhance individual and collective human WB. Here, a clear interrelation between SD and WB can be further explained through exploring the characteristics of basic human needs, assuming that these are regarded as the fundamental substances to be attained in both achieving SD and enhancing WB.

Basic human needs refer to primary basic rights, social goods, and socio-economic benefits (Bleys, 2012; Sirgy, 2011); including, for instance, nutrition (adequate food), clean air and water, shelter (protective houses), sanitation, basic medical care physical, economic, and occupational safety, safe environment, basic education, and human relationships (Doyle & Perez-Alaniz, 2017; King, Renó, & Novo, 2014). Basic human needs are generally considered to exist in a hierarchy, and the aforementioned needs are regarded as lower-order needs and its fulfillment contributes to meet higher-order needs, such as (self) esteem, self-actualisation, social needs (e.g., competence), aesthetic needs, psychological needs (psychological well-being), and a community’s collective needs (King et al., 2014; Schaubroeck & Rugani, 2017; Sirgy, 2011).

Given the multi-dimensionality and essentiality of basic (human) needs, they can be embedded in the concept of SD. SD is understood to comprise three pillars of the planet system (e.g., environmental, social, and economic) and can be achieved, considering their interdependency, interrelation, and interconnection, although each pillar is independently important (Bleys, 2012; Le Tournieu et al., 2013; Moser, 2009). Basic (human) needs in the environmental pillar (e.g., clean air and water) are fulfilled by enjoying natural resources and a healthy environment; and by sustaining ecosystem, given that the environmental pillar aims to secure ecosystem’s productivity and capacity that respond to pressures, produced by human activity, such as exploiting natural resources and emitting pollutants (Bleys, 2012; Kjell, 2011; Sirgy, 2011). The social pillar considers social development and progress, whereby diverse social norms need to be realised over time, such as social cohesion, involvement, and justice, as well as equity between genders, social classes, and generation (Gallego-Álvarez, Galindo-Villardón, & Rodríguez-Rosa, 2015; Moser, 2009; Ness et al., 2007; Ottaviani, 2018). Accordingly, it is assumed that basic needs in this pillar (e.g., (person’s) social needs and community’s collective needs) are characterised in relation to or based on the norms, and its persuasion contributes to meet the needs. In the economic pillar, basic needs primarily refer to securing a person’s economic safety (e.g., a certain income level); additionally, several basic needs belonging to the other pillars can also be identified - explicitly associated with an economic aspect, given that this dimension endorses economic growth while minimising environmental degradation, conserving natural resources, and contributing to human development and equity, including poverty eradication (Doyle & Perez-Alaniz, 2017; Gallego-Álvarez et al., 2015; Mayer et al., 2017).

Well-being is also understood as a multi-dimensional concept and often features the objective and subjective dimensions (Chaaban Irani, & Khoury, 2016; D’Acci, 2011; Higgs, 2007; Jordan et al. 2010; King et al. 2014; Loring, Hinzman, & Neufeld, 2016; Villamagna & Giesecke, 2014; Wang, Kang, & Yu, 2018). Objective WB entails material and social attributions in relation to person’s life circumstances (King et al., 2014). First, material WB is met by achieving a certain level of material satisfaction or utility; it includes material needs for a life basis and safety, such as sufficient food, access to ecosystem service (e.g., clean air and water), and material conditions and possessions (D’Acci, 2011; Loring et al., 2016). Second, social WB is attained through meeting social needs which contribute to a person’s social life, such as social-connection and relationships, participation, educational conditions, and freedom; and collective needs, including social cohesion, civil engagement, social equity, collective association, and political representation (Barrington-Leigh & Escande, 2016; Bertin, Carrino, & Give,
In contrast, subjective WB is addressed through an individual’s perception, experience, feelings, or level of satisfaction with life circumstances and attained by meeting perceived and psychological needs (e.g., self-esteem); it is frequently used interchangeably with similar concepts, such as quality of life, life satisfaction, or happiness (D’Acci, 2011; Diener & Sue, 1997; King et al., 2014; Moser, 2009; Wang et al., 2018). It is argued that a person’s material need condition influences their subjective WB. For instance, a higher income contributes to greater subjective WB (King et al., 2014; Hamann, Biggs, & Reyers, 2016; Zorrilla-Miras et al., 2018). However, examining an interrelation between the differentiated WB is out of this study’s scope, given its focus on clarifying the conceptual characteristics and association to the given indicator systems. Accordingly, basic human needs are substantially embedded in SD and WB as their fundamental substances to be attained and maintained, and identifying the common needs helps conceptually interrelate the two concepts, while subjective WB needs to be further incorporated in the context of SD. Nevertheless, measuring several elements of subjective WB may not be feasible in long-term SD assessment, such as an individual’s emotional response or affection towards their life circumstances (Diener & Sue 1997).

### 4. Empirical Findings: Examining the Characteristics of Three Distinctive SDI Measurements, Measuring Differentiated WB by Exploring Sustainable Development and Well-Being Assessment Practices

In this section, major indicators employed in state-of-the-art practices of SD and WB indicator-based assessment are examined, whereby the overall trends of the three SDIs, complemented by examining indicators measuring the most relevant WB are highlighted, according to a pillar-based categorisation.

#### 4.1 Objective Indicator Trends: An Objective Approach and Measuring Material Well-Being

Table 3 presents major SDIs using quantification of subjects, while Table 4 features major indicators measuring objective material WB. Note that the individual indicators and ‘other pillars’ in the tables through this section are classified, based on the original studies’ categorisations. The results highlight the two primary trends, corresponding with the theoretical findings. First, the existing indicators are frequently referred to in both assessments; for instance, the environmental indicator ecological footprint, the social indicator life expectancy, and the economic indicators GDP and income gap (referring to Gini coefficient). Second, most indicators quantitatively weight variables, referring to publicly available statistic data; for instance, environmental indicators GHG, water, and air, social indicators education, including literacy, health, safety, and population and economic indicators (un)employment, and income. Furthermore, the results also suggest that most objective SDIs - in particular, the environmental and economic indicators - represent material needs (e.g., clean air and water and income), while WB indicators represent basic human needs (e.g., house, clothing, and food) which are seen merely in WB assessment. Alternatively, several indicators measure subjects based on not inherently objective concepts, such as biodiversity, and (good) governance by quantifying the variables, which appear merely in SD assessment. The trends resonate with the conceptual findings: The indicators highlighted incorporate indicators often employed in upper-level assessments into local practices, whereby it plays a role to understand the universal issues (e.g., GHG emission), according to the local contexts.

#### Table 3. Sustainable development assessment research subjects and major objective indicators identified in the literature analysed (Note that the abbreviations represent specific indicator items; water: water quality, pollution, or usage; air: air quality or pollution; biodiversity: number of species, change of landscape; education: educational level, school enrolment; population: numerical population or growth)

| Reference                          | Study Subject     | Example of Sustainable Development Indicators According to Pillar-Based Categorisation |
|------------------------------------|-------------------|--------------------------------------------------------------------------------------|
| Alfaro-Navarro et al. (2017)       | Sustainable urbanisation | Water, Air, Land use, Waste management                  Safety, Health, Education GDP, (Un)employment |
| Dobrovolskiiené & Tamošiūniené (2016) | Sustainable construction | GHG, Water, Renewable energy          Worker safety & health, Worker training Maintenance cost |
| Esteoque & Murayama (2014)         | Sustainable urbanisation | Ecological footprint                  Life expectancy, Education Income, Poverty |

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| Authors & (Year) | Type of Assessment | Parameters | Indicators | Sustainability Aspect(s) |
|------------------|--------------------|------------|-----------|------------------------|
| Floridi et al. (2011) | Regional sustainable development | GHG, Air, Renewable energy use | Life expectancy, Safety (traffic), Education | GDP, (Un)employment, Income gap |
| Gallego-Álvarez et al. (2015) | Sustainable development indicator study | GHG, Air, Water, Renewable energy use, Biodiversity | Health, Education, Sufficient food/drink, Gender equity | GDP, Employment, Good governance |
| Gómez-Limón & Sanchez-Fernandez (2010) | Agricultural sustainability | Water, Erosion, Biodiversity | Population (agricultural) | GDP, Employment, Income |
| Hara et al. (2009) | Sustainable development indicator study | Water, Air, Green space, Waste management | Life expectancy, Literacy | GDP, Employment, Income gap |
| Li et al. (2012) | Sustainable manufacturing | GHG, Air, Renewable energy use, Waste management | Worker health, Legal costs, Worker training, investments (human and natural resources) | - |
| Moctezuma-Malagón et al. (2008) | Sustainability of wetland | Water, Land use, Biodiversity | Participation, Gender equity | Income |
| Phillis et al. (2011) | Sustainable development indicator study | Water, Air, Land use, Biodiversity | Life expectancy, Education, Population | GDP, Unemployment, Poverty, Political rights, Governance |
| Pop & Borza (2016) | Sustainability of museum | Water, Energy consumption | Worker productivity, Volunteer work | Efficient financial resource use |
| Shmelev (2011) | Inter-regional sustainable development assessment | GHG, Water, Renewable energy use, Energy consumption | Life expectancy, Safety (crime) | GDP, Unemployment, Income gap |
| Shmelev & Rodrigues-Labajos (2009) | Multidimensional assessment of sustainability | GHG, Water, Renewable energy use, Energy consumption | Life expectancy, Safety (crime), Education, Gender equality, Population | GDP, Unemployment, Poverty, Good governance |
| Strezov et al. (2017) | Sustainable development indicator study | GHG, Air, Water, Ecological footprint | Life expectancy, Education, Gender equality | GDP, Income, Poverty, Good governance |
| Talukder et al. (2017) | Sustainable agriculture | Water, Land use | Health, Education, Gender equity | Income, Economic equity |
| Yang et al. (2014) | Inter-regional sustainable development assessment | Air, Land use, Waste management | Education, Population | GDP, Unemployment, Income gap |
Table 4. Major indicators, measuring objective material well-being, identified in the literature analysed (Note that a study that uses indicators measuring different well-being is referred to accordingly in Table 6 and 8)

| Reference         | Attribution | Environmental | Social | Economic | Other |
|-------------------|-------------|---------------|--------|----------|-------|
| Chaaban et al. (2016) | Air          | Safety, Life expectancy, Education, Housing (Un)employment, Income | Cultural-scientific progress (Research) |
| D’Acci (2011)     | -            | Life expectancy, GDP, Education, Gender equity Unemployment, Income gap | Human progress (Freedom) |
| Ferrara & Nisticó (2013) | Waste management | Life expectancy, GDP, Income, Economic equity (opportunity) (Un)employment | - |
| Hamann et al. (2016) | Water       | Life expectancy, Education, Income, Unemployment | - |
| Loring et al. (2016) | Material    | Education, Income | - |
| Nissi & Sarra (2018) | Water, Air  | Life expectancy, Income, Education, Unemployment | - |
| Ottaviani (2018)  | Air          | Food, Housing Income gap | - |
| Schimmel (2009)   |             | - | Income | - |
| Segre et al. (2011) | Water, Air, Land use, Waste management | Housing, Basic service access, Unemployment, Poverty Income gap | - |
| Sirgy (2011)      | Air, Water, Land use, Energy consumption | Health, Population, Food, Housing Employment, Poverty | - |
| Zorondo-Rodrígues et al. (2014) | - | Food, Clothing, Property | - | - |

4.2 Subjective Indicator Trends: An Exogenous Approach and Capturing Social Well-Being

Table 5 presents major SDIs, which rely on an exogenous approach measurement, while Table 6 presents major indicators measuring social WB. In this context, experts represent practitioners, such as representatives of a local authority, professional advisers, or scholars from the given fields. The results indicate two major trends. First, most indicators intend to measure subjects representing social and collective needs, whose fulfillment influences on a community’s WB. For example, environmental indicators regarding environmental management and protection, social indicators community involvement, and social Development, cohesion, equity, and engagement, and economic indicators economic prosperity, income/economic equity, and business cooperation/collaboration. Second, several indicators feature an intersectoral scope, such that the outcomes have an impact across the pillars. For example, the outcome of environmental management initiatives indicator can influence across the environmental and social dimensions as do economic indicators income equity and economic partnership across the social and economic dimensions. Likewise, the customer satisfaction with green products indicator produces the outcome which can influence across all pillars. Alternatively, in assessing social WB social indicators measuring education and social ties (e.g., support network and social cohesion) are most often employed, whereas only three environmental and one economic indicators are observed. It is noted that an indicator education is observed in
measuring social WB, although its measurement is often identical to the objective SDIs of which. This is due to that the outcome is expected to contribute to meet social WB in this context. Similarly, several indicators employed in the objective approach (e.g., biodiversity, water, and health) are also confirmed. Nevertheless, the outcomes reflect local reality as the conceptual findings suggest, thus these indicators are more tailor-made to the local contexts by this approach.

Table 5. Sustainable development assessment research subjects and major indicators, relying on expert knowledge and judgement, identified in the literature analysed (Note that 1 indicates indirect assessments through an evaluation of the indicator system, and 2 indicates joint evaluation by experts and local residents through a workshop)

| Reference                        | Study Subject                          | Example of Sustainable Development Indicators According to Pillar-Based Categorisation |
|----------------------------------|----------------------------------------|-------------------------------------------------------------------------------------|
| Bhandari1 et al. (2018)          | Sustainable community micro hydro-power plant | Legislation compliance, Impact on environment, Environmental management, Community involvement, Social stability, User satisfaction, Employment opportunity, Business potential, Serviceability of energy supply, Expansion possibility [Technical] |
| Gill et al. (2016)               | Sustainability management of contaminated land | Water, Erosion, Ecology, Neighbourhood & locality, Community involvement, Ethics, Employment capacity [ ] |
| Gopal & Thakkar (2015)           | Sustainable supply chain               | Environmental management initiatives, Availability of evaluation/reward system, Worker health & safety, Corruption, Customer satisfaction with green products, Revenue improvement, Recycle cost, New technology adoption [Technological], Political stability [Political] |
| Haider et al. (2018)             | Neighbourhood sustainable development  | Environmental quality, Natural land protection, Social WB, Public mobility & accessibility, Economic prosperity [ ] |
| Herrera12 et al. (2016)          | Sustainable farming                    | Farm management & practices, Ecology, Social engagement, Social diversification, Quality of life, Market diversification, Investment modernisation, Architectural cultural assets, Knowledge transmission [Cultural] |
| Peano et al. (2015)              | Sustainable agri-food system           | Landscape conservation, Biodiversity, Education, Relationship with externals, Market diversification, Economic partnership, Investment, Research & development [ ] |
| Pinar et al. (2014)              | Sustainable development indicator study | Biodiversity, Energy intensity, Health, Education, Energy security, Profitability, Specific equipment needs [ ] |
| Sadok et al. (2009)              | Sustainable cropping system            | Environmental quality & impact, Biodiversity, Health risks, Operational difficulties, Material & financial capitals, Institutions and entitlement [Institutional] |
| Schneider et al. (2015)          | Sustainable water governance           | Water, Resource efficiency, Learning capacity, Cooperation, Basic needs (water), Justice, Conformance to international standard [Institutional] |
| Sureeyatanapas et al. (2015)     | Corporate sustainability in manufacturing | Management commitment to environmental protection, Social development & participation, Social responsibility, Income equity, Business support & collaboration, Conformance to international standard [Institutional] |
| Touzard et al. (2016)            | Sustainability evaluation of local wine chain | Environment conservation, Water-use practice, Social cohesion, Food safety, Business cooperation, Added value distribution [ ] |
Table 6. Major indicators, measuring objective social well-being, identified in the literature analysed (Note that a study that uses indicators measuring different well-being is referred to accordingly in Table 4 and 8)

| Reference             | Well-being Attribution | Examples of Well-being Indicators According to Pillar-Based Categorisation |
|-----------------------|------------------------|----------------------------------------------------------------------------|
|                       |                        | Environmental                  | Social                  | Economic                  | Other                  |
| Chaaban et al.        |                        |                              | Support network,        | Volunteering             | -                      |
| (2016)                |                        |                              |                         |                          |                        |
| D’Acci (2011)         |                        |                              | Education, Gender equity | -                        | -                      |
| Ferrara & Nisticò (2013) |                      |                              | Education, Social equity (opportunity) | - | - |
| Hamann et al.         |                        |                              | Education               | -                        | -                      |
| (2016)                |                        |                              |                          |                          |                        |
| Loring et al.         |                        |                              | Education               | -                        | -                      |
| (2016)                |                        |                              |                          |                          |                        |
| Ottaviani             |                        |                              | Social resources access, Participation, Work life balance | - | - |
| (2018)                |                        |                              |                          |                          |                        |
| Petrosillo et al.     | Social                 |                              | Soc. cohesion           | -                        | -                      |
| (2013)                |                        |                              |                          |                          |                        |
| Schimmel (2009)       |                        |                              | Education, Political & social condition, Social relation | - | - |
| Segre et al.          |                        | Environmental illegality/management, Sustainable mobility | Education, Participation, Gender equity, [Institutional] | - |
| (2011)                |                        |                              | Political participation Social exclusion |                          |
| Sirgy (2011)          |                        |                              | Social equity           | Economic equity          | Culture                |
|                       |                        |                              |                          |                          | [Cultural]             |
| Zorondo- Rodrigues et al. (2014) |      | Healthy environment | Social & family relationship | - | Rights & legal system [Institutional] |

4.3 Subjective Indicator Trends: An Approach Based on Personal Evaluation and Capturing Subjective Well-Being

Table 7 presents major SDIs, which rely on personal evaluation based on self-perception in the measurements, while Table 8 presents major indicators measuring subjective WB. In this context, individuals refer to those who reside or work in the study areas, whether or not on behalf of the interests of the studies. The results highlight an overarching trend that indicators measuring the degree of an individual’s life satisfaction or their satisfaction with life issues are employed in numerous cases of both SD and WB assessments. In addition, several SD and WB indicators in all pillars measure subjects that explicitly represent perceived and psychological needs. For instance, environmental indicators environmental-awareness and association, social indicators aesthetic value and perceived/close relationship with other people, economic indicators economic vulnerability and perceived economic benefits, and other-pillar indicators responsibility for SD, and feeling stressed. Accordingly, the overarching trend suggests that the concept of subjective WB can be most explicitly addressed in SD assessment outcomes by using this approach.
### Table 7. Sustainable development assessment research subjects and major indicators, relying on individual’s self-perception, identified in the literature analysed (Note that 1 indicates indirect assessments through evaluation of indicator system)

| Reference            | Study Subject                        | Example of Sustainable Development Indicators According to Pillar-Based Categorisation                                      |
|----------------------|--------------------------------------|----------------------------------------------------------------------------------------------------------------------|
|                      |                                      | Environmental                      | Social                                      | Economic                        | Other                              |
| Adams et al. (2014)  | Community engagement in sustainable land-use | Biodiversity, Perceived environmental quality | Family support, Leisure                      | Job and income satisfaction     |                                   |
| Antwi et al. (2017)  | Sustainability impact assessment of local mining | Perceived environmental quality    | Aesthetic value, Cultural landscape loss, Perceived social equity | Income diversification | Local knowledge use [Institutional] |
| Arceo & Granados-Barba (2010) | Sustainable marine protection | Resource status perception | Perceived personal capability, Social vulnerability | Job diversification, Economic vulnerability | - |
| Bhuiyan & Siwar (2016) | Sustainable tourism | Perceived environmental quality (residents), Environmental awareness (tourists) | Tourism facility and service satisfaction (tourists) | Income satisfaction, Economic contribution to nature (residents) | - |
| Blancas et al. (2011) | Sustainable tourism | Natural environment satisfaction | Safety satisfaction | Quality-price relation satisfaction | - |
| Choi & Sirakaya (2005) | Sustainable community tourism | Biodiversity, Env. regulations | Participation, Comfort | Livelihood diversification, Econ. contribution | Quality of life |
| Kunasekaran, et al. (2017) | Sustainable tourism | Environmental awareness (e.g., cleanliness) | Perceived relationships | Local economic sustainability | - |
| Le Tourneau et al. (2013) | Sustainable development assessment of community projects | Environmental awareness/association | Life satisfaction | - | Responsibility for SD[Governance] |
| Smith et al. (2017) | Sustainable agroecosystem | Self-reported environmental impact | Self-reported social equity/ connection, Food security | Self-reported financial access | - |
| Wilson et al. (2014) | Sustainable waste management | Waste management quality | Social equity (e.g., public service distribution) | Financial sustainability | Local institutional coherence/capacity [Institutional] |
Table 8. Major indicators, measuring subjective well-being, identified in the literature analysed (Note that a study that uses indicators measuring different well-being is referred to accordingly in Table 4 and 6)

| Reference | Well-being Attribution | Examples of Well-being Indicators According to Pillar-Based Categorisation |
|-----------|------------------------|------------------------------------------------------------------------|
|           |                        | Environmental | Social | Economic | Other                                      |
| Barrington-Leigh & Escande (2016) | - | - | - | Life satisfaction |
| Chaaban et al. (2016) | Water quality satisfaction | Self-reported health, Housing/public transport satisfaction | - | Life satisfaction (overall), Political voice |
| D’Acci (2011) | - | - | - | Subjective WB (happiness) |
| Higgs (2009) | - | Close relationship | - | Life satisfaction, Mental state |
| Loring et al. (2016) | Subjective | - | - | - | Life satisfaction, Happiness, Feeling stressed |
| Ottaviani (2018) | Perceived environmental quality | Mutual trust, Education satisfaction | Perceived income equity, Job satisfaction | Feeling stressed, Self-assertiveness |
| Petrosillo et al. (2013) | - | Sense of safety | - | - |
| Schimmel (2009) | - | - | - | Happiness, Self confidence |
| Wang et al. (2018) | Perceived urban landscape quality | - | - | Life satisfaction |

5. Discussion: An Overview of the Distinctive Scopes and Functions of Objective and Expert-Led and Citizen-Based Subjective Sustainable Development Indicators

Based on the conceptual, theoretical, and empirical findings, this section discusses the distinctive scopes and functions of objective SDIs and expert-led and citizen-based subjective SDIs, while providing the overview (see Figure 2).
The findings suggest that objective SDIs are most capable of measuring subjects that represent material needs corresponding to, for instance, physical environmental qualities, income levels, and life expectancy. Meanwhile, basic needs attributing to material WB, in particular, regarding life basis and material safety (e.g., housing and food) are frequently overlooked in SD assessment, thus need to be further incorporated in objective SDIs. The assessment outcomes produced by objective SDIs present referenceable and statistically reliable indicator values by referring to the existing indicators, such as GDP or publicly available statistics. Accordingly, the outcomes (data) are particularly applicable for a spatial comparison, given that the reference values are shared by different entities, and for ex-ante and post comparisons, given the temporal availability of the reference data.

Meanwhile, expert-led subjective SDIs (e.g., social cohesion, economic prosperity, and healthy environment) most...
optimally measure subjects that represent collective human and social needs, which attribute to and its fulfillment contributes to meet social WB, assuming that exogenous approach can incorporate social norms and preferences reflecting different dimensions of interests in developing indicators and delivering the assessment outcomes, which thus represents the heterogeneity of a community (Bertin et al., 2018; Rausepp-Hearne et al., 2010; Reig-Martínez, 2013). Moreover, this approach is frequently employed in measuring subjects based on multi-faceted concepts, which resonates with the theoretical findings: Using expert knowledge enables indicators to reflect sustainability theory and ensures the scientific robustness of the measurement [and outcomes] (Graymore, 2014). For instance, the environmental indicator healthy environment echoes the idea of environmental health, which understands environmental factors as significant determinants of human WB (Loring et al., 2016); likewise, the economic indicator economic equity represents economic welfare, which aims to develop the economy by understanding general social WB (Bleys 2012). Accordingly, expert-led subjective SDIs and the assessment outcomes most reflect SD rationale and social norms and preferences recognised by a community.

Finally, the citizen-based subjective SDIs are most applicable for measuring an individual’s (present) satisfaction level and subjects representing perceived and psychological needs, which significantly contributes to meet individual’s subjective WB (Diener & Sue, 1997; Moser, 2009). For instance, economic indicators, such as perceived income-satisfaction and equity, measure the relative impact of an individual’s economic conditions on their life satisfaction (Diener & Sue, 1997). Accordingly, incorporating this approach in SD assessment allows for capturing and addressing subjective WB in the outcomes, which several conventional SDIs have overlooked (Stiglitz et al., 2009).

The findings also highlight that the respective SDIs can implicitly capture the other dimensions of WB, while the characteristics of the outcomes remain based on the given measurements (see Figure 2). First, objective SDIs can measure and address social and subjective WB through quantifying subjects. For instance, an indicator education frequently relies on existing indicators or publicly available statistics, such as literacy rate or years in education, but enhancing the outcome conceptually contributes to meet social WB. Likewise, an individual’s subjective WB with respect to the happiness level can be partially measured through gauging their income level, given the correlation between them, although exceeding a certain level of economic wealth does not significantly influence one’s happiness (O’Neill, 2012). Second, expert-led subjective SDIs can measure material needs and material WB by utilising an expert’s subjective evaluation in measurements. The empirical results present that this approach is frequently employed to indicators, such as biodiversity, water, and health, in a case that there are no reference values or relevant statistical data available. Finally, citizen-based subjective SDIs can measure subjects representing objective material and social WB. For instance, indicators income satisfaction and perceived environmental quality represent economic and environmental needs respectively, which can however influence on individual’s perceived needs. This suggests that the fulfillsments contribute to meet material WB, which are regarded as proxies of individual’s subjective WB, assuming that subjective WB is frequently influenced by fulfilling material and other non-self-perceived basic needs (Schaubroeck & Rugani, 2017; Sirgy, 2011). Alternatively, this approach helps identify and present local needs and locally embedded values in the assessment outcomes through incorporating local aspects in constructing indicators and measuring subjects (Graymore, 2014; Kammerbauer et al., 2001; Nissi & Sarra, 2018; Zorrilla-Miras et al., 2018). This suggests that the outcomes can represent social WB, assuming that local needs and values are shaped by a consensus of individual’s social needs (e.g., participation).

6. Conclusion

This study advocates that using objective indicators is inadequate to measure SD, given that the objective SDIs are conceptually optimal to capture material needs and material WB but limited or inaccurate to capture higher-order basic human needs and the other dimensions of WB. In contrast, using the expert-led and citizen-based subjective SDIs complements the shortcoming by capturing social and collective needs associated with social WB as well as perceived and psychological needs attributing to subjective WB, respectively. Accordingly, the complementary use of the three types of SDIs in the SD assessment practice is desirable, given that not all indicators measure subjects and progress at the same level (Sarriot, Ricca, Ryan, Basnet, & Arscott-Mills, 2009). Hence, using the SDIs assessing (present) conditions of ‘material’ and subjective WB helps better recognise the WB of the current generation in the SD context, while using the SDIs assessing social WB and its enhancement in the long-term assessment helps depict the WB of the future generation (Barrington-Leigh & Escande, 2016; Kammerbauer et al., 2001).

However, this study faces several limitations. First, the variety of the articles retrieved was subject to the constraints of the literature search, given that the search results could be limited by citation distribution (Cohen, 2017). Accordingly, literature relevant to this study’s aim might have been found under different search conditions,
such as city and urban SD. Second, several subjective indicators referred to in this study may have provided limited information for this study’s discussion and characterising the subjective SDIs. This was due to that the subjective indicators are usually developed, taking into account specific aims or interests of the given studies, and the context dependency in developing and employing the indicators in each study was inevitable. Hence, overcoming the limitations by, for instance, elaborating a broader range of studies and indicators helps identify the conceptual and theoretical function and implications for the practical use of SDIs.

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