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Signifying well-being in measuring a progress of municipal sustainable development in Japan: An examination of 'subjective' sustainable development indicators

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Abstract

Undertaking local actions, such as implementing public (sustainability) policy, plays a crucial role in achieving sustainable development (SD) at the municipal level. In this regard, indicator-based assessment supports effective implementation by measuring the SD process, based upon evidence-based outcomes that indicators produce. Over the last decade, using subjective indicators, which rely on an individual's self-perception to measure subjects, has gained its significance in sustainability assessment, in line with the increasing importance of signifying individual's and community's well-being (WB) in the context of SD. This study aims to discuss and clarify the scope and functions of subjective sustainable development indicators (SDIs) conceptually and theoretically while examining the usability of such indicators employed in the practice of assessing sustainability policy and action process in a Japanese municipality. Furthermore, the potential usability of using subjective SDIs in monitoring a municipal initiative of the United Nations' Sustainable Development Goals (SDGs) is also explanatorily examined. The present paper consists of a framework paper and three individual studies.

In the framework paper, Section 1 introduces the global transition of SD discourse and the role that local authorities and implementing public policy play in achieving SD while outlining how WB positions in the SD context. Section 2 provides a brief overview of the major scope of overall SDIs at the conceptual and theoretical levels. Section 3 defines WB in the study's own right while exploring the scope of indicators measuring WB. In addition, this study strives to further clarify the peculiar scope of SDIs, measuring WB by synthesising the findings. Section 4 overviews how SD at the municipal level in Japan is practiced while acknowledging the extent to which residents perceive WB and SDGs in policymaking. Section 5 provides a brief yet extensive summary of the three individual studies. Section 6 discusses the findings while presenting implications for further study and practices of subjective SDIs.

Furthermore, the three individual studies provide a thorough and in-depth discussion of the study subject. Study 1 illustrates the SD trend at the municipal level in Japan and the growing recognition of using subjective SDIs in public (sustainability) policy assessment in exploring comparative SDI systems to municipality groups. The findings, in turn, raise the need for a further study on subjective SDIs. Study 2 extensively discusses the concept of WB as the overarching subject to be measured while examining varying approaches and scopes of SDIs. It identifies three differentiated WB (i.e., *material* and *social* objective WB as well as subjective WB) and distinctive approaches of subjective SDIs (i.e., *expert-led* and *citizen-based* approaches) alongside objective SDIs. The findings suggest that these SDIs identified are, conceptually, most capable of measuring associated WB; for instance, *citizen-based* subjective SDIs can most optimally measure subjective WB. Finally, Study 3 examines the usability of (*citizen-based*) subjective SDIs in a practice of assessing public policy, aiming at municipal SD, and the potential usability of using such indicators in monitoring a municipal SDG initiative. The findings highlight the determinants and obstacles of using subjective SDIs as well as signifying WB in measuring progress of a municipal SD practice.

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Chapter 1: Framework paper

Framework Paper

1. Introduction

1-1. Global transition of sustainable development and the significance of undertaking local actions

Sustainable Development (SD) is the overarching goal to achieve by all human societies at all administrative levels. In 1987, the United Nations (UNs)' World Commission on Environment and Development (WCED), which is known as the Brundtland Commission named after the chair, the Norwegian Prime Minister Gro Harlem Brundtland, addressed the globally accepted definition of SD in its report *Our Common Future* (Michelsen *et al.*, 2016): SD is '*to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs* (WCED, 1987)'. The definition suggests that (basic) human needs must be sustained and ultimately enhanced over time, thus ensuring a temporal condition in measuring and achieving SD is of essence (Munda, 2013). In 1992, UNs Conference on Environment and Development (UNCED) in Rio de Janeiro succeeded but rendered the philosophy of *Our Common Future* more practically relevant by focusing more on an action-oriented approach to development. In this vein, the conference adopted the comprehensive action plan *Agenda 21*, and its local version *Local Agenda 21* urged to undertake necessary actions at the local level, such as implementing sufficient public policy. The *Local Agenda 21* clarified the participation and cooperation of the local authorities in achieving SD. This is due to that most SD challenges are often rooted in local activities, whereas the conventional UNs-led conferences had developed the argument in a global arena, which frequently called for the national governments' and the international organisations' efforts (Tuxworth, 1996; UNCED, 1993). Additionally, the approach of sustainability science facilitates identifying problems, setting agenda, and formulating policies towards SD (Allen *et al.*, 2017; Peeters & Schomerus, 2016).

In 2015, the UN assembly adopted the comprehensive, global agenda *2030 Agenda for Sustainable Development*, in which the overarching policy goals common to all actors across the globe *Sustainable Development Goals* (SDGs) was formulated as the sequence of expanding and revising *Millennium Development Goals* (MDGs) (Costanza *et al.*, 2016; Hák *et al.*, 2016). The transition of the global SD discourse from MDGs to SDGs sought necessary actions, including effective policies towards the goal which must be undertaken in all countries while collaborating stakeholders in as diverse fields as possible (Allen *et al.*, 2017; Zinkernagel *et al.*, 2018). For instance, target 14 of SDG 17 addresses the need to 'enhance policy coherence for sustainable development', and target 7 of SDG16 states to 'ensure responsive, inclusive,

participatory, and representative decision-making at all levels' United Nations Social and Economic Council, 2018). Remarkably, SDG 11, aiming at 'Sustainable Cities and Communities' emphasises that most implementations should be conducted at the local level despite the need for global outcomes (Smith *et al*., 2018). Additionally, the focal point in achieving the global SD shifts from the goals *per se* to monitoring and assessing the achievement process in the SDG context (Zinkernagel *et al*., 2018).

1-2. Indicator-based assessment to public (sustainability) policy

In the context of public (sustainability) policy, SD is frequently manifested as an overarching policy agenda and a major policy challenge by numerous entities. To this end, evidence-based policy is one of the most useful means to the aim, which facilitates problem identification and agenda setting, based upon systematic evidence, as do its monitoring and evaluation (Allen *et al*., 2018; Hezri & Dovers, 2006; Munda, 2013). To support its implementation, a number of instruments have developed, such as sustainability strategies and sustainability assessment (Heinrichs & Biermann, 2016), including assessments of baselines, trend analysis, and benchmarking progress against different types of numerical targets, which are regarded as key tools to evidence-based decision making (Allen *et al.*, 2017; Allen *et al.*, 2018). Particularly, indicator-based assessment that incorporates appropriate indicators has increasingly been employed, given that indicators, which rely on a reliable scientific and conceptual basis, allow for ensuring the conceptual coherence and relevance of sustainability (policy) assessment to the subjects to measure (Ramos & Caeiro, 2009). This approach helps policymaking and public communication by delivering tangible information of policy performances to environmental, social, economic, and technological development (Singh *et al*., 2012). Accordingly, indicator-based assessment is of particular importance in managing and monitoring policy process towards the inherently complex and intangible goals, such as SD.

Meanwhile, the adoption of SDGs encourages all entities who aim at the goal to use appropriate indicators to monitor and assess the process, given that SDGs will be 'elaborated by indicators focused on measurable outcomes (UNSEC, 2018).' Although a number of indicators to monitor SDGs suggested by the UNs are suitable to the global level implementation, which can be applied to the national level, most SDG indicators can also be relevant to the localised SDGs (Zinkernagel *et al*., 2018), given that the framework can be used to generate disaggregate data (UNSEC, 2018). This suggests that the SDGs indicators are theoretically applicable to the assessment of SDGs at any administrative level.   However, a

direct application of the global SDG indicator framework to the local context will jeopardize the reliability of indicator-based assessment, as the global framework overlooks the context-specificity in interpreting SDGs, including the current social debate and the relevance to a policy formulation, reflecting policy priorities as well as local needs and desire (Hák *et al.*, 2016; Zinkernagel *et al.*, 2018).

1-3. Signifying well-being in the sustainable development context

1-3-1. Basic human needs: Common, conceptual foundation, bridging well-being and sustainable development

WB in relation to SD can be clearly outlined by understanding how those two conceptions relate to one another (Kjell, 2011). Exploring the characteristics of basic (human) needs helps outline how WB can position in SD, given Brundtland's definition of SD that aims to meet the current and future generations' basic needs, and several WB studies suggest that WB consists of various basic (human) needs as its fundamental components (e.g., Bijl, 2011; Summers *et al.*, 2012). Basic human needs refer to the fundamental needs to secure and maintain human safety (Bleys, 2012; Sirgy, 2011), including, nutrition (adequate food), clean air and water, shelter (protective houses), sanitation, basic medical care, physical and economic safety, safe environment, basic education, and human relationships (Doyle & Perez-Alaniz, 2017; King, Renó, & Novo, 2014). Several studies suggest that basic human needs are understood and categorised in threefold. First, material needs refer to basic 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 needs are represented by basic needs that 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, 2018; Nissi & Sarra, 2018; Raudsepp-Hearne *et al.*, 2010). Finally, several basic needs – i.e., perceived and psychological needs - are attained by an individual's self-perception, based on meeting the aforementioned basic needs, such as self-esteem, self-actualisation, social competence, aesthetic needs, psychological needs (psychological well-being) (King *et al.*, 2014; Sirgy, 2011) (See Figure 1). Accordingly, exploring what composes basic human needs helps clarify how WB is understood in relation to SD.
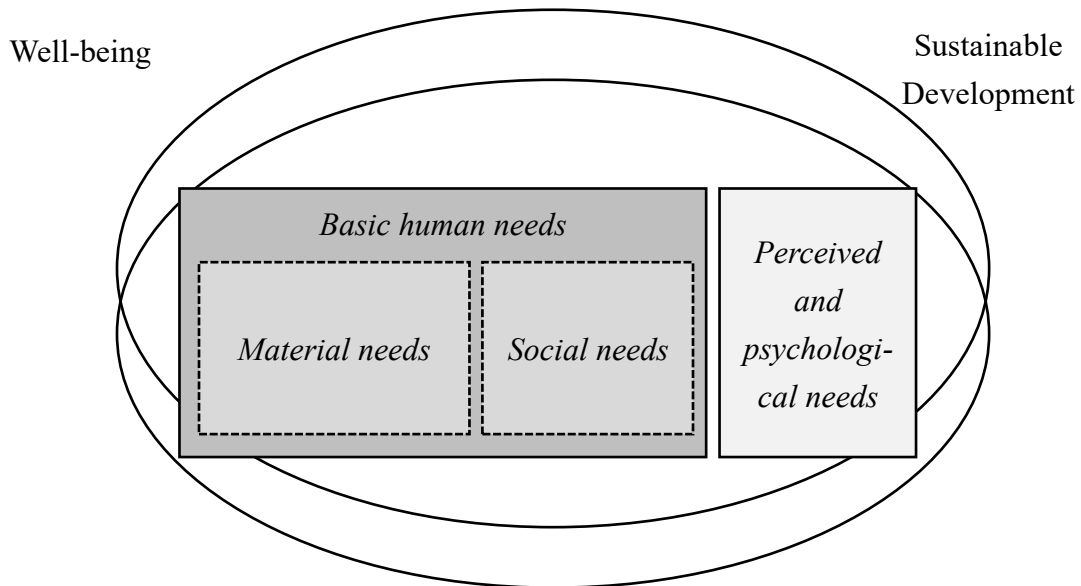
Fig 1. The relationship between well-being and sustainable development at the conceptual level, bridged by entailing basic (human) needs as the common, overarching aim to achieve.

1-3-2. Articulating well-being in the Sustainable Development Goals

In the SDGs context, the United Nations General Assembly stated the significance of assuring physical, mental, and social WB while developing equitable and universal access to social welfare and higher education. In fact, SDG3 denotes WB, addressing 'Ensure healthy lives and promote well-being for all at all ages (UNGA, 2015)'. Alternatively, attaining WB can be latently presented in several targets of the various SDGs. For instance, target 4 of Goal 3 addresses 'By 2030, reduce by one-third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being.' Likewise, target 1 of Goal 9 mentions 'Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all'. Likewise, target 2 of Goal 4 aims to improve the 'Percentage of children under 5 years of age who are developmentally on track in health, learning and psychosocial well-being (UNGA, 2015)'. Alternatively, one of the major principles of SDGs – i.e., the idea of inclusiveness – can associate with WB. Gupta & Vegelin (2016) argue that (social) inclusiveness has its own root in human rights, [social] equality, [economic] redistribution, or capability concepts; 13 SDGs intend to ensure social inclusiveness by enhancing material, social, and psychosocial WB by undertaking actions toward inclusive development. However, the idea can be seen in the aid of

developing countries most, given that the focus is particularly on empowering poor groups and communities by investing human capital and creating the opportunity for participation and reducing their vulnerability experienced through, e.g., natural disasters (Gupta & Vegelin, 2016).

1-4. Aim of the study

Indicators employed in SD assessment - this study defines them as sustainable development indicators (SDIs) - play a decisive role, as the use of appropriate indicators offers efficient management of implementing and evaluating public policy towards SD. In addition, it has been recognised that community's and individual's WB is influenced by local challenges and concerns, associated with local sustainability issues in public (sustainability) policymaking (Honda *et al.*, 2015; Shirai *et al.*, 2013). However, it has long been criticised that *objective indicators* that rely on quantitative measurements have been predominantly employed to measure progress towards SD, which frequently fail to measure factors that influence on citizen's WB, due to its economy-based, quantitative measurement and neglecting subjective assessment (Stiglitz *et al.*, 2009). Similarly, the internationally agreed SDG indicator framework consists largely of objective indicators and lacks subjective measurements, although various targets of SDGs are purely qualitative, leaving much room for interpretation (Biermann, Kanie, & Kim, 2017). To allow for a more reliable SD assessment by overcoming the constraints found in the conventional approach of indicator-based assessment, the practitioners and researchers recognise a growing significance of employing *subjective indicators* that rely on one's personal evaluation, based on self-perception is believed to measure the degree of WB more accurately. Nevertheless, few studies have examined the scope of subjective SDIs, in particular, used for municipal-level assessment. Accordingly, this study poses an overarching research question as follows:

'*What role do subjective SDIs play in assessing the progress of municipal sustainable development?*'

The whole study aims to clarify the conceptual characteristics, theoretical scope, as well as the practical usability of subjective SDIs in assessment practice, by carrying out case studies in Japanese municipalities. The whole doctoral study is divided into three single studies, through which the research question is further elaborated in detail and answered accordingly.

Framework Paper

2. Characteristics of overall sustainable development indicators

2-1. Major scopes and functions

A well-designed indicator framework will be a place that allows science knowledge production and political-norm creation, which results in forming the concept of SD by mutually acknowledging and integrally embodying (Hák *et al*., 2016). Table 1 illustrates the major scopes that overall SDIs present.

Scope	Function
Scaling	Pillar-based scaling
	Spatiotemporal scaling
Managing (Technical scope)	Monitoring policy progress
	Measuring policy targets
	Assessing sustainability condition
Managing (Theoretical scope)	Reducing the complexity
	Objectifying phenomena
	Anticipating sustainability trends
Reporting (Technical scope)	Highlighting sustainability trends
	Presenting sustainability states
Reporting (Theoretical scope)	Warning signals
	Diagnosing problems
	Educating the public
Communication	Changing of individual behaviour/political responsibility
	Raising individual awareness to SD themes
	Promotes active participation in assessment

Table 1. Major scopes and functions of sustainable development indicators.

Most SDIs rely on two major scaling to measure subjects. First, pillar-based scaling defines measurement subjects, in accordance with environmental, economic, and social dimensions of SD; it analyses and addresses an interaction or trade-offs of SD issues across pillars(UNCED, 1993). Some may consider other dimensions, such as the cultural pillar, given that society entails cultural reality in its own context (Bleys, 2012). Similarly, the institutional pillar gains its importance in measuring SD, as ensuring institutional capacity in undertaking SD initiative becomes increasingly crucial alongside other concepts, such as

economic welfare or social WB (Haider *et al*., 2018). Second, the spatiotemporal scaling that defines measurement subjects, taking into account the spatial and temporal framing. Ensuring this scaling is crucial to the accuracy of indicators, as spatiotemporal variability can present a significant implication for the divergence of collecting, processing, and analysing outcome data, thus (Kaklauskas *et al*., 2018; Ramos & Caeiro, 2009).

On top of that, several studies suggest the other major SDI functions with respect to monitoring and reporting conceptually and technically. For instance, Monitoring policy progress, measuring policy targets, assessing sustainability conditions; highlighting sustainability trends, and reducing the complexity of sustainability to manageable information (e.g., Eurostat, 2014; Singh *et al*., 2012).

Alternatively, SDIs play a role as a communication tool with which the target audience is informed about the whole range of SD issues of society. It encourages the change of individual behaviour and their political responsibility in generating solutions (Eurostat, 2014; Warhurst, 2002), raises their awareness of SD themes, and promotes their active participation in an assessment process (Hák *et al*., 2016; Reed *et al*., 2006).

However, 'the key challenge here is to deliver simple, but not simplistic, messages based on evidence and easily understood by the target audience (Allen *et al*., 2017)'. Accordingly, incorporating the particular scopes of SDIs is fundamental to indicator-based assessment towards SD, as it facilitates clarifying the inherent ambiguity and complexity of the concept, appearing as policy agenda and challenge in a practice.

2-2. Objective and subjective measurements

Measurements [of SD] are not a sole technical exercise, but value judgement, thus both objective and subjective data are required to understand what has already been achieved and to identify gaps in available information in all fields (Stiglitz *et al*., 2009).

On the one hand, SDIs relying on objective measurement – i.e., objective SDIs - are capable of quantifying the complexities of a dynamic system and gauging the physical conditions, thus this approach is particularly relevant to measuring subjects that are substantially independent of subjective awareness (Reed *et al*., 2006; Singh *et al*., 2012; Veenhoven, 2002). For instance, Gross Domestic Product (GDP), which is one of the most widely used indicators, measures economic performance in the market and understanding the

outcome helps macroeconomic policies to stimulate economic activities, such as optimising tax or facilitating markets and trade to invest (Bleys, 2012). GDP has however used to assess societal progress and SD in various cases, which has therefore attracted frequent critiques from scholars and practitioners, as it regards negative costs, such as oil spills, and the cost of clean-up and remediation as economic gain; likewise, it does not consider human activities that are not counted within a market economy, including household works (Kubiszewski *et al.*, 2013). This also suggests the inappropriate use of GDP to measure SD condition and progress cannot distinguish activities that have negative from that have a positive impact on WB and does not consider non-economic factors that contribute to enhancing WB (D'acci, 2011).

To overcome the negative impact of inappropriately using objective measurements in assessing SD, numerous studies developed alternative indicators to measure societal development and SD progress more relevantly. For instance, the Genuine Progress Index (GPI) uses the GDP score adjusted by calculating the value of unpaid works (e.g., volunteer works), the value of negative costs (e.g., commuting time or loss of leisure time), and environmental externalities (e.g., the cost of pollution) (Böhringer & Jochem, 2007; Sirgy, 2011). The outcome of the GPI depicts a trajectory with a constant yet slight increase over time, contrary to that the GDP outcome presents a sharp spike. Hence, the GPI outcome depicts more accurate SD progress than the GDP of which. A similar approach can be seen in other indicator systems, such as Living Planet Index, City Development Index, Environmental Sustainability Index, Environmental Performance Index, and Index of Sustainable Economic Welfare (Böhringer & Jochem, 2007). However, a large part of those alternative indicator systems still relies on objective measurements, thus remaining prone to overlook social basic needs, such as several welfare-related issues and political freedom (Kubiszewski *et al.*, 2013). This, in turn, will provide misinformation of the SD progress in the outcomes.

On the other hand, SDIs relying on subjective measurement – i.e., subjective SDIs - utilise individual's personal judgement, based on self-perception to measure subjects, by which a systematic understanding of the environment and society is delivered (Reed *et al.*, 2006; Singh *et al.*, 2012). This approach provides the assessment outcomes that are inherently subjective or associated with the context values, instead of relying on existing standard/reference values (Craheix *et al.*, 2015). Similarly, several studies suggest that subjective SDIs play a distinctive role to reflect stakeholder's preferences and divergent opinions in an assessment process, thus the most appropriate to use in a local-level assessment (e.g., Herrera *et al.* 2016; Choi &

Sirakaya, 2005). Indicators that measure basic human needs as well as subjective WB has significantly evolved in the study of WB assessment and indicators (e.g., Bleys, 2012; D'Acci,2011) while the concept of WB has been increasingly acknowledged in the SD context (Munda, 2013). Therefore, the thorough characteristics of objective and subjective SDIs will be depicted by exploring the concept of WB and the indicators employed in WB assessment.

3. Measuring well-being in sustainable development assessment

3-1. Defining well-being

The discussion of well-being (WB) in the study of SD has increasingly evolved over the last decade (Kjell, 2011). Moser (2009) argues that (sustainable) development not only aims to be harmonious with the environment but also should recognize and enhance human individual and collective WB. In sustainability (public) policy, Estoque & Murayama (2014) argue that the effect of sustainability policy and development plan is revealed by evaluating ecological capacity and socio-economic WB. As such, a profound understanding of WB and the link between the two concepts help clarify the value of SD and further validation of the development (Kjell, 2011). The concept of WB is inherently multi-dimensional with no universally accepted definition, and its interpretations depend on different perspectives and research aims (Clark, 2014; King *et al*., 2014; Wang *et al*., 2018). Thus, it is of significance to defining the concept in the study's own right: In the context of SD policy and assessment, WB is subjects that are manifested as policy targets and goals thus measurable, and the degree is addressed in assessment outcomes through indicators.

The concept of WB is often understood, taking into account its objective and subjective facets (King *et al*., 2014). First, objective WB entails material and social attributions. On the one hand, *material* WB is met by achieving a certain level of material satisfaction and conditions, including material possession, wealth status, and material utilities (Clark, 2014; D'Acci, 2011; Loring *et al*., 2016). On the other hand, *social* WB represents 'social attribution of people's life, such as social condition or education level (King *et al.*, 2014)'. Second, subjective WB is recognised through an individual's experience, feelings, and perceptions of satisfaction with life circumstances (Huppert *et al*., 2009; King *et al*., 2014; Petrosillo *et al*., 2013), which is frequently used synonymously with other similar terms, such as happiness or quality of life (Costanza *et al*., 2007; Diener *et al*., 1999). Subjective WB further includes individual's emotional responses, such as positive or negative affect (Diener, 1984;

Diener *et al.*, 1999). There are evident correlations and contradictions between objective and subjective WB. For instance, those who with a higher level of income can easily meet material conditions (e.g., food and housing) at a satisfying level, which in turn leads more likely to experience higher subjective WB (Sirgy, 2011); or, on the contrary, the degree of individual's happiness may decrease even if their material condition or wealth increases (D'Acci, 2011). However, discussing those points is out of the study's scope, as improving an individual's emotional state or reaction is hardly targeted in implementing public policies. Similarly, this study's focus is on specifying and arguing the conceptual characteristics of the given WB. Hence, in the following section, the present paper discusses major scopes and functions of sustainable development indicators (SDIs) while examining the major characteristics of indicators, measuring WB, based upon the results of reviewing relevant literature.

3-2. Major scope of well-being indicators

3-2-1. Objective and subjective measurements

Given the objective and subjective facets of WB at the conceptual level, the measurement of indicators can also be classified in accordance with the bipolar traits.

Objective measurements gauge material basic needs (e.g., income, physical health, or housing) and physical resources, referring to quantifiable units, such as frequency or quantity, which theoretically resulted in that basic (material) needs are embodied in development assessment (Bleys, 2012; King *et al.*, 2014). Thus far, there are remarkable developments and applications of WB indicators, relying on objective measurements. For instance, the Human Development Index (HDI), which is one of the most widely used WB indicators, accounting for three major dimensions and representing human WB: Health, education, and (economic) living standard. Each dimension is measured by the corresponding objective indicators, such as life expectancy at birth, mean years of schooling, expected years of schooling, and gross national income per capita respectively (King *et al.*, 2014). Although HDI is applied in numerous cases of WB assessment - in particular at the national level -, the scope of the index is still rather limited to measure a whole WB concept, as it focuses merely on the three dimensions. Moreover, the method used to the index has attracted a number of critiques, as it calculates individual indicator values by assigning equal weighting, which cannot be considered as genuinely value-neutral and requires normative implication to the outcomes (Chaaban *et al.,* 2016). Alternatively, several organisations employed other WB indicator systems, such as the Canadian Index of Well-being, the Index of Child Well-being in Europe, the Index of Social

Health and the Sustainable Society Index (see an extensive list in Summers *et al*., 2014).

On the contrary, subjective measurement relies on an individual's personal evaluation of life circumstances, which reveals the relative importance of various domains of WB (Barrington-Leigh & Escande, 2016). In addition, this approach is a straightforward measurement of the degree of individual's subjective WB, given that subjective WB is most optimally measured by directly asking individuals about its overall level (Bleys, 2012; D'acci, 2011). There are growing numbers of developments of WB indicator systems, which incorporate measurements of subjective WB (Barrington-Leigh & Escande, 2016). In a practice, policymaking often fails to include public preferences and latent concerns that people perceive, although a policy goal must reflect what they need. In this vein, subjective measurements play a crucial role to obtain necessary information from them through public opinion research (Veenhoven, 2002). However, it is argued that one's subjective response may reflect their limited aspirations and thus represent merely its adaptation to their current circumstances rather than absolute evaluation to calibrated experience (Barrington-Leigh & Escande, 2016). Likewise, it has long been controversial that an individual's interpretation of the evaluation scale differs in each respondent, which limits practical importance in the use (Chaaban *et al*., 2016).

This suggests that objective and subjective measurements are also the major means to most WB indicator systems. This study further specifies the scope of SDIs by synthesising the findings.

3-2-2. Specifying the scope of sustainable development indicators, reflecting the well-being indicator scope

Table 2 highlights the major characteristics of an SDI scope with respect to the measurement, method, and outcome. It contrasts that objective SDIs measure subjects through quantification, to which quantitative weighting, e.g., normalisation of variables, is assigned, whereas subjective SDIs exclusively rely on individual's personal judgement or evaluation of their measurements, to which qualitative weighting, e.g., self-reporting, based on individual self-perception is assigned. Therefore, the outcomes that objective SDIs produce can be the absolute standard, to which other measurement models and indicators can refer while outcomes that subjective SDIs deliver underlie relative values that can merely provide temporary information of what is measured.

Objective Measurement	Subjective Measurement
Measurement Subject	
Objective	Subjective
Measurement Method	
Quantification; e.g., normalisation, and aggregation	Individual subjective evaluation; e.g., self-appraisal and reporting
Measurement Outcome	
Statistically reliable thus referenceable data	Relative importance and values

Table 2. Major characteristics of SDI measurement, method, and outcome, in accordance with objective and subjective measurements.

Furthermore, the examination and comparison of the two indicators suggest that SDIs seem to be designed, focusing rather on the practical applicability than the conceptual relevance, although underlying concepts, such as basic human needs, are often explicitly embodied in policy targets and goals (Kuhlman & Farrington, 2010). In contrast, WB indicators seem well-developed to measure more conceptual subjects. Hence, incorporating the approach of WB indicators, in particular measuring subjective WB in SDIs, will help enhance the scientific reliability and conceptual relevance of the indicator system in addition to the practical usability.

A clearer picture of the scope of SDIs has been depicted, complemented by discussing the scopes of WB indicator measurements. In the next section, the present paper discusses the extent to which the norms of SD are recognised and operationalised in public policy making in the Japanese municipal context. Moreover, the status quo of initiating SDGs in the same context is also illustrated.

4. Overview of the Japanese cases

4-1. Key factors to sustainable development at the municipal level

In the Japanese context, municipal governments play a decisive role to initiate actions and strategies to achieve sustainable development. They serve as entities that operationalise the programmes of Local Agenda 21, and a municipal master plan represents a fundamental arena, in which diverse local challenges with respect to sustainability are comprehensively and systematically addressed (Honda *et al.*, 2015).

Thus far, various research of municipal sustainable development regarding public (sustainability) policy and assessment have been carried out in Japan (Shirai *et al.*, 2013).

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Matsuhashi & Nagano (2013) reviewed on municipal master plans of various Japanese municipalities to examine the extent to which a sustainability perspective, which consisted of environmental, social, economic, and individual's WB, was presented in the overarching public policy goals. The authors pointed out the overall trend that the vast majority of the municipalities addressed the greatest economic perspective followed by a social perspective while an environmental perspective was least prioritized in their master plans. In addition, a few yet ambitious municipalities addressed individual WB as a more prioritized target to deal with than environmental issues. This suggests that a sustainability perspective is explicitly addressed in a way that corresponds with their own local challenges in a number of cases, in which improving WB that represents the citizen's quality of life or happiness that they perceive in a municipal life is also prioritized. However, the comprehensiveness of the sustainability perspective in terms of satisfying all pillars of sustainability is often met insufficiently. Shirai *et al*. (2013) examined the correlation between residents' happiness and several elements of *local sustainability*. They highlighted the high level of residents' happiness could be determined by the same degree of local sustainability that they perceived: for instance, *perceived local vitality*, *closeness to nature*, and *commitment to the community*. This implies that enhancing citizens' happiness will contribute to improving several parts of sustainability or *vice versa*. Empirically, Honda *et al*. (2015) proposed an indicator framework that measured the sustainability of Nagasaki city, referring to the municipal master plan. The indicator framework assessed the extent to which individual policies helped solve corresponding local challenges to achieve the overarching policy goal that represents the city's future vision. The authors addressed two key remarks that could be a basis for the sustainable development of the city. First, a comprehensive indicator framework that covered diverse policy fields and issues helped identify a weak field of public policy, and the use of cross-cutting indicators, e.g., socio-environmental indicators, played a crucial role to complement the shortcoming, which therefore supported to achieving thorough sustainable development of the city. Second, inclusion of key stakeholders, e.g., the citizens, in an assessment process, including the development of the indicator system and the policy evaluation, was strongly recommended, as it allowed for reflecting local values that they perceived.

4-2. Municipal initiatives of SDGs

Regarding a local practice of SDGs in Japan, Kawakubo *et al*. (2018) pointed out that 389 Japanese municipalities did not recognise SDGs at all; in particular, this trend was evident in municipalities with a population size of smaller than 50,000, and 475 municipalities did not

have any plans to initiate SDGs practices. However, 269 municipalities either had planned SDGs actions or already implemented initiatives. Moreover, Masuhara *et al*. (2019) examined a relationship between the goals and targets of SDGs and the indicators that were designed to monitor a local SDG initiative of Kyoto city. They highlighted that merely 16 indicators employed in the initiative resonated with the aim of the SDG goals or targets. For instance, an indicator, measuring a percentage of women in an executive post corresponded with the target 5 of Goal 5; likewise, an indicator, measuring a recycling rate contributed to meeting the target 5 of Goal 12. In addition, the authors also revealed that merely eight municipalities in addition to Kyoto employed subjective indicators, such as an indicator, measuring residents' perceived health in their SDG initiatives.

5. Summary of the individual studies

5-1. Study 1

5-1-1. Research aim

As the foundation of the whole doctoral study, Study 1 explored what kind of SDIs were most supported by the Japanese municipal governments as well as what sustainability policy trend could be seen in the same context. To this aim, this study developed and proposed comparative sustainable development indicators (SDIs) in accordance with differentiated sustainability policy priorities orientations towards a single goal at large, a sustainable city.

5-1-2. Method

A paper-based questionnaire survey was carried out to all Japanese municipalities (n= 1,741). A representative of a municipal administration rated 30 pre-selected indicators from the perspective of the policy priority of their municipalities. Twenty-seven percent of the respondents (n=474) were statistically significant, so that their answers were regarded as eligible raw data for further analysis. This study employed principal component analysis and k-means cluster analysis: The former helped detect a certain pattern of data by reducing the data volume to a lower level while the latter method allowed for clustering numerous subjects in accordance with the data pattern generated.

5-1-3. Results

The results highlighted five SDI sets, reflecting differentiated policy orientations to a sustainable city, which were, in turn, regarded as representing sustainability policy trends at the

Japanese municipal level. Framework 1/Group 1 presented the most comprehensive view to 'achieving a sustainable city', although the result suggested that the group's SDI set focused significantly on socio-economic policies, such as *Community attachment* or *Employment status*. Given that most respondents supported this SDI set, this study regarded it as the major trend of sustainability policy in the Japanese municipalities: Most municipalities prioritised socio-economic policies while underweighting the environmental policies to a great extent. Framework 2/Group 2 consisted largely of environmental policy indicators, such as *Green space* and *Water quality*. However, the statistic showed that the municipalities that responded to the survey most negatively supported this SDI set. Therefore, the study regarded that this framework was rather a statistic error and did not represent a specific approach, although the result could be an alternative factor to explain the trait of Framework 1 that lacked an environmental aspect in public sustainability policy. Framework 3/Group 3 presented an institutional approach of public sustainability policy, represented by policies fostering governmental initiatives or requiring large-scale tasks, such as *Financial administration* and *Renewable energy*, were most selected by the respondents. Likewise, Framework 4/Group 4 consisted significantly of economic policy indicators among other groups, thus presenting an economic-focused approach. Finally, the approach of Framework 5/Group 5 showed that the municipalities opted for policies, aiming to enhance public welfare as well as the community's quality of life, supporting the use of associated subjective indicators, such as *Community attachment* and *Neighbourhood safety* most. This result suggested that several yet ambitious municipalities in Japan acknowledged the need for policies that aimed to improve WB as well as using associated subjective indicators in the assessment.

5-1-4. Discussion and conclusion

This study revealed that the vast majority of respondents supported a socio-economic approach of public (sustainability) policy in aiming at a sustainable city, thus regarded as the major sustainability policy trend in the Japanese municipalities. Meanwhile, it addressed open questions regarding how WB can be understood in sustainability policy as well as a more profound understanding of the scope and usability of subjective indicators. Accordingly, the coming two studies extensively elaborated and answered those questions.

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5-2. Study 2

5-2-1. Research aim

Previous studies pointed out the increasing importance of acknowledging individual and collective WB in the SD context, alongside the call for using subjective indicators in SD assessment. It is assumed that subjective indicators are the most accurate and appropriate measurement in SD assessment to measure subjects that represent individual and collective WB, for instance, citizens' life satisfaction or social cohesion. In the exploration, this study initially examined how the concept of WB was positioned in SD; subsequently, defined the theoretical scope of subjective indicators compared to objective ones by exploring literature and indicators employed in practices of SD and WB assessments. Consequently, this study provided an overview of distinct and varying scopes of objective and subjective SDIs that could optimally measure associated WB.

5-2-2. Method

This study carried out a literature review on studies of indicator-based assessment of SD and WB. To this end, it used the Web of Science database for a literature search. The initial search result presented numerous literature (n= 3,045), which was further screened to retain 236 possible articles. This study assigned criteria to include eligible literature on the possible articles and consequently retrieved 85 eligible articles for the analysis.

5-2-3. Results

The results revealed three distinctive approaches of SDIs along with three differentiated WB (i.e., objective *material* and *social* WB as well as subjective WB). Meanwhile, it also highlighted that those three SDIs were capable of measuring the corresponding WB most optimally. 1) Objective SDIs tended to measure subjects that represented basic material needs (e.g., income), thus allowing for capturing and presenting objective *material* WB in the assessment outcomes. 2) *expert-led* subjective SDIs could most optimally measure subjects that represented (community's) collective human and social needs, which attributed to and its fulfilment contributed to meet *social* WB, thus most capable of capturing and presenting *social* WB in the outcomes. 3) *citizen-based* subjective SDIs permitted straightforward measurements of perceived and psychological needs, such as satisfaction with life domains and happiness (D'Acci, 2011; Diener *et al*., 1999), which underlie in subjects to measure, thus most capable of capturing the degree of individual's subjective WB in the assessment outcomes.

5-2-4. Discussion and conclusion

The findings suggested that three distinctive SDIs were capable of measuring corresponding WB. In particular, *expert-led* and *citizen-based* subjective SDIs could most optimally measure social and subjective WB, respectively, which were overlooked by the measurement of objective SDIs. Accordingly, incorporating the approaches of subjective SDIs in an indicator-based assessment system contributed to a thorough assessment, given that not all indicators measured subjects and progress at the same level (Sarriot *et al*., 2009). To understand the relevance and usability of the scope of subjective SDIs in the practice of SD assessment, the coming study carried out a case study in the Japanese municipality of Tsukuba.

5-3. Study 3

5-3-1. Research aim

The usability of subjective indicators employed in a practice of SD assessment, especially at the municipal level, has not been fully examined. Similarly, its usability in the assessment of a local SDG action has been hardly studied, due to that few subjective indicators are incorporated in SDG indicator frameworks proposed by various organisations. Hence, this study aimed to examine the usability of subjective indicators in SD assessment, with respect to sustainability policy, which was represented here by the most comprehensive municipal policy. Further, it also explored the potential usability of such indicators in monitoring a municipal SDG action. To this end, this study carried out an exploratory case study in the municipality of Tsukuba, Japan.

5-3-2. Method

This study conducted a semi-structured interview with the civil servants in the municipal administration of Tsukuba who engaged with implementing and evaluating the comprehensive public policy and the SDG initiative, and paper-based questionnaire to the residents who participated in SDG workshops hosted by the Tsukuba administration during the period between February to March in 2019. Each data were analysed, using Content analysis and Exploratory Factor Analysis respectively. To complement the reliability of the data, it also performed Thick Description on the two public reports: '*Regional Empowerment for Japan's Growth of Tsukuba*', which presented the policymaking processes and the effect of the policy implementation; '*SDG Future City Initiative of Tsukuba*', which described how the SDG norms were locally interpreted and operationalised in line with setting related action programs.

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5-3-3. Results

The results of thick description suggested that subjective indicators, employed in assessing the *Regional Empowerment for Japan's Growth programme of Tsukuba* widely covered (subjective) WB as measurement subjects, such as satisfaction with public services and facilities, work-life-balance, and the community attachment and continuingly delivered positive outcome values.

The empirical findings highlighted that the usability of the subjective indicators was acknowledged as a credible assessment tool to measure the corresponding policy progresses, delivering expected assessment outcomes as especially the policymaker intended, and the description of indicators, as well as the explanations of the outcomes were understandable to its audience. However, there were two tensions between the civil servants' and residents' views: The gap between WB that the residents experienced in a livelihood and that public policy intended to improve; whether or not using resident's perception is a relevant method to measure policy targets, in terms of the representativeness of the resident's perception.

Meanwhile, using subjective indicators in monitoring the *CIVIC program* had yet commenced, thus currently played merely a guiding role to illustrate target values to achieve by 2030 as the milestones of the program actions. Furthermore, the empirical findings suggested using indicators relying on resident's perceptions and improving their WB did not show significant value in monitoring and aiming at municipal SDGs. Instead, this study identified alternative key contributors to implementing municipal SDGs, namely developing a sold and systematic action plan, as well as gaining stakeholders' knowledge of SDGs especially in relation to their own municipality.

5-3-4. Discussion and conclusion

While the current usability of subjective indicators in sustainability policy assessment was recognized as high, the contrasting view of the two stakeholders on the method of the subjective indicators and the recognition of WB could question the significance of using subjective indicators in practice. This study suggested that including residents in policymaking and indicator development from an early stage helped overcome the constraints. Moreover, This study's findings also implied that SDGs seemed purely international goals and did not necessarily represent or even contribute to achieving municipal sustainability or sustainable municipal development.

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6. Discussion and outlook

The collective insights from the findings of the three studies answer the overarching research question: '*What role do subjective SDIs play in assessing the progress of municipal sustainable development?*' It points out the two major approaches of subjective SDIs (i.e., *expert-led* and *citizen-based*) at the conceptual and theoretical level, which are most capable of capturing and signifying social and subjective WB through measuring subjects, respectively. Meanwhile, the usability of subjective SDIs, in particular, the *citizen-based* approach, is recognised as high, whereas its role in monitoring municipal SDGs is rather limited.

Practices of measuring and improving WB in public policy implementation are undertaken across the globe, seen in, for instance, the 'City of Sydney Indicator Framework' (Partridge *et al*., 2011) and in the 'Well-being of Wales 2019' (Welsh Government, 2019). In the Japanese municipal context, such practices are also observed, including Kyoto, Yokohama, and Toyota (Matsuhashi & Nagano, 2013). As complementing the previous study, the findings of Study 1 highlighted that several Japanese municipalities recognised the importance of enhancing community's and individual's WB by implementing public (sustainability) policy and the need of using appropriate indicators that can measure the degree of WB in policy assessment. Meanwhile, clarifying the varying scopes of three distinctive SDIs in Study 2 helped explain the need of using subjective SDIs that specifically measured community's and individual's WB while pointing out the conceptual and theoretical limitation of objective SDIs, which is often recognised as a limitation of the conventional indicator-based SD assessment (e.g., Stiglitz *et al*., 2009). Objective SDIs can exclusively capture and signify basic material needs and *material* WB while *expert-led* subjective SDIs could capture basic social needs and *social* WB, such as social cohesion, social equity, and political representation which address social norms and preferences of a community in the outcomes (Barrington-Leigh & Escande, 2016; Bertin *et al*., 2018; Raudsepp-Hearne *et al*., 2010). Furthermore, *citizen-based* subjective SDIs were the most accurate means to measure the degree of individuals' subjective WB, through measuring subjects, reflecting perceived and psychological needs, such as perceived environmental quality. In practice, Study 3 unveiled that the subjective indicators, employed in the case of Tsukuba utilised the *citizen-based* approach. These indicators allowed for 1) manifesting a broad range of subjective WB as concrete policy targets, such as satisfaction with cultural activities, work-life-balance, and community attachment (see more details in Chapter 4); 2) ex-post analysis of the policy effectiveness and ex-ante evaluation to set future target

values to achieve; 3) communicating with the audience by presenting the understandable description of the targets and outcomes of indicators. On the contrary, the subjective indicators in monitoring the municipal SDG initiative played merely a guiding role, and the outcomes were regarded merely as reference values to meet over the coming year. Consequently, the residents' critical view on using the subjective indicators and recognising WB stands as a challenge for using such measurements in assessing municipal SD.

Through all three studies, this doctoral study has faced several limitations. The insights into the scope and usability of subjective SDIs were derived merely from subjective indicator examples in a sole case study. This leads to that the finding can be biased by the context-specificity and peculiarity of the subjective indicators studied. Thus, examining and comparing various municipalities in different countries especially in a similar social- and cultural context will complement the findings of this Japanese case study. Accordingly, it helps generate more generalized insights and a universal understanding of the scope and the validity of using subjective SDIs in the practice of indicator-based SD assessment. Meanwhile, the practical effect and function of the *expert-led* approach were not examined in this study. Given its conceptual scope, this approach is of help to manifest *social* WB, which informs the state of a society at large (Nissi & Sarra, 2018). Furthermore, academic findings and insights into social WB are scarce. Therefore, further elaboration of how the concept is conceptually and theoretically understood and practically treated in SD and its assessment is needed.

Finally, this study illustrates an outlook for further research and practices of indicator-based SD assessment at the municipal level, providing implications. For instance, applying the approaches of subjective SDIs in a municipal-level SD assessment practice leads to fostering citizen participation in the assessment, which can therefore reinforce the participatory approach of SD governance. In a context where indicators are used for policymaking or co-produced with stakeholders (e.g., communities or citizens), such 'value-driven' SDIs reflect the social debate and priorities in the development process (Zinkernagel *et al*., 2018). Similarly, incorporating local inputs helps reveal local needs and values (King *et al*., 2014; Mitchell *et al*., 1995; Peterson, 2016), and clear reflection of what is important for the local stakeholders helps enhance the capability of the indicator system (Hezri, 2004; Reed *et al*., 2006). Application of the approach of the identified SDIs can be further undertaken in various studies and practices, given that the globally adopted SDG indicators help cooperate different sectors, such as academic, public, private, and civil groups who contribute to the monitoring with providing data (Zinkernagel *et al*., 2018). Moreover, a growing number of local initiatives have targeted improving local peoples' WB by directly inquiring the degree of their life satisfaction as a basis

for the assessment (Barrington-Leigh & Escande, 2016). In addition, measuring social WB is particularly important in terms of informing us of the state of society, highlighting social inequalities and trends (Nissi & Sarra, 2018). Accordingly, collecting further empirical data of how and/or whether social and subjective WB are manifested and measured in light of municipal SD assessment will contribute to expanding the theoretical and empirical ground of the subjective SDI scope.

Sustainable development seeks to meet the present and future generations' WB while satisfying environmental sustainability (Moser, 2009). In addition, WB [latently] underlies across all SDGs in addition to its articulation in Goal 3 (Allen *et al*., 2017). Accordingly, assessing the progress towards the SD goals requires a more precise means to address and measure WB. In this vein, incorporating the approaches of subjective SDIs in a 'conventional' indicator system in indicator-based assessment facilitates more context-relevant policy making and assessment by presenting local needs, values, and priorities in a way that achieves SD, especially at the municipal level.

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Chapter 2: Study 1 "Sustainable development indicators: Conceptual frameworks of comparative indicators sets for local administrations in Japan"

<u>Research Article</u>

Sustainable development indicators: Conceptual frameworks of comparative indicators sets for local administrations in Japan

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Abstract

Comparative indicators, with which local governments monitor and evaluate policy progress, help effective implementation of public policy toward sustainable development (SD). However, such policy tools have been less developed at the local level. This study proposes conceptual frameworks of sustainable development indicators (SDIs) taking Japanese municipal governments as examples. The results illustrated five SDIs thereby indicating four approaches and highlighted the most feasible and optimal frameworks. The former, supported by the vast majority of local governments, had a strong predilection for socioeconomic policies while disregarding environmental aspects despite their holistic aim, reflecting the current trend of sustainability at the local level in Japan. In contrast, the latter tended to encompass three

dimensions of SD in a balanced manner, focusing largely on well‐being. Hence, this

framework helped complement the lack of environmental orientation and potentially maintain the consistency of public policy.

Keywords comparative indicators, Japan, municipality, public policy, sustainability policy, sustainable city, sustainable development indicators

1. Introduction

1.1. Sustainable development in the global context and local initiatives

Sustainable development (SD) has broadly prevailed and gained recognition by numerous policy-makers in recent decades. This concept embraces essential realms that must be grounded in theory and transformed in praxis, such as three pillar dimensions (e.g., the environment, society and economy), spatial scales (e.g., global, national or local scales) and temporal scales (e.g., short- and long-term aspects) (Gibson, 2006a; Hopwood, Mellor, & O'Brien, 2005; Michelsen, Adomßent, Martens, & von Hauff, 2016). The Earth Summit in 1992 adopted the comprehensive action plan, Agenda 21, that articulated the importance of SD as a holistic policy agenda, calling for the essential roles of local governments to take initiatives to reach the goal (UNCED, 1992). In particular, the idea of three pillars has become the main political discourse when setting the agenda of SD since 2012, where the Johannesburg Declaration of Sustainable Development adopted the pillars of economic development, social development and environmental protection as the key principles of SD (Quental, Lourenço, & da Silva, 2011). This is the core aspect of sustainability challenges, although there are various perspectives from which to define the dimensions of SD; for instance, four pillars (i.e., traditional three pillars + institutional dimension) (see Spangenberg, 2002) and five pillars (i.e., the three pillars + political and cultural dimensions) (see Gibson, 2006a). The current discourse surrounding SD mentions 5P, which represents peace and partnership in addition to people, planet and prosperity, as adopted in the 2030 Agenda for Sustainable Development in 2015 (UN General Assembly, 2015). The local level is a key arena to meet SD targets, so taking local initiatives are crucial.

The local context is connected to how communities handle potential tension between the awareness of environmental protection and socioeconomic goals (Hawkins & Wang, 2012). Sustainability initiatives enacted by local governments have emerged in response to the importance of taking local action toward global sustainability (Saha, 2009). Thus far, progress has been made in implementing SD in many areas, cooperating with their communities, and producing SD strategies in accordance with Chapter 28 of Agenda 21 (Cartwright, 2000). In Japan, increasing numbers of local authorities have made efforts to establish a package of comprehensive policies formulated in a municipal master plan or a basic environmental plan. A survey conducted by the Ministry of the Environment revealed that 100% of major cities (n = 41), for example, Osaka City, Nagoya City or Metropolitan Wards in Tokyo, and 46.8% of other municipalities (n = 813) have formulated policy programs that form the foundation of the basic environmental plan (Ministry of the Environment, 2009). In fact, a large number of Japanese local governments have planned community-specific Local Agenda 21 schemes or a collective package of various policies with which they seek to reach comprehensive policy goals, such as "Sustainable City" or "Local Sustainable Development" (Numata, 2009).

1.2. The roles and the use of SD indicators

Numerous studies have attempted to develop appropriate indicators and use them to assess policy progress in practicing local SD (Bossel, 2001; Rydin, 2007). In this regard, Valentin and Spangenberg (2000) highlighted that a community needs to develop its own indicators with specific considerations of the local context. Thus, it is of great importance to understand what indicators local governments need to use to achieve public policy goals. Spangenberg, Pfahl, and Deller (2002) mentioned the necessity of key qualities of suitable sustainability indicators, which should enable a comparative and context-specific analysis of a certain place and progress toward SD based upon constructing improved information and data collection. A number of scholars refer to composed policy tools with various names, such as sustainability indicators (see PASTILLE, 2002), SD indicators (see Cartwright, 2000) or indicators of SD (see Bossel, 1996) among others. Various scholars define indicators in different, sometimes contradictory ways because of the ambiguities and contradictions of the fundamental meaning of indicators in general (Gallopín, 1996). Hence, this study does not explicitly distinguish the term of such indicators, but applies sustainable development indicators (SDIs). Given that SD is a complex process, indicators can be used to facilitate and foster understanding of its characteristics (Rydin, 2007). That is, indicators, on the one hand, objectify the composed concept in accordance with detailed targets and/or programs in real-world public policy. On the other, they simplify the phenomena, providing intelligible information and explanations. A common system of indicators allows not only production of individual policy outcomes in respective entities, but also contributing to provide significant information concerning the extent of policy progress in a whole area (Mascarenhas, Coelho, Subtil, & Ramos, 2010). Assuming the findings, using comparative indicators is a great help to support praxis of local SD, enhancing the effectiveness of public policy, potentially solving social challenges prevailing throughout a country. Several Japanese local administrations have considered using a collective set of indicators measuring policy progress and evaluating policy outcomes toward local SD by comparison. However, a set of comparative indicators across the horizontal boundaries have not been introduced into practice yet, because of, for instance, the lack of sufficient data or the limitation of available statistical data regarding local information for further development of effective indicators (Kurasaka, 2013; Shirai, Tasaki, & Tanaka, 2013).

1.3. Objective of the study

Taking the ability of comparative indicators as well as the lack of relevant policy tools in the Japanese local context into consideration, this study poses the following research questions. What indicator sets allow local governments to compare their policy progress with others that are similar? What characteristics do the comparative indicator sets in question have? To answer these, this study first identifies what policy priorities the Japanese municipal governments overall have in terms of implementation of public policy toward a sustainable city. This is

because the nature of a sustainability goal is context-dependent and value-laden, and relevant policy for implementation is highly subject to administrative capabilities that are determined predominantly by available financial and human resources as well as social priorities in a jurisdiction. Hence, it is reasonable to discuss some mutual policy aspects toward a sustainable city, which are shared by similar interest groups of the municipalities. Secondly, the municipalities are classified into several groups in accordance with the basic attribution derived from the common policy priorities identified. Finally, the study selects several indicators on the basis of the attributions from preselected indicators in each group so that there is the development of differentially characterized SDIs. Consequently, the study proposes several SDIs as common frameworks of comparative indicator sets.

2. Materials, sampling, and methods

2.1. Selecting a sample and deriving data

This study conducted a postal questionnaire to all Japanese municipal governments (n = 1,741) to gain primary data. The respondents were representatives from a department of, for instance, the environment, city development or general affairs. The survey inquired about the degree of importance of sustainability indicators that they will employ in practice aiming at a sustainable city on a five-point scale (i.e., very important, important, neutral, rather unimportant or unimportant) to which a Likert scale was applied to view the ordinal scale as an interval scale, thus enabling quantification of the data. Although it was of debate whether handling ordinal data as interval data in scientific analyses was adequate, parametric statistical analysis might have been more powerful than nonparametric alternatives (Allen & Seaman, 2007).

For the questionnaire, the study had selected 10 single indicators for question items in accordance with the three pillars of SD. In practice, the numbers of approaches of assessment depict SD as an intersection by addressing the three dimensions separately as they suit advantageously existing capacities, data and appropriate mandates (Gibson, 2006b). Hence, the three-pillar rationale is here not purely normative, but relevant to practices. To do so, the study referred to the "database of the status of environmental or sustainability indicators of national authorities" (National Institute for Environmental Studies, 2010) and indicators used by local authorities across the world (e. g., Kyoto City, 2014; Amt für Statistik Berlin-Brandenburg, 2014). This was because indicators were better selected from existing data as the local governments' abilities to collect data were limited (Valentin & Spangenberg, 2000) and indicators should be comprehensive and universal so that they are applicable to broader public bodies.

Table 1. Final eigenvalues and cumulative variance of the respective factors and a matrix of 30 indicators in accordance with the three fields of sustainable development (SD) indicating relevant principal component analysis (PCA) loadings (extraction method: PCA

Dimensions	Indicators	Factor numbers				
		1	2	3	4	5
		PCA loadings				
Soc.	1. Health Expectancy	0.54	0.20	0.38	-0.02	0.09
	2. Leisure	0.58	0.00	-0.01	-0.15	-0.35
	3. Neighbourhood Safety	0.61	-0.03	0.45	-0.11	0.01
	4. Community Attachment	0.49	0.14	0.23	0.54	-0.21
	5. Social Cohesion	0.55	0.13	0.26	0.40	-0.04
	6. Social Involvement	0.59	0.05	0.11	0.51	0.14
	7.Opportunity for Higher Education	0.63	0.17	-0.16	-0.09	-0.41
	8. Senior Care Homes	0.59	0.14	0.07	-0.19	-0.11
	9. Childcare Facilities	0.60	0.09	0.15	-0.09	0.11
	10. Change Ratio of Young Female Population	0.51	0.50	-0.01	0.08	0.13
Econ.	11. Local Productivity	0.54	0.34	-0.09	-0.06	-0.15
	12. Employment Status	0.50	0.40	-0.27	0.04	0.12
	13. Unemployment Rate	0.69	0.35	-0.21	-0.10	0.09
	14. Economic Stability	0.70	0.22	-0.09	-0.15	-0.06
	15. Standard of Living	0.60	0.40	-0.19	-0.20	-0.21
	16. Poverty Rate	0.72	0.25	-0.08	-0.20	-0.15
	17. Inter-industrial Relations	0.61	0.13	-0.40	0.17	0.06
	18. Local Job Creation	0.64	0.21	-0.24	0.39	0.17
	19. Public Assets	0.56	0.35	0.27	-0.22	0.32
	20. Financial Administration	0.55	0.36	0.29	-0.22	0.33
Env.	21. Renewable Energy	0.64	-0.42	-0.30	-0.01	0.23
	22. Self-sufficient Energy	0.57	-0.31	-0.41	0.01	0.19
	23. Material Recycling	0.68	-0.45	-0.02	0.00	0.23
	24.GreenhouseGas Emissions	0.69	-0.51	-0.04	-0.09	0.13
	25. Biodiversity	0.68	-0.39	-0.06	0.06	-0.09
	26. Air Quality	0.72	-0.42	0.03	-0.13	0.14
	27. Water Quality	0.61	-0.40	0.13	-0.11	0.00
	28. Amenity	0.63	-0.20	0.05	0.17	-0.26
	29. Closeness to Nature	0.59	-0.38	0.12	0.01	-0.31
	30. Green Space	0.67	-0.41	0.18	-0.07	-0.09
Final eigenvalues		11.22	2.93	1.41	1.28	1.11
Variance %		37.39	9.76	4.69	4.27	3.71
Cumulative %		37.39	47.16	51.84	56.11	59.82

This study considered types of single indicators apart from its disciplinal characteristics— both qualitative and quantitative indicators were included. Qualitative indicators should have been included more so in a sustainability assessment tool (Balkema, Preisig, Otterpohl, & Lambert, 2002) as the public perceptions of sustainability have been increasingly recognized as necessary to achieve SD by policy-makers. Thirty indicators were finally selected in line with the three pillars of SD (Table 1), although choice of the indicators as well as the process to develop SDIs might be arbitrary. Indicators that are based on statistical data available on the homepages of the ministries, governments or institutions concerned are considered here as quantitative indicators. By contrast, those requiring qualitative survey to derive relevant data are categorized as qualitative indicators. Consequently, the subjects who responded to the questionnaire accounted for 29% of the population (n = 505). However, statistically effective subjects declined eventually to 27% (n = 474) as 31 respondents had not provided convincing answers for analysis, and hence they were treated here as missing values. More than 70% of the population had not responded to the survey as the respondents were civil servants from a specific department so that it was difficult to evaluate the importance of all indicators that exceed their administrative jurisdictions. Nevertheless, the author regarded the response rate as adequate for further analysis as a "response rate of 20–30% is fairly typical for a mail-out survey to a large sample of [organizational representatives]" (Baruch, 1999).

2.2. Outlook of methods

Two statistical methods, principal component analysis (PCA) and k-means cluster analysis, were employed to analyze the data. PCA was useful for reducing high-dimensional data to that of a lower level and detecting certain patterns of the data, namely generating data clustering that was in turn continuous data for subsequent cluster analysis (Din & He, 2004). Therefore, using these methods was valid specifically to reveal underlying common factors behind the ambiguous target, such as sustainable city, and for grouping subjects. Initially, PCA using SPSS ver.22 (IBM) was used to synthesize variables derived from the question items (n = 30) into a smaller number. The method identified five factors that marked scores of 1 or greater (eigenvalues ≥1), to which 30 variables indicated how they influenced and provided PCA loadings. Thereafter, the author interpreted the characteristics of the respective factors based upon analyzing the degree to which the PCA loadings contributed, which in turn became the fundamentals of group attributions. Subsequently, k-means clustering analysis was conducted for classification of the local governments (n = 474) into five groups in line with the characterized factors. Nonhierarchical clustering was an effective method when subjects were

numerous as well as when grouping similar subjects together in accordance with mutual factors. With this method, specific numbers of clusters to create were usually not given, so the author set the number to five, the same number as the given factors. Having allocated the subjects to appropriate groups based on mutual factors, this study identified the group attributions influenced by the factors characteristics respectively. This study finally examined 30 indicators in the given groups by calculating average points of each indicator as well as groups' average points based upon Likert scale scores. It thus selected indicators that had higher average scores than the group averages so the constructs formed SDIs, reflecting the respective group attributions.

3. Results

3.1. Identifying five factors and their characteristics

Table 1 presents a matrix of PCA loadings in relation to five factors, indicating both positive and negative scores. The five factors were assigned PCA loadings with both positive and negative scores so that positive variables contributed to characterization of the factors while negative variables formed features that the factors did not intend to form. The cumulative contribution rate of PCA loadings was 59.8%; it was reasonable that the five factors accounted for nearly 60 % of the whole data as the primary data differed in its characteristics and significances largely, besides selections of relevant indicators to a sustainable city relied fairly on respondents' values or interpretations.

The study then provided appropriate titles to the five factors, which helped explain their characteristics, reflecting both plus and minus features and regarded here simply as bipolar vectors (Table 2).

Table 2. Interpretation of positive and negative characteristics and entitling respective factors

	Factors				
	1	2	3	4	5
Feature (+)	Comprehensive, high	Social Infrastructure	Quality of Life	Citizens' Initiatives	Organizational Activities
Feature (-)	Comprehensive, low	Natural Environment	Encouraging Economy	Governments' Initiatives	Individual Activities
Appellation	Sustainability	Community - Nature	Livelihood - Job	Bottom Up - Top Down	Institutional - Individual

Factor 1 consisted of variables showing positive scores in its column, with score ranging between 0.49 for the Community Attachment indicator and 0.72 for both the Air Quality and the Poverty Rate indicators. For this factor, the average score for all variables was positive (0.61), reflecting the comprehensive character of sustainability policy. This factor was thus named a sustainability factor.

By contrast, Factor 2 was composed of mostly positively scored indicators, such as Change Ratio of Young Female Population (0.50), and the most negative one (−0.51) of Greenhouse Gas Emissions. This factor also included contrastive vectors, such as Employment Status and Standard of Living (scores of 0.40) which particularly influenced the characterization. However, environmental indicators, such as Material Recycling (−0.45), were not considered significant measures. The positive and negative vectors were defined as Social Infrastructure and Natural Environment, and hence the factor was dubbed the Community-Nature factor.

Factor 3 indicated Neighbourhood Safety (0.45) as having the highest value and Self-sufficient Energy (−0.41) the lowest. It contained, on the one hand, indicators regarding livelihood quality, such as Neighbourhood Safety (0.45) and Health Expectancy (0.38) with high scores, and thus the positive vector was interpreted as Quality of Life. On the other hand, indicators linked to organizational activities, for example, Self-sufficient Energy (−0.41) and Inter-industrial Relations (−0.40), were demonstrated as the most negative, so the vector was identified as Encouraging Economy. Factor 3 was thus identified as the Livelihood-Job factor.

For Factor 4, the indicator of Community Attachment was positive with the top score of 0.54, while the Financial Administration indicator had the most negative value of −0.22. Factor 4 consisted of variables concerning residents' perceptions or behaviors toward a community. For instance, Community Attachment (0.54) and Social Involvement (0.51) largely contributed to the positive vector, so the vector was termed Citizens' Initiatives. In contrast, variables such as Financial Administration or Public Assets (−0.22) were on the negative side. In this regard, stable administration seemed to relate directly to fiscal sustainability, so the name of the vector was set to Governments' Initiatives. This factor was therefore identified as the Bottom Up-Top Down factor.

Factor 5 highlighted Financial Administration (0.33) and Opportunity for Higher Education (−0.41) as highest and lowest scoring, respectively. The factor indicated Financial Administration (0.33) and Public Assets (0.32) as the most positively contributing variables, so the positive vector was interpreted as Organizational Activities, whereas negative variables, for example, Opportunity for Higher Education (−0.41) and Leisure (−0.35), were identified as determinants of the negative vector, Individual Activities. This study termed Factor 5 the Institutional – Individual factor.

3.2. Classifying local governments and developing SDIs

Using k-means clustering analysis, all respondents (n = 474) were automatically aggregated into five clusters. The results showed that each cluster was formed in accordance with the highest factor scores, thus forming relevant group attributions reflecting characteristics of the respective factors (Table 3). Cluster 1 was influenced by Factor 1 (Sustainability) with the most positive score of 0.993. This group, which consisted of 159 municipalities, was in turn the largest group among the sample. In contrast, Cluster 2, which was the smallest group among the five, was composed of 63 public bodies. This group was influenced marginally by Factor 4 (Bottom Up-Top Down) with a score of 0.030, which this study regarded as nearly null, and therefore those local governments that responded to the questionnaire generally negatively converged on the cluster. Cluster 3 was characterized by Factor 5 (Institutional-Individual) with a score of 1.046, including 79 authorities. Cluster 4 consisted of 85 authorities and was most strongly characterized by Factor 2 (Community-Nature) followed by Factor 4 (Bottom Up-Top Down) with scores of 0.986 and 0.941, respectively. Cluster 5, which was composed of 88 local governments, mirrored Factor 3 (Livelihood–Job) with a remarkable score of 1.334 among the remaining negative factors. Above all, each cluster exhibited differentiated group attributions resonating with the most influential factors that revealed various policy tendencies toward a sustainable city among the groups.

Table 3. Results of cluster analysis with effective cases in respective clusters on the right, while, on the left, the final cluster centers provide scores in line with the five factors, respectively.

Cluster number	Cluster cases	Final cluster centres				
		Factor				
		Sustainability	Community - Nature	Livelihood -Job	Bottom Up - Top Down	Institutional - Individual
1	159	0.993	0.023	-0.124	0.102	-0.115
2	63	-0.868	-1.227	-0.801	0.030	-0.546
3	79	-0.307	-0.080	-0.081	-1.001	1.046
4	85	-0.531	0.986	-0.480	0.941	0.183
5	88	-0.386	-0.044	1.334	-0.216	-0.518

Consequently, this study selected several indicators that showed higher scores than the groups' average as components of SDIs in the respective groups (Table 4) in which notably two types of indicators, that is, "common" and "peculiar" indicators, were identified. The former referred to indicators that all groups chose, such as Local Productivity and Employment

Status, and that four groups out of the five chose, such as Social Cohesion or Financial Administration. By contrast, the latter referred to the remaining indicators selected, which differed in each group.

Table 4. Breakdown of developed SDIs in respective groups. Indicators with asterisks are regarded as 'common' indicators while the others refer to 'peculiar' indicators.

Group 1		
Field	Indicators	Likert point
Soc.	1. Health Expectancy *	4.67
	3. Neighborhood Safety	4.65
	4. Community Attachment *	4.86
	5. Social Cohesion *	4.75
	6. Social Involvement	4.66
	9. Childcare Facilities	4.53
	10. Change Ratio of Young Female Population *	4.75
Econ.	11. Local Productivity *	4.67
	12. Employment Status *	4.82
	15. Standard of Living	4.51
	18. Local Job Creation	4.51
	19. Public Assets *	4.78
	20. Financial Administration *	4.74
Average point		4.51

Group 3		
Field	Indicators	Likert point
Soc.	1. Health Expectancy *	4.24
	3. Neighborhood Safety	4.11
	9. Childcare Facilities	3.97
	10. Change Ratio of Young Female Population *	4.34

Group 2		
Field	Indicators	Likert point
Soc.	4. Community Attachment *	3.97
	5. Social Cohesion *	3.70
Econ.	11. Local Productivity *	3.75
	12. Employment Status *	3.81
Env.	21. Renewable Energy	3.86
	22. Self-sufficient Energy	3.65
	23. Material Recycling	3.95
	24. Greenhouse Gas Emissions	3.78
	27. Water Quality	3.86
	28. Amenity	3.83
	29. Closeness to Nature	3.83
	30. Green Space	3.65
Average point		3.58

Group 4		
Field	Indicators	Likert point
Soc.	1. Health Expectancy *	4.08
	4. Community Attachment *	4.62
	5. Social Cohesion *	4.34
	6. Social Involvement	4.34
	10. Change Ratio of Young Female Population *	4.72

	11. Local Productivity *	4.15
Econ.	12. Employment Status *	4.47
	13. Unemployment Rate	3.90
	19.Public Assets *	4.71
	20. Financial Administration *	4.63
Env.	21. Renewable Energy	3.91
	23. Material Recycling	4.04
	24. Greenhouse Gas Emissions	3.86
	27. Water Quality	3.94
Average point		3.84

	11. Local Productivity *	4.22
	12. Employment Status *	4.73
	13. Unemployment Rate	3.99
Econ.	15. Standard of Living	3.96
	17. Inter-industrial Relations	4.05
	18. Local Job Creation	4.25
	19.Public Assets *	4.28
	20. Financial Administration *	4.26
Average point		3.74

Group 5		
Field	Indicators	Likert point
Soc.	1. Health Expectancy *	4.50
	3. Neighborhood Safety	4.53
	4. Community Attachment *	4.60
	5. Social Cohesion *	4.30
	6. Social Involvement	3.91
	8. Senior Care Homes	3.84
	9. Childcare Facilities	4.06
	10. Change Ratio of Young Female Population *	4.23
Econ.	11. Local Productivity *	4.15
	12. Employment Status *	4.02
	19.Public Assets *	4.40
	20. Financial Administration *	4.45
Env.	27. Water Quality	4.10
	28. Amenity	3.89
	29. Closeness to Nature	3.98
	30. Green Space	3.82
Average point		3.82

4. Discussion and interpreting characteristics of respective SDIs

The present paper also discusses what characteristics each SDI has and what approaches they suggest to local governments toward developing a sustainable city by analysing the results.

Group 1 consists of local governments that have given positive responses (i.e., important or very important) to most question items of the survey. Tables 2 and 3 illustrate that the group bases its characteristics on a Sustainability factor, thus having a holistic approach. However, the SDIs of the group are composed of just socioeconomic indicators and none of the environmental indicators are selected (Table 4). This suggests that although some policy makers are aware of SD, the focus that comprehensive public policy tends to have is preferentially on social development and economic growth such that environmental aspects are somewhat discarded in real-world public policy in Japan. This underlines that local governments do not consider comprehensiveness of policy, and therefore there are constraints that prevent cross-cutting cooperation amongst sectors, which seems to be caused by the hierarchical nature of public administrations. Hence, a lack of coherence in sustainability policy appears as socioeconomically centred SDIs, despite a holistic approach.

Group 2 showed the least orientation toward SD among all the groups, reflecting that almost none of the factors had positive scores (Table 3). This suggests that the group had no outstanding factors that influenced its characterization and so had no specific features in terms of sustainability and this is a group showing a convergence of negative results. Nevertheless, the group had the greatest number of environmental indicators among the five, which accounted for 60% of the group's SDIs. This may be an alternative factor that complemented the results of Group 1, indicating a lack of environmental awareness in local sustainability policy so the study found that this group itself had no specified approach.

The indicators selected in Group 3 revealed that local governments of the group tended to implement institutional measures. All environmental indicators here urged policies that deal with large-scale tasks, for example, introducing a renewable energy supply, reducing CO_2 emissions or providing safe water, in addition to the most highly scored indicators being necessary to strengthen governmental initiatives (Table 4). Moreover, the work presented here determined that the approach of Group 3 resonated with what Hawkins and Wang (2012) noted—local governments can be significantly influential on sustainability issues (e.g., energy consumption, reducing greenhouse gas emissions, protecting environmentally sensitive areas) as well as decision-making processes, such as setting goals and developing alternative strategies.

Therefore, the group's SDIs are particularly suitable for local governments that carry on sustainability initiatives with a strongly governmental lead with sufficient financial resources.

The SDIs of the Group 4 results are similar to those of Group 1 in terms of containing merely socioeconomic indicators. However, the group distinguishes itself from Group 1 by including economic measures to the greatest extent, thus having an economically focused approach: nearly two-thirds of the indicators selected were purely economic or socioeconomic measures, of which the Employment Status indicator scored the highest (Table 4). In addition, the Community-Nature factor considerably influenced the group attribution so the group focused more on policies that enhance the value of communities than on environmental awareness (Tables 2 and 3). To sum up, the group's SDIs will provide a viable tool for local governments that strive to foster local economies with respect to stabilizing activities of local industries and individuals' incomes, simultaneously improving policies regarding social infrastructure and future demographics.

The results of Group 5 showed that the positive vector (well-being) is the most influential determinant of the group attribution. Likewise, it characterized the group's SDIs such that Neighbourhood Safety was the "peculiar" indicator that had the highest score, following the highest "common" indicator of Community Attachment. Moreover, the environmental indicators selected here are all policies relating to human well-being as determined by environmental conditions or environmental well-being (Table 4). Hence, the group tended to have an approach securing public welfare so that there was an enhanced community quality of life. The group's SDIs seemed to encompass both practical and normative functions that indicators should instill, which could respond to "the call for the effective interdependency of human and ecological well-being" (Gibson, 2006a).

In general, all SDIs developed in this study echo a "policy-based" approach that is derived by considering political priorities, thus making indicators related more closely to sustainability policy-making, although this approach might disregard key normative aspects of SD. However, only SDIs of Group 5 appeared to be coincident with a "model-based" approach that is designed based on a normative model of SD, so that indicators of the approach covered all normative issues, although it did not necessarily include political priorities (Steurer & Hametner, 2013). This study regarded the "common" indicators as being of primary importance for sustainability policy, which could identify the policy agenda confirmed in the Japan as a whole while identifying four differentiated approaches based on "peculiar" indicators that outline specified policy interests of the respective groups. To sum, the vast majority of Japanese local governments support the SDIs of Group 1 such that it could be the most viable policy tool. Otherwise, Group 3 will be more applicable for municipalities where a top-down administrative system is predominant, and the SDIs of Group 4 are of particular value where public bodies concentrate on local economic growth. Overall, these findings imply the status quo of social

challenges are at the local level in Japan. However, the SDIs of Group 5 will be an optimal policy tool in terms of satisfying normative objectives as the model-based indicators help accomplish the three dimensions of SD in a balanced and integrated manner, thereby ensuring the comprehensiveness of sustainability objectives and the reliability of the policy.

5. Conclusion

This study developed conceptual frameworks of comparative SDIs identifying four approaches. Comparative indicators provide a common mechanism that enables (similar) local authorities to compare themselves, integrating local efforts, which helps encourage the acknowledgment of differences of sustainability among cities (Cartwright, 2000; Shen, Jorge Ochoa, Shah, & Zhang, 2011). Moreover, the results revealed the trend that public policy focusing largely on socioeconomic issues may be dominant in local sustainability policy so that environmental policies are considered collateral measures. This is because sustainability is deemed not very important to decisionmakers and policy-makers at the local level (Mascarenhas *et al*., 2010). In this regard, disregarding environmental concerns and relevant policies are critical losses in local administrations and thus local sustainability policy is often prone to remaining unbalanced and inconsistent.

However, comparative SDIs invite competition among public bodies under mutual policy priorities, which produces incentives that increase awareness, thereby allowing them to share existing or potential challenges, best practices, or expertise and knowledge. This fosters local governments taking further initiatives and raises interactive learning that ensures unenthusiastic public bodies become involved in cooperative improvement of their policies, which in turn improves the general effectiveness of public policy. Alternatively, specific indicators permit scale interactions in assessment (Coelho, Mascarenhas, Vaz, Dores, & Ramos, 2010), and thus integrating local efforts through "common" indicators provides opportunities to solve social challenges acknowledged nationally. Such indicator systems have the potential to enable local commitment to global sustainability norms with the claim: We are committed to achieving sustainable development in its three dimensions in a balanced and integrated manner (UN General Assembly, 2015), given that model-based SDIs (i.e., those of Group 5) are optimal to maintain the coherence of sustainability policy.

The SDIs suggested indicate four different approaches toward sustainability. However, why each group tends to have a specific approach relies on what local governments prioritize in sustainability policy, considering numerous fundamental needs to a society regardless of the municipalities' scales, demographics or administrative abilities, which this study did not examine. Hence, revealing correlations between determinants and characteristics aids in understanding the mechanisms of community-specific indicator sets in more detail. Likewise, the findings showed that there are model-based SDIs differentiated from policy-based

models, which theoretically confirm normative objectives of SD. However, how this model could demonstrate transforming the norms in a local praxis by implementing sustainability policy remains to be shown. Finally, the study developed comparative frameworks on behalf of practitioners' interest largely considering the validity and reliability of SDIs for policy implementation, regardless of such indicators reflecting local values, concerns, or desires for and of a future society (Coelho *et al*., 2010). Therefore, a further challenge is to integrate the public perceptions of sustainability issues into the indicator systems and ensuring the relevance of indicators to a wide range of stakeholders.

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Chapter 3: Study 2 "Examining Distinctive Indicator Scopes Measuring Well-Being in Sustainable Development Assessment"

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.

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 & Giesecke, 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, i 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.
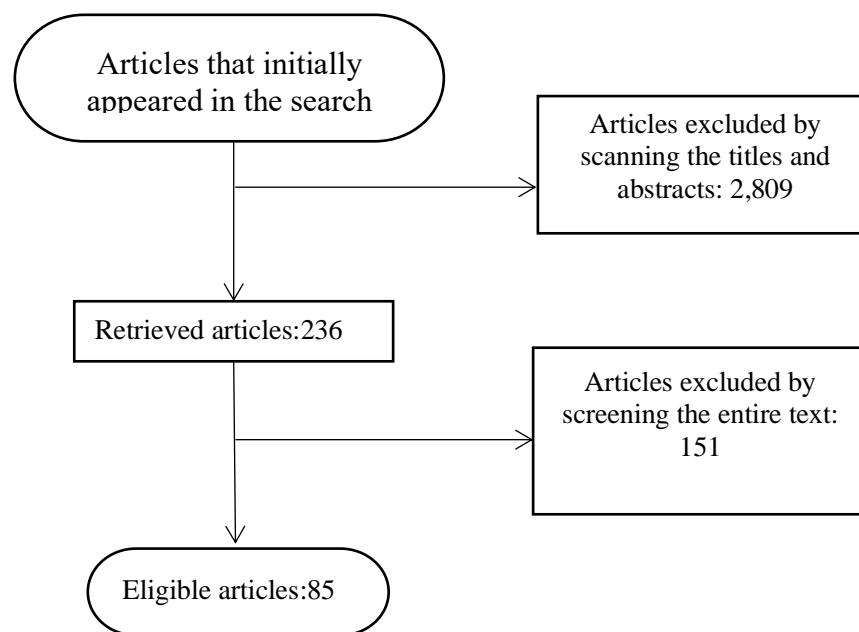
Figure 1. A flowchart representing the literature selection process

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

3.1 Theoretical Background and Different Scopes of Sustainable Development Indicators

Table1 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				
Construction Order	Raw data ↓ Indicator (scientifically converted)			
	↓(grouped) Composite Indicators		↓(synthesized) Aggregate Indicators Index/Indices	
Selection Criteria	*SMART criteria*	Specific Measurable Attainable Realistic Time-related	*Other essential criteria*	Policy relevance Understandability Data availability Analytical soundness Stress sensitive Representativity

The findings also highlight the two major s 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 jurisdictive 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, Tecco, 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.,* 2012). 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., CO_2 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

Theoretical Scopes of Sustainable Development Indicators				
Scaling	*Pillar-based/ triple bottom line scaling*	Environmental dimension Economic dimension Social dimension Other dimensions	*Spatiotemporal scaling*	Spatial boundary
				Temporal boundary
Valuation method and underlying value in data (according to measurement type)	*Measurement*	*Valuation method*		*Underlying value*
	Objective	Quantification (Quantitative weighting)		Normative value/scale
	Subjective	Exogenous approach (Expert judgment and knowledge) Personal judgement and self-perception		Relative value/importance

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 Tourneau *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, 2018; Ferrara & Nisticó, 2013; Nissi & Sarra, 2018; Raudsepp-Hearne *et al*., 2010; Villamagna & Giesecke, 2014). 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 thedifferentiated 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			
		Environmental	Social	Economic	Other
Alfaro-Navarro *et al*. (2017)	Sustainable urbanisation	Water, Air, Land use, Waste management	Safety, Health, Education	GDP, (Un)employment	-
Dobrovols kiené & Tamošiūni ené (2016)	Sustainable construction	GHG, Water, Renewable energy	Worker safety & health, Worker training	Maintenance cost	-

Estoque & Murayama (2014)	Sustainable urbanisation	Ecological footprint	Life expectancy, Education, Population	Income, Poverty	-
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 [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, Worker training, Gender equity	Legal costs, 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[Political]
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 & Rodrígues-Labajos (2009)	Multidimensional assessment of sustainability	GHG, Water, Renewable energy use, Energy consumption	Life expectancy, Safety(crime), Education, Population	GDP, Unemployment, Income gap	Research and development [Institutional]
Strezov *et al.* (2017)	Sustainable development indicator study	GHG, Air, Water, Ecological footprint	Life expectancy, Education, Gender equality	GDP, Income, Poverty	Good governance [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	Well-being Attribution	Examples of Well-being Indicators According to Pillar-Based Categorisation			
		Environmental	Social	Economic	Other
Chaaban *et al.* (2016)	Material	Air	Safety, Life expectancy, Education, Housing	(Un)employment, Income	-

D'Acci (2011)	-	Life expectancy, Education, Gender equity	GDP, Unemployment, Income gap	Cultural-scientific progress (Research & development), Human progress (Freedom)
Ferrara & Nisticó (2013)	Waste management	Life expectancy, Education, Social equity (opportunity)	GDP, Income, (Un)employment	-
Hamann et al. (2016)	Water	Life expectancy, Education	Income, Unemployment	-
Loring et al. (2016)	-	Education	Income	-
Nissi & Sarra (2018)	Water, Air	Life expectancy, Education	Income, 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, Income gap, Poverty	-
Sirgy (2011)	Air, Water, Land use, Energy consumption	Health, Population, Food, Housing	Income, 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 domains 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			
		Environmental	Social	Economic	Other
Bhandari[1] *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 adaption [Technological], Political stability [Political]
Haider *et al*. (2018)	Neighbourhood sustainable development	Environmental quality, Natural land protection	Social WB, Public mobility & accessibility	Economic prosperity	-
Herrera[1,2] *et al*. (2016)	Sustainable farming	Farm management & practices, Ecology	Social engagement, Social diversification, Quality of life	Market diversification, Investment modernisation	-
Peano *et al*. (2015)	Sustainable agri-food system	Landscape conservation, Biodiversity	Education, Relationship with externals	Market diversification, Economic partnership	Architectural cultural assets. Knowledge transmission [Cultural]
Pinar *et al*. (2014)	Sustainable development indicator study	Biodiversity, Energy intensity	Health, Education, Energy security	Investment, Research & development	-
Sadok *et al*. (2009)	Sustainable cropping system	Environmental quality & impact, Biodiversity	Health risks, Operational difficulties	Profitability, Specific equipment needs	-

Schneider *et al.* (2015)	Sustainable water governance	Water, Resource efficiency	Learning capacity, Cooperation, Basic needs (water), Justice	Material & financial capitals	Institutions and entitlement [Institutional]
Sureeyatanapas *et al.* (2015)	Corporate sustainability in manufacturing	Management commitment to environmental protection	Social development & participation, Social responsibility	Income euity, 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*. (2016)	Social	-	Support network, Volunteering	-	-
D'Acci (2011)		-	Education, Gender equity	-	-
Ferrara & Nisticó (2013)		-	Education, Social equity (opportunity)	-	-
Hamann *et al.* (2016)		-	Education	-	-
Loring *et al*. (2016)		-	Education	-	-
Ottaviani (2018)		-	Social resources access, Participation, Work life balance	-	-
Petrosillo *et al.* (2013)		-	Soc. cohesion	-	-
Schimmel (2009)		-	Education, Political & social condition, Social relation	-	-
Segre *et al*. (2011)		Environmental illegality/management, Sustainable mobility	-	Education, Participation, Gender equity, Social exclusion	Political participation [Institutional]
Sirgy (2011)		-	Social equity	Economic equity	Culture [Cultural]
Zorondo-Rodrígues *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 1indicates 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[1] *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[1] *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)	Subjective	-	-	-	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)	-	-	-	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).
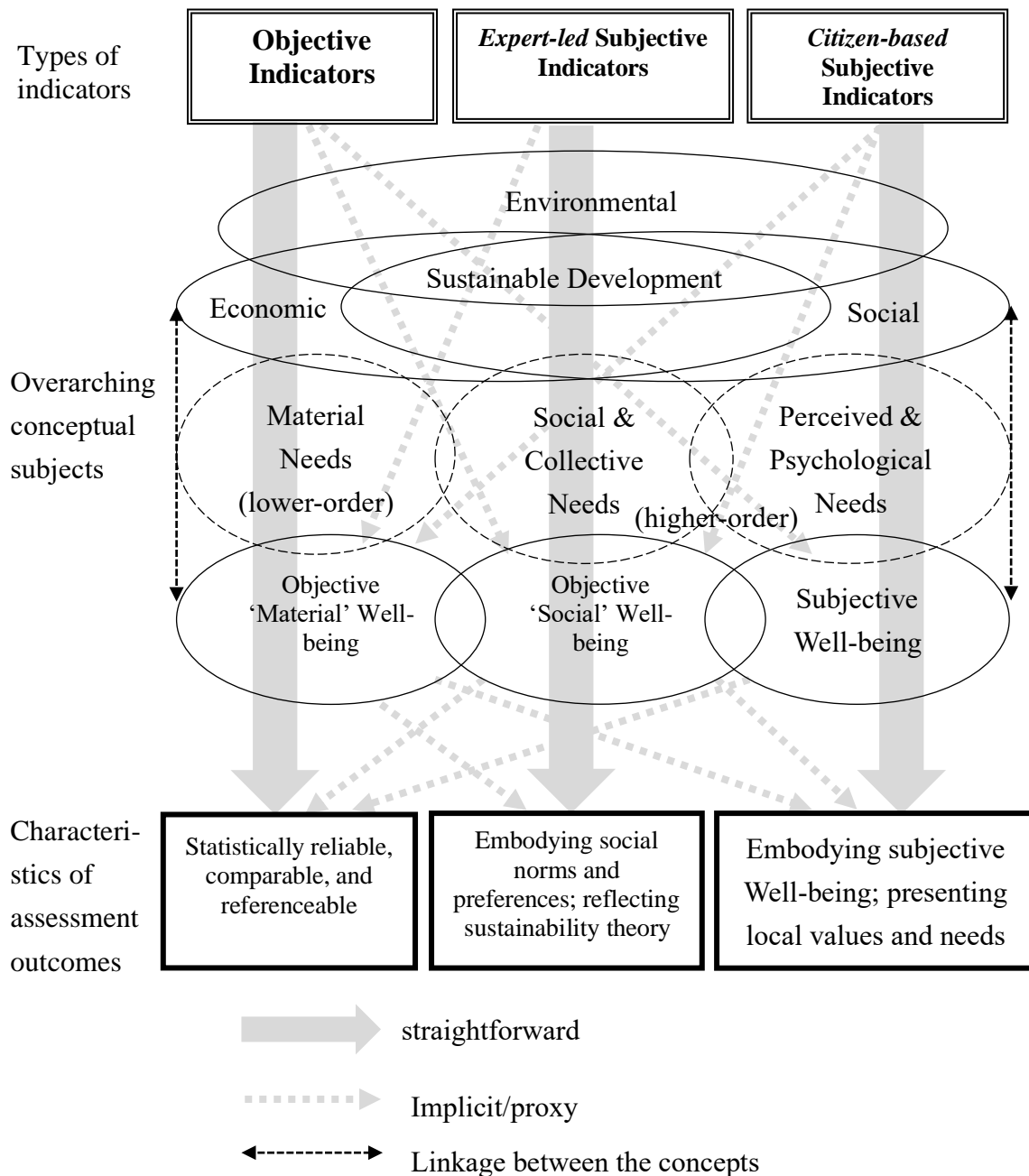
Figure 2. A distinctive characteristics of objective sustainable development indicators and *expert-led* and *citizen-based* subjective sustainable development indicators

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; Raudsepp-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 scientifical 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 (Bley.s 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 fulfilments 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 limitedor 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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Chapter 4: Study 3 "Subjective Indicators of Well-being and Municipal Sustainable Development: A Case Study of Tsukuba, Japan"

Subjective Indicators of Well-being and Municipal Sustainable Development: A Case Study of Tsukuba, Japan

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Abstract

To achieve sustainable development at the municipal level, including the United Nations Sustainable Development Goals (SDGs), the development process must be adequately monitored and evaluated using the appropriate indicators. In this context, acknowledging individual's well-being (WB) and using subjective indicators that rely on self-perception to measure WB have grown in significance over the last decade. This study elaborates on the current usability of subjective indicators employed in assessing municipal sustainable development with respect to associated public policies. Also, it explores the potential usability of such indicators in monitoring a municipal SDG initiative while seeking key determinants for locally feasible implementation of the initiative. To this end, an exploratory case study of the Japanese municipality of Tsukuba was conducted. This work involved analyzing public documents and empirical data collected from policymakers and residents of Tsukuba, Japan. The findings highlighted how the current usability of subjective indicators was observed to be high in light of the coverage of various facets of WB, the credibility as an assessment tool, and the policy relevance. However, residents' contrasting views of WB – between what the residents experienced and what policymakers intended to improve – could diminish the value of their use. Meanwhile, the potential usability in monitoring a municipal SDG initiative was limited. This is because the applicability of using subjective indicators in monitoring the SDGs and improving the resident's WB in achieving the goals was unclear. Instead, developing an established initiative plan and gaining residents' knowledge of the SDGs seemed crucial to the feasible implementation of municipal SDGs.

1. Introduction

The importance of implementing sustainability assessments to evaluate and monitor progress toward sustainable development at the municipal level has been growing in recent years as an increasing number of municipalities have come to regard sustainability as one of the core aspects of their developments (Assmann et al. 2018; Mapar et al., 2020; Musa et al. 2019). In this vein, indicator-based assessment plays a crucial role, as the use of appropriate indicators ensures reliable assessment and quality assurance (Allen et al. 2017; Hong et al., 2019; Warhurst, 2002). In 2015, the United Nations (UNs) adopted its 2030 Agenda that embraces 17 sustainable development goals (SDGs) and 169 corresponding targets. The goals emphasize operationalization at the local level, including municipalities. For instance, Goal 11 on creating sustainable cities and communities encourages an inclusive (sustainable) development where local governments and stakeholders play a central role (Gupta and Vegelin, 2016; Zinkernagel, Evans, and Neij 2018).

Meanwhile, the concept of well-being (WB) has been emphasized in the context of sustainable development and is deeply connected to local practices and experiences designed to aim at sustainable development (e.g., Bellantuono et al. 2021; Musa et al. 2019; Peterson 2016). Previous studies discuss how to pursue sustainable development by satisfying basic human needs (e.g., clean air and water, economic safety, and basic education) for present and future generations. Likewise, WB can be improved by addressing fundamental needs (Hatakeyama, 2021; Helne and Salonen, 2016). Proponents of this view suggest that basic human needs are inherently embedded in sustainable development and WB as their common, most fundamental targets to meet, thus satisfying WB contribute to achieving sustainability goals and vice versa (Hatakeyama 2021). For instance, a healthy environment, characterized, for instance, by clean air, can be a barometer of local and regional environmental sustainability, while exposure to a clean environment will significantly contribute to the physical and

psychological WB of individuals (Kjell 2011). Furthermore, pursuing sustainable development seeks to enhance individual and collective WB, which is frequently recognised as one of the central goals by communities (Musa et al. 2019). The importance of addressing WB is articulated in the SDGs: SDG 3 is devoted specifically to ensuring good health and well-being, stating that WB of all generations needs to be attained, to which good governance and effective institutions are a crucial foundation to fulfil the aim (Allen et al. 2017; Skevington and Epton, 2018).

In assessing sustainable development at the municipal level, objective indicators, which measure targets, referring to publicly available quantitative data (e.g., income level, household status) have been a central means of public policy assessment (Garau and Pavan, 2018; Gasper, 2007). Meanwhile, subjective indicators that rely on individual personal evaluation based on a self-perception or experience have increased the attention to practitioners and scholars, assuming that the 'conventional' approach of assessment often fail in capturing essential elements of municipal SD, such as quality of life or life satisfaction, which profoundly relates to individual subjective WB (Hatakeyama, 2021; Mouratidis, 2019). In the SDG context, using appropriate indicators is encouraged, and 232 indicators are proposed by the UNs to monitor the implementation at all administrative levels (Allen et al. 2017). However, objective indicators are predominantly employed in the SDG indicator set as with public policy assessment, although many SDG targets are imprecisely addressed by quantitative measurements (Biermann et al. 2017; Skevington and Epton, 2018; Zinkernagel et al. 2018

2. Using subjective indicators in assessing and monitoring sustainable development at the municipal level

Thus far, several studies have employed subjective indicators and suggested its contributions to improve the quality of assessment of sustainable development. For instance, a case study carried out in the Italian municipality of Cagliari measured a city's quality of life in aiming at urban sustainability, employing an evaluation framework that incorporated a number of subjective indicators based on the citizen's perception of urban quality of life. Their findings revealed that involving the citizen's view in the evaluation helped increase the efficacy and effectiveness of a public urban policy, which, in turn, improved the citizen's WB (Garau and Pavan, 2018). Likewise, a case study conducted in the Turkish city of Kocaeli assessed the urban quality of life for sustainable development of the city, using a number of subjective indicators based on the citizen's perception of, for instance, urban safety, public service quality/satisfaction, and the environmental quality (Senlier et al., 2009). Their findings indicated that resident's subjective assessment revealed local needs: for instance, urban safety was the most important priority for the city's sustainable development from the citizen's perspective. Accordingly, an assessment incorporating subjective indicators could be a guiding principle for urban quality of life by specifying public priorities and more suitable public policy, enhancing citizens' quality of life.

Using subjective indicators in monitoring municipal SDGs has frequently faced challenges. For instance, Zinkernagel et al. (2018) argued that no indicators based on qualitative measurements or subjective indicators were included in the internationally adopted SDG indicator systems, although incorporating local needs and desire into such frameworks rendered the existing SDG indicators more locally relevant. Likewise, Assmann et al. (2018) proposed SDG indicators for the German municipalities by examining the most relevant SDG indicators to the context, complemented by selecting further context-specific indicators from the German indicator database. They pointed out an apparent lack of subjective indicators in any existing indicator systems, thus the necessity of further incorporation of such indicators to complete an indicator system for municipal SDGs.

In the Japanese context, Honda et al. (2015) discussed that involving local aspects in assessing public policy through citizen participation helped identify key indicators measuring elements that attribute to their WB, such as a perception of a good environment and solidarity. Meanwhile, an increasing number of municipalities have been considered in the citizen's WB as the primary goal of government policy (Kuhlman and Farrington, 2010), to which a further use of subjective indicators are also considered. However, how subjective indicators could facilitate a real-world

policy assessment in the Japanese context remains an open question (Hatakeyama, 2018). Regarding SDG practices, the Japanese national government has held the SDGs Future City Initiative. It encourages the municipalities to propose outstanding programs that aim to achieve SDGs, taking into account their own local values, priorities, and solutions to the challenges (Cabinet Office, the Government of Japan, 2018a); a total number of 94 municipalities have been designated as of 2020. A study indicated that several entities recognised that citizen's quality of life and the local identity could be enhanced in a way that achieved the municipal SDGs (Kawakubo et al., 2018). Meanwhile, another study found that merely a few Japanese municipalities employed subjective indicators to measure the initiative targets contributing to, for instance, the SDG 7 and 17. For instance, indicators measuring the proportion of the citizens who 'feel healthy', 'are interested in municipal development', and 'are willing to live in the city for the long term', (Masuhara et al., 2019). However, the extent to which improving citizen's WB in achieving SDGs and using subjective indicators are practically relevant in monitoring municipal SDGs remains understudied.

3. Aim of the Study

There is still broad room to examine the usability of subjective indicators in the practice of assessing municipal sustainable development. Therefore, this study aims to identify the most significant determinants and obstacles to the usability of subjective indicators in assessing public (sustainability) policy as well as an SDG initiative, taking a Japanese municipality for an example. To this end, an exploratory case study in the Japanese municipality of Tsukuba is conducted. Given that few Japanese municipalities employ sufficient quantity and quality of subjective indicators and address SDGs in a single public policy plan. The case study is designed in two-fold: 1) Examining the current usability of subjective indicators employed in assessing the most comprehensive public policy plan; 2) examining the potential usability of subjective indicators in monitoring a municipal SDG initiative.

4. Methodology

Figure 1 presents how the explorative case study is undertaken, which includes theoretical analysis followed by empirical examinations, incorporating qualitative and quantitative methods.
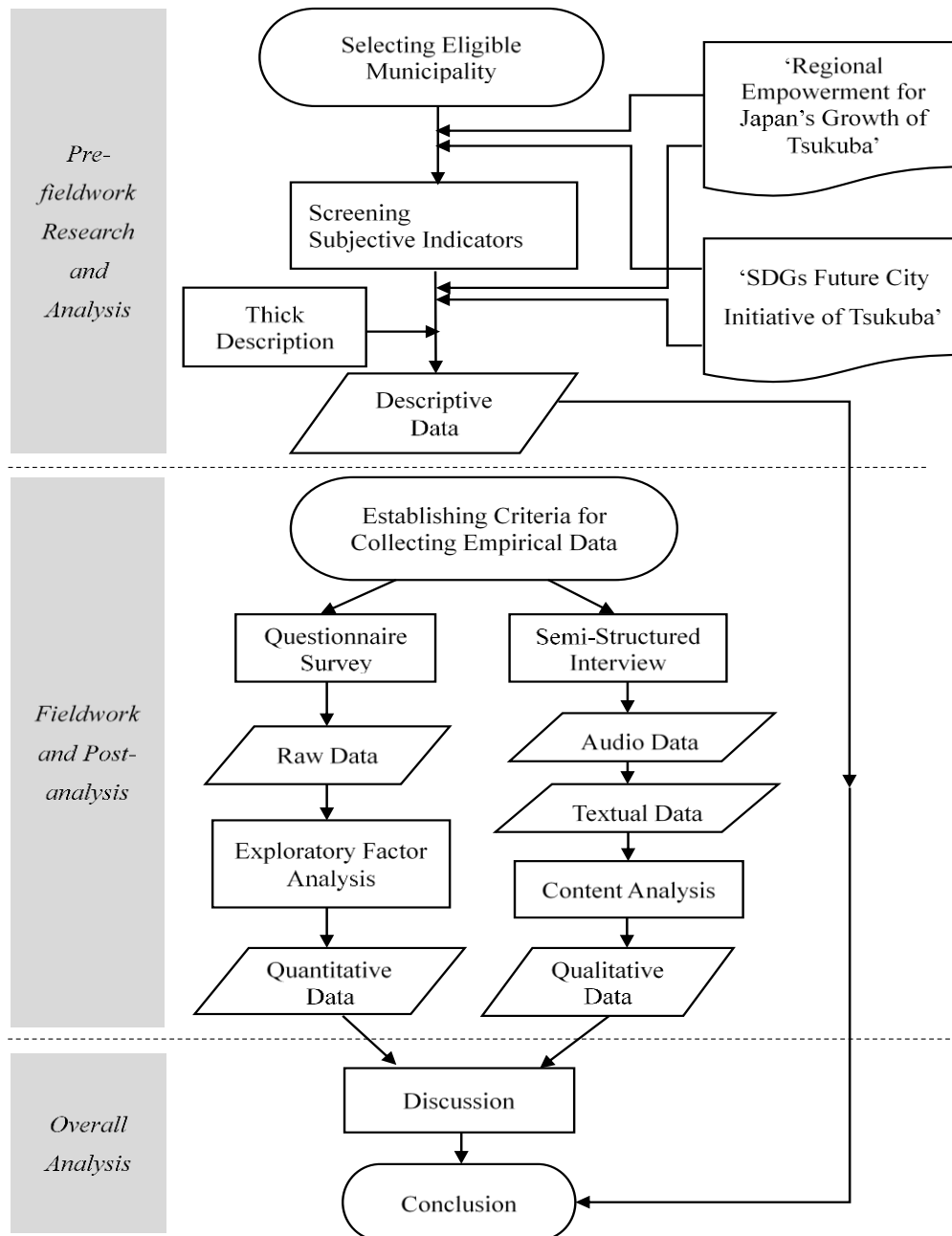
Figure 1. A flowchart of the explorative case study.

4.1. Selecting a Municipality

To select a relevant municipality, this study initially searched municipalities that had been designated for the SDGs Future City Initiative and subsequently explored their comprehensive public policy plans 'Regional Empowerment for Japan's Growth ' to ensure whether or not sufficient numbers and quality of subjective indicators were employed in the assessments. Consequently, this study selected the municipality of Tsukuba which inhabits a population of 239,921 and is located in Ibaraki prefecture, stretching approximately 50 km away from Tokyo to the Northeast (Figure 2). It was designated for a national development scheme, which

attracted a large number of national research institutes to establish, thus renowned as the Tsukuba Science City. Given the intellectual advantage, many transdisciplinary research and social experiments to create social innovation and solve environmental issues have been conducted (Tsukuba City, 2018a).
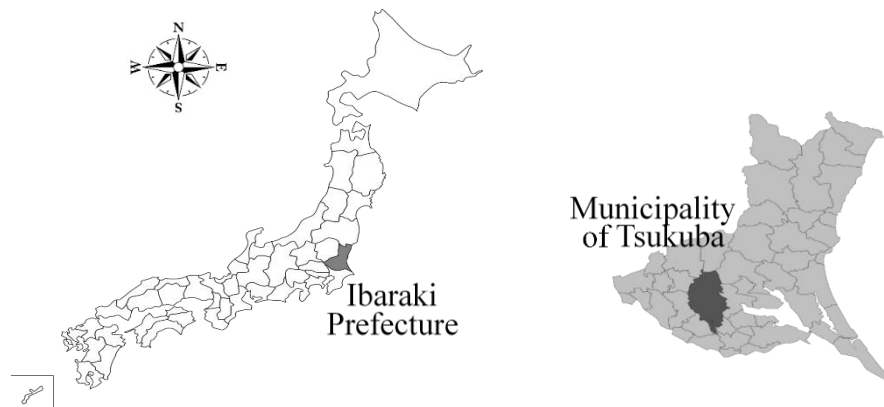
Figure 2. The locations of Ibaraki Prefecture and the municipality of Tsukuba (created by the author at https://n.freemap.jp/)

4.2. Screening Subjective Indicators

To derive eligible subjective indicators for the analysis, this study scrutinises the plans of public policy 'Regional Empowerment for Japan's Growth of Tsukuba' and of the SDG initiative 'SDGs Future City Initiative of Tsukuba'. The former scheme was first introduced in 2015 and modified in 2017 by the municipal administration of Tsukuba (Tsukuba City, 2017a). It consists of four overarching public policy goals, representing the major public priorities (e.g., creating a safe society), which are further broken down into a number of policy targets. To achieve the goals and targets, they set associated policies, accompanied by concrete policy programs. These are systematically managed and evaluated by a composite set of 54 Key Performance Indicators (KPI), where 11 subjective indicators are incorporated (see Table 1) (Tsukuba City, 2017a). Meanwhile, an action plan 'CIVIC program' (which is an acronym consisting of the initials of five major goals: Child, Inclusive, Value, Infrastructure, and Circulate) as the core force to steer the 'SDGs Future City Initiative of Tsukuba' is established. In the action plan, three subjective indicators are employed to monitor the progress, which are the greatest number among the other peer municipalities (see Table 1) (Tsukuba City, 2018a). Most subjective indicators employed in the aforementioned plan and initiative are derived from the citizen attitude survey, annually conducted to randomly selected 3,000 citizens of Tsukuba, while those measuring student's perception are developed, referring to its counterparts employed in the student progress report, answered by primary school students of the municipality (Tsukuba City, 2017a)

Table List of the policy goals and targets, as well as corresponding subjective indicators in the Regional Empowerment for Japan's Growth of Tsukuba as well as the major themes, action targets, and corresponding subjective indicators in 'CIVIC program' in the 'SDGs Future City Initiative of Tsukuba'.

'Regional Empowerment for Japan's Growth of Tsukuba'		
Policy goals	Policy targets	Subjective indicators
Creating employment by enhancing local competitiveness	-	n/a
Creating a liveable and healthy environment	Enriching education	The proportion of students who have self-esteem
		The proportion of students who have a sense of purpose and cooperation in problem-solving
	Establishing a school support system	The proportion of students who have a feeling of enjoyment in daily school life
		The proportion of students who are satisfied with friendships
	Promoting a gender-equal society	The proportion of the residents who feel having a good work-life balance

Attracting new residents from other regions	Creating a liveable residential environment	The proportion of the residents who are satisfied with the liveability of the municipality

	Promoting cultural and art activities in the municipality	The proportion of the residents who are satisfied with city cultural facilities
	Promoting sports activities in the municipality	The proportion of the residents who are satisfied with city sports programs
	Enhancing the municipality's popularity	The percentage of resident attachment to the city
Developing a safe society	Maintaining public transport system	The proportion of the residents who are satisfied with the community bus service
	Revitalizing local community and promoting resident participation	The proportion of the residents who are satisfied with community activities (e.g., volunteer work)
'CIVIC program' (in the 'SDGs Future City Initiative of Tsukuba')		
Major themes (goals)	Action targets	Subjective indicators
Securing children's future (Child)	Implementing measures against childhood poverty and promoting education for sustainability	The proportion of students who have self-esteem
		The proportion of students who have a sense of purpose and cooperation in problem-solving
Developing an inclusive society (Inclusive)	Re-discovering the local values and sufficing mutual aid	n/a
Creating and succeeding local values (Value)	Generating new values and solving social challenges through SDGs x Society 5.0[1]	n/a

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[1] It refers to 'an anthropocentric society, in which the economy is enhanced in a way that solves social problems through a system that high-dimensionally integrates cyber and physical spaces (Cabinet Office, the government of Japan, 2016)'.

Developing a basic infrastructure (Infrastructure)	Promoting inter-regional exchange through an established community transport	n/a
Protecting the natural environment and ecosystem (Circulate)	Encouraging local consumption of local products and civic environmental activities that empower the community	The proportion of the residents who are satisfied with the municipal low-carbon initiative

4.3. Methods

Having identified subjective indicators that assess sustainable development of Tsukuba, this study initially performs a thick description of the 'Regional Empowerment for Japan's Growth of Tsukuba' and the 'SDGs Future City Initiative of Tsukuba'. This method helps ensure the study's credibility by describing and interpreting social actions in detail (Ponterotto, 2006). It also provides an in-depth understanding of how the subjective indicators are employed in the assessment practice.

In addition, obtaining and analysing empirical knowledge of a phenomenon helps complement fragmented information from the literature (Kallio et al., 2016). Therefore, this study performs mixed methods, combining semi-structured interviews with the policymakers and a questionnaire survey to Tsukuba residents. Applying concurrent qualitative and quantitative explorations and analysis of information helps disseminate practically usable knowledge (Sale et al., 2002; Venkatesh et al., 2013).

Semi-structured interview is adequate to explore underlying values in a study context (Barriball and While, 1994). Policymakers who belonged to the Department of Policy Innovation of the municipality administration of Tsukuba and engaged with creating and implementing the 'Regional Empowerment for Japan's Growth of Tsukuba', including developing the indicator system, assessing policies, and reporting the outcomes, were asked to join the semi-structured interview. Two out of five had the most profound knowledge and experience of the task, thus designated as interviewees. The interview was initially recorded and treated as audio data. Subsequently, this study generated textual data by using a qualitative analysis software, MAXQDA and assigned the directed approach of qualitative content analysis. The method allowed for modifying or expanding a pre-existing coding system (i.e., this study's five criteria) where key concepts and variables were identified through exploring further additional codes with exemplars (e.g., sub-codes) or descriptive information (Hsieh and Shannon, 2005; Morgan, 1993). Moreover, data analysed by qualitative content analysis provided diverse inferences from a large data body to reveal trends and differences [of the observed phenomenon] (Krippendorff, 1989).

Meanwhile, a questionnaire survey allows for collecting information from a representative sample of a specific population and inference of the result is applicable to a broader population (Rattray and Jones, 2005). The residents of Tsukuba, who participated in SDG workshops to learn the basic

knowledge of SDGs and the information of 'SDGs Future City Initiative of Tsukuba' held by the municipal administration responded to a paper-based questionnaire. This study designed the questionnaire with four-point Likert scale (e.g., very much, somewhat, somewhat not, and not at all) to obtain the magnitude of responses, while avoiding a neutral answer. To analyse the data, this study assigned exploratory factor analysis (EFA), which delivered manifest variables by revealing latent variables and unveiled common underlying factors (Costello and Osborne, 2005; Ferguson and Cox, 1993).

Prior to carrying out the mixed-method research, this study established criteria to define the current and potential usability of subjective indicators by scrutinizing relevant literature of policy assessment and SDG practice in accordance with the policymakers' and residents' views and the two municipal plans in question (see Table 2).

Table2. Criteria and the definitions for semi-structured interview and questionnaire in accordance with the study subjects and target groups

| | | Target Group | | | |
| | | Policymakers | | Residents | |
		Criteria	Definition	Criteria	Definition
Study Subject	**The Current Usability of Subjective Indicators in Assessing Policies in the Regional Empowerment for Japan's Growth**	*Credibility*	Indicators are methodologically stable to produce a reliable outcome (Reed et al., 2006; Niemeijer and de Groot, 2008)	*Credibility*	Indicators are methodologically stable to produce reliable data (Reed et al., 2006; Niemeijer and de Groot, 2008)
		Relevance	Indicators sufficiently represent sustainability or public policy are (Janouskova et al, 2018) and meet the needs of the user and audience (Hezri, 2004)	*Relevance*	ndicators sufficiently represent sustainability or public policy are (Janouskova et al, 2018) and meet the needs of the user and audience (Hezri, 2004)
		Data Reliability	Outcome data ensures the quality with respect to reproducibility, availability, and measurability (Böhringer and Jochem, 2002; Janouskova et al., 2018; Saris et al., 1998)	*Capability*	Indicators allow for explicit judgement to measure what is important to the audience (Hezri, 2004; Reed et al., 2006)
		Flexibility		*Simplicity*	

			Indicators and the measurements can change in accordance with content, purpose, method, and focus (Booysen, 2002; Singh, 2012)		Presentation structure, content, and purpose of indicators are clear and understandable to the audience (Hezri, 2004; Singh et al., 2009)
		Well-being	(Dis)satisfaction with various life domains perceived by individuals or groups (Costanza et al., 2007)	*Well-Being*	(Dis)satisfaction with various life domains perceived by individuals or groups (Costanza et al., 2007)
	The Potential Usability of Subjective Indicators in Monitoring the 'CIVIC Program' in Implementing the 'SDGs Future City Initiative of Tsukuba'	*Use of Indicators*	Indicators are appropriate to use in operationalizing, managing, and reporting the SDG implementation strategy (Biermann et al., 2017; SDSN, 2014)	*Use of Indicator*	Indicators are appropriate to use in operationalizing, managing, and reporting the SDG implementation strategy (Biermann et al., 2017; SDSN, 2014)
		Action Relevance and Integrity	The action is locally relevant and reflects local priority, which does not contradict the global SDG vision (Zinkernagel et al., 2018)	*Action Relevance*	The action is relevant to the local context, which does not jeopardize SDG implementation (Burford et al., 2013; Zinkernagel et al., 2018)
		Multi-stakeholder Governance	C Addressing complex interaction and synergy in the SDG governance structure through cooperation among responsible stakeholders (Zinkernagel et al., 2018; Waas et al., 2015)	*Action Integrity*	Including key stakeholders (aspects) and local needs, values, and priorities in the action to support implementing SDGs (Burford et al., 2013; Zinkernagel et al., 2018)
				Well-Being	

		Inclusive Development	Including various aspects through multiple actor participation in and engagement with the SDG process (Gupta and Vegelin, 2016; Zinkernagel et al., 2018)		Perceived individual (dis)satisfaction with multiple life domains (Costanza et al, 2007), specified in the SDG discourse (Skevington and Epton, 2018)
		Capacity Building	Gaining knowledge and experience regarding SDGs to promote participatory governance (Gupta and Vegelin, 2016)	Capacity Building	Gaining knowledge and experience regarding SDGs to promote participatory governance (Gupta and Vegelin, 2016)

5. Results

In this section, the results of this study are provided of the empirical examinations in three-fold: Thick description, semi-structured interview with the policymakers, and questionnaire survey to the residents of Tsukuba.

5.1. Thick Description on public reports of Tsukuba

Initially, this study extensively examined the assessment reports of the 'Regional Empowerment for Japan's Growth program of Tsukuba' from 2016 to 2018. The reliability and the efficacy of all policies were respectively assessed by policymakers, based upon the indicator outcome scores with a three-point scale (i.e., High, Medium, and Low). Meanwhile, they also provide the overall judgement of all policies, considering whether the respective indicators met their outcome values of the target year with a six-point scale: from S (the convincing reliability and efficacy), A, B, C, and D, to E (substantial improvement required) (Tsukuba City, 2016; 2017b; 2018b).

As of 2018, they have employed the most subjective indicators presented in Table 1 since 2012, while a few indicators (e.g., resident attachment to the municipality) were developed in 2015. The report highlighted that six subjective indicators reached their target outcome values, presenting higher values than the goals (Tsukuba City, 2018b). For example, indicators measuring 'student enjoyment in school life' and 'student satisfaction with friendships' reached the target outcome values by surpassing the score by 0.3% and 0.2 %, respectively. An indicator measuring 'resident work-life balance' outpaced the target value over 5 % as of 2017, due to that no survey was conducted in 2018. Likewise, indicators measuring 'resident satisfaction with the municipality liveability' and 'resident attachment to the municipality' both presented 2.6 % higher than the target values. Remarkably, an indicator measuring 'resident satisfaction with the community bus service' considerably exceeded the target value over 17.5%.

Regarding the reliability and efficacy of corresponding policies, a policy represented by the 'resident satisfaction with the community bus service' indicator was evaluated High for reliability and efficacy. Thus, the overall judgement was A (i.e., continue to implement, while maintaining the reliability and efficacy). Similarly, the evaluation of a policy represented by the 'resident satisfaction with the municipality liveability' indicator presented High for the reliability and Medium for the efficacy. Thus, the overall judgment was A. Policies represented by all other subjective indicators were assessed Medium for the reliability and the efficacy, and the overall judgment was B (i.e., continue to implement, while improving the reliability and efficacy).

In contrast, the other five subjective indicators could not meet the target outcome values. For instance, indicators measuring 'student self-esteem' and 'student sense of purpose' marked - 0.2% and - 9.7 %, respectively, compared to the target value as of 2018. Likewise, indicators measuring resident satisfaction with 'cultural programs', 'sports programs', and 'community activities' presented -0.8%, -10.4%, and -18.8%, respectively, against the target values as of 2017. The report analyzed that the significant decline of the 'resident satisfaction with community activities' indicator was because the indicator description substantially changed from satisfaction with the community-driven council to

satisfaction with voluntary community activities (Tsukuba City, 2017b). The reliability and effectiveness of policies presented by those subjective indicators were all evaluated Medium. However, the overall judgement of policies represented by the two subjective indicators assigned to students presented A, while the results for other policies were B. Assuming that all subjective indicators, except the one measuring 'community activities', had presented clear increases in their outcome values over three years. Subsequently, the public reports of the 'SDGs Future City Initiative of Tsukuba' were examined. To conceptualize the 'SDGs Future City Initiative of Tsukuba', the normative ground 'Sustainability City Vision' was adopted in 2018 (Tsukuba City, 2018a). The vision manifested a pathway to a sustainable municipality by 2030 in a way that solved emerging local challenges (e.g., an aging population with a declining birth rate) based on the SDG norms; simultaneously, the goal was meant to be achieved by using more inclusive, universal, transparent, and sustainable approaches (Tsukuba City, 2018c). To steer the initiative effectively, the core action program the 'CIVIC program' was established in the initiative. The program consists of five major themes specified by corresponding targets and reflect the challenges and priorities of the municipality, associating with SDGs (Tsukuba City, 2018e). For instance, Target 1 aims at 'implementing measurements to reduce child poverty and promoting education for people who can realize a sustainable society in a future', which contributes to SDG 1 (No Poverty), 2 (Zero Hunger), and 4 (Quality Education). Target 2 focuses on 're-discovering the municipality's values and enhancing mutual community aids among the citizens', which relates to SDG 10 (Reduce Inequality) and 11 (Sustainable Cities and Communities). Target 3 addresses 'creating new values and solving social challenges by SDGs × Society 5.0', which contributes to SDG 8 (Decent Work and Economic Growth) and 9 (Industry, Innovation, and Infrastructure). Target 4 proposes 'promoting inter-regional exchange and communication through an established community transport', which aims at SDG 11. Finally, Target 5 points to 'encouraging local consumption of local products and civic environmental activities that empower the community', meets SDG 7 (Affordable and Clean Energy), 12 (Responsible Consumption, and Production), and 13 (Climate Action) (Tsukuba City, 2018e). In assessing these targets, they employed subjective indicators merely to targets 1 and 5 (see Table 1). Given the novelty of the initiative, each subjective indicator presents merely its reference value as of 2018, which is expected to increase by 2030. For instance, an indicator measuring 'student self-esteem' showed a reference value of 83 % to be increased by 88%. An indicator measuring 'student sense of purpose and cooperation' showed the reference value of 89% to be increased by 92%. An indicator measuring 'resident satisfaction with the municipal environmental initiative' showed 19.7% as a reference value to be increased by 30% (Tsukuba City, 2018e).

Accordingly, the two public reports address that the subjective indicators provide tangible outcome values and support the overall assessment in the 'Regional Empowerment for Japan's Growth program of Tsukuba'. Given that using such indicators in the 'CIVIC program' has commenced, it provides merely a guiding role to illustrate milestones of the actions when this study is conducted.

5.2. Empirical information representing the policymakers' perspective

Table 3 outlines the superordinate codes and the sub codes alongside their frequencies observed in a

screening of the textual data. The sub codes with the highest and higher frequencies represent the greatest explanatory features to the five criteria of the respective study subjects.

Study Subject		Study Subject	
The Current Usability of Subjective Indicators in Assessing Policies in the Regional Empowerment for Japan's Growth		**The Potential Usability of Subjective Indicators in Monitoring the 'CIVIC Program' in Implementing the 'SDGs Future City Initiative of Tsukuba'**	
Superordinate- and sub-codes	Frequency	Superordinate- and sub-codes	Frequency
Credibility		*Use of Indicators*	
Capturing complexity	12	Selecting appropriate indicators to action goals	12
Accurate measurement of targets	11	Time frame	5
Informing policy outcome	11	Existing indicators	5
Enhancing policy output	8	Subjective indicators	4
Policy validation	7	Objective indicators	3
Methodology Solidity	3	Referring to international SDG indicators in monitoring the municipal action plan	3
Relevance		*Action Relevance and Integrity*	
Capturing issues of concern (major policy goal)	6	Identifying local challenges related to SDG agenda	16
Resonance with local context	6	Interpreting SDGs resonating with local context	15
Relationship between individual policy targets and major policy goals	5	Resonating SDG goals with the comprehensive public policy plan	14
Capturing issues of concern (individual policy targets)	5	Envisioning municipal SDG goal	13
Aimed at target audience	3	Creating a relevant action plan	9
Selecting appropriate indicators to policy targets and goals	1	Implementing policy and actions aiming at SDGs	7
Data Reliability		Creating concrete action programs	5
Complementarity with quantitative data	9	Resonating SDG targets with the comprehensive public policy plan	2
Representing latent factors	7	*Multi-stakeholder Governance*	
Rigor of data value	5	Cooperation with other departments of the municipal administration	15
Comparability with other entities	4	Need of expertise or specialized know-how	11
Sensitivity to time series	2	Existence of the core actor	11
Flexibility		Existence of cross-cutting decision making	6
Allowing bottom-up feedback	12	Action management through different administrative layers	5
Involving multiple stakeholders' view in the measurement	10	Stakeholder diversity	5
Sensitivity to social change	6	*Inclusive Development*	
Revising indicator descriptions and targets	5	Collaboration between the municipal administration and stakeholders	11

Well-Being		Role of organisational participants	9
Resident perception	12	Role of individual participants	8
Policy maker intention	12	Securing places to implement action	8
Captured by indicators	8	Horizontal interaction or exchange among stakeholders	6
Enhancement	5	Long term engagement	5
Generation as policy outcome	4	Initiatives from stakeholders	4
Relation to policy targets and goals	3	*Capacity Building*	
		Gaining basic knowledge of SDGs	11
		Variation of learning programs	9
		Understanding of the complexity of SDGs	9
		Introducing learning programs	8
		Voluntary learning	8
		Availability of experts for the learning programs	6

On the one hand, the left table highlights the greatest explanatory features to the current usability of the subjective indicators in assessing policies in the 'Regional Empowerment for Japan's Growth of Tsukuba'. For instance, 'accurate measurement of targets' and 'informing policy outcome' are decisive to secure the 'credibility' of the subjective indicators. 'Allowing bottom-up feedback', 'capturing complexity', and 'involving multiple stakeholders' view in the measurement' most represent the 'flexibility' of those indicators. 'Resident perception' and 'policymaker intention' are key to understanding the extent to which those indicators can capture and present the resident's 'well-being'. Additionally, elaborating the most frequent co-occurrences of two sub codes can reveal another feature, which appeared not only with other subcodes within the same superordinate codes, but also across the other superordinate codes (see Appendix 1). For instance, 'accurate measurement of targets' occurred most often with 'involving multiple stakeholders' view in the measurement' and 'capturing complexity'. The former combination was observed when the policymakers mentioned that the outcome of education policies were assessed through measuring teachers' and school councilors' subjective evaluation in addition to the student's subjective satisfaction. Meanwhile, the latter combination as well as the co-occurrence of 'capturing complexity' with 'resident perception' suggest that utilizing their perception as a measurement was practically relevant, given the inherent subjectivity of the concept (Craheix et al. 2015).

On the other hand, the table on the right highlights the greatest explanatory features to the potential usability of subjective indicators in monitoring the 'CIVIC program' in implementing the 'SDGs Future City Initiative of Tsukuba'. For instance, 'selecting appropriate indicators to action goals' is recognized as decisive to the 'use of indicators' in the monitoring. 'Envisioning municipal SDG goal', 'identifying local challenges related to SDG agenda', 'interpreting SDGs

resonating with a local context', and 'resonating SDG goals with the comprehensive public policy' are a key to 'ensuring integrity and consistency of action'. 'Cooperation with other departments of the municipal administration', 'need of expertise or specialized know-how', and 'existence of the core actor' have a great influence on 'multi-actor governance'. 'Collaboration between the municipal administration and stakeholders' is regarded as most crucial to 'inclusive development'. Finally, 'gaining basic knowledge of SDGs' is the core of 'capacity building'. Additionally, elaborating the most frequent co-occurrences of two sub codes unveil other significant features (see Appendix 2). For instance, the highest co-occurrences of 'envisioning municipal SDG goal' with 'identifying local challenges related to SDG agenda' and 'interpreting SDGs resonating with a local context' were respectively observed. 'Selecting appropriate indicators to action goals' most frequently occurred with 'identifying local challenges related to SDG agenda' and 'resonating SDG goals with the comprehensive public policy', when interviewees stressed the importance of the context-relevant setting and use of indicators.

The findings highlight the key explanatory features to understand the current and potential usability of subjective indicators in assessing sustainable municipal development from the practitioners' perspective. For the same purpose, this study explores and analyses the residents' perspectives as follows.

5.3. Empirical information representing the residents' perspective

The number of valid respondents was rather limited (n = 46). However, recent studies suggested that Exploratory Factor Analysis could yield reliable results from a small sample size (n ≤ 50) and the minimum sample size was determined, depending on how well the data were conditioned (e.g., high factor loading, low factor numbers, or high variables) (Costello and Osborne, 2005; de Winter et al., 2009). In addition, a normality test on the raw data, using SPSS Statistics 26 verified the statistical reliability of the questionnaire results by examining the p-value of each criterion (i.e., treated as the independent variable), using the Shapiro-Wilk approach. The results showed that the p-values of all variables met the level at which the null hypothesis was rejected (≤0.05). Thus the data was statistically significant.

Table 4 outlines the breakdown of the eigenvalues and variances of five independent variables regarding the current usability of the subjective indicators in assessing policies in the 'Regional Empowerment for Japan's Growth of Tsukuba', derived by ex- and post-ante rotations. The initial eigenvalues show that Factor 1 accounts for greater than one, while Factor 2 presents slightly less than the standard value. Hence, the former is regarded as the greatest explanatory factor, while the latter provides supplementary information, considering that the cumulative contribution rate of squared loadings with the two factors shows 75.8% to explain the study subject. Simultaneously, assigning Varimax rotation with Kaiser normalisation explains that Factor 1 is characterized by 'simplicity' and 'well-being', and 'relevance', and Factor 2 is

formed by 'credibility', 'capability', and 'relevance'. The results show that the characteristic of Factor 1 suggests that the subjective indicators describing the corresponding policy targets and presenting the outcome values are understandable without prior knowledge and are a relevant tool to measure the resident's WB. Interpreting 'relevance' contributing to Factor 1 and 2 additionally implies that ensuring the relevance of subjective indicators is decisive in delivering the evident assessment outcomes and performing accurate measurements of the corresponding policy targets. However, the low eigenvalue of factor 2 implies that the respondents may not consider that the technical usability of the subjective indicators is sufficient to measure policy targets that aim to enhance and represent resident WB.

Table 4. Initial eigenvalues and squared loading score, with two factors extracted and most significant contributing variables for the current usability of subjective indicators from the resident perspective.

			Factor				
			1	2	3	4	5
Total Variance Explained	Initial Eigenvalues	Total	3.392	0.896	0.341	0.255	0.116
		% of variance	67.833	17.929	6.817	5.103	2.319
		Cumulative %	67.833	85.762	92.579	97.681	100
	Extraction Sums of Squared loadings	Total	3.176	0.614			
		% of variance	63.518	12.286			
		Cumulative %	63.518	75.804			
	Rotation Sums of Squared Loadings	Total	2.202	1.588			
		% of variance	44.038	31.766			
		Cumulative %	44.038	75.804			
Rotated Factor Matrix*	Variables	Credibility	0.345	0.818			
		Capability	0.182	0.701			
		Relevance	0.657	0.526			
		Simplicity	0.883	0.308			
		Well-being	0.916	0.237			

Extraction method: principal axis factoring. Rotation method: Varimax with Kaiser normalization; *Rotation converged in 3 iterations.

Likewise, Table 5 outlines the breakdown of the eigenvalues and variances of five independent variables regarding the potential usability of subjective indicators in monitoring the 'CIVIC'program' in implementing the 'SDGs Future City Initiative of Tsukuba'. Eigenvalue of the three factors are greater than one, thus the greatest explanatory factors and the cumulative contribution rate of the squared loadings is 53.75%. Factor 1 is significantly attributed by 'action relevance', factor 2 is mostly characterised by 'action integrity', and factor 3 greatly features 'capacity building'. This suggests that the initiative is relevant to depict and implement the municipal SDGs (Factor 1). Similarly, incorporating stakeholders' participation and/or views can enhance the feasibility and local relevance of the action (Factor 2), while gaining resident's knowledge about SDGs also plays a vital role in fostering the implementation by stimulating their awareness (Factor 3). However, 'indicator use' and 'well-being' hardly contributed to characterise any factors, given their low and minus scores. This implies that using subjective indicators in monitoring the SDG program and measuring the resident's WB in achieving the municipal SDGs do not present any significance.

Table 5. Initial eigenvalues and squared loading score, with three factors extracted and most significant contributing variables for the potential usability of subjective indicators in assessment in a municipal SDG initiative from the resident perspective.

			Factor				
			1	2	3	4	5
Total Variance Explained	Initial Eigenvalues	Total	1.624	1.097	1.043	0.904	0.332
		% of variance	32.485	21.938	20.858	18.071	6.648
		Cumulative %	32.485	54.423	75.281	93.352	100
	Extraction Sums of Squared Loadings	Total	1.537	0.724	0.426		
		% of variance	30.744	14.481	8.523		
		Cumulative %	30.744	45.225	53.748		
	Rotation Sums of Squared Loadings	Total	1.211	0.886	0.591		
		% of variance	24.21	17.727	11.811		
		Cumulative %	24.21	41.937	53.748		
Rotated Factor Matrix*	Variables	Action Relevance	0.996	0.084	-0.01		
		Action Integrity	0.415	0.891	-0.175		
		Use of Indicator	-0.049	0.256	0.007		
		Capacity Building	0.086	-0.133	0.7		
		Well-being	0.194	-0.056	-0.265		

Extraction method: principal axis factoring. Rotation method: Varimax with Kaiser normalization; *Rotation converged in 5 iterations.

Accordingly, this study analysed the empirical information concerning the current and potential usability of the subjective indicator in three differentiated methods and derived major remarks for a further discussion.

6. Discussion

In this section, this study discusses and consequently presents the major determinants and obstacles of using subjective indicators in the two municipal sustainability practices in accordance with the policymaker and resident perspectives.

6.1. The current usability of subjective indicators in assessing public policy

In assessing public policies of the 'Regional Empowerment for Japan's Growth of Tsukuba', the findings highlight that the subjective indicators cover a wide range of (subjective) WB that the residents perceive as the outcomes of the related policies, such as feelings of enjoyment, perceived city liveability, satisfaction with public services and facilities, work-life-balance, and the community attachment (see Table 1). In addition, the municipal administration has stably employed these indicators, except that measuring community activity satisfaction, to assess policy performances over the three years. The policymakers acknowledge that the subjective indicators are credible to deliver sufficient policy assessment outcomes as they intend. Similarly, the residents recognise those indicators are selected relevant to corresponding policy targets. While also recognising that those indicators intelligibly describe the scope and present sequence of the outcome values over time.

In contrast, this study confirms several constraints in practice. There is a gap between the policy outcomes that residents enjoy in their livelihood and that policymakers intend to improve by implementing public policy, although the most subjective indicator scores show the increase. Similarly, the policymakers recognise that utilising the resident's perception is an appropriate method to measure policy targets, which represent the resident's WB, while the resident's view opposes. In fact, the policymakers acknowledge that fulfilling those gaps remains a great practical challenge. In addition, this study found that several policy outcomes might not have a direct positive impact on improving the quality of the residents' livelihood. Although those are high priority to implementing the 'Regional Empowerment for Japan's Growth of Tsukuba'. To overcome the challenges, resident participation in the assessment from an early stage can mitigate the tensions, as citizen participation helps unveil local problems and deliver added values that contribute to increasing the efficacy of public policies (Garau and Pavan, 2018; Hong et al., 2019).

Overall, this study regards the current usability of the subjective indicators assessing the 'Regional Empowerment for Japan's Growth of Tsukuba' as high. WB measurements often face challenges concerning validity and reliability, given that it takes into account not only the statistical procedure in the indicator construction, but much broader issues (Arcagni et al., 2021). Nevertheless, subjective

indicators play a particular role that allows for reflecting (subjective) inputs from local actors into assessment, which helps ensure the local relevance of the indicator system (Graymore, 2014).

6.2. The potential usability of subjective indicators in monitoring municipal SDGs

The results suggest that the policy makers' perspective acknowledges that using subjective indicators is practically appropriate to implementing municipal SDGs. On the contrary, the residents' perspective recognises that using subjective indicators is not necessary in monitoring and implementing the municipal SDG initiative, and aiming to increase resident's WB alone does not significantly contribute to achieving the municipal SDGs. This implies that the residents may understand SDGs as a political agenda rather than what they experience and/or recognise in their livelihood, although SDGs, especially for cities, evidently cover a number of elements that consist of WB, such as public health, active lifestyle, and green space (Mapar et al., 2020; Szaboova et al., 2021). Moreover, the vast majority of the questionnaire respondents did not have prior knowledge of SDGs. It suggests that gaining residents' knowledge of SDGs leads to a better understanding of the goals and the initiative, thus can facilitate the implementation of a municipal SDG initiative. Otherwise, developing an established initiative plan can be a basis for a feasible implementation of a municipal SDG initiative, given that an apparent initiative view and goals in the given context is depicted in a way that resonates with the ambition of the global SDGs.

  Accordingly, using subjective indicators play a limited role in monitoring the implementation of the 'SDGs Future City Initiative of Tsukuba'. Instead, other factors are found to be a catalyst for a feasible implementation of the initiative.

7. Conclusion

This study acknowledges that the current usability of the subjective indicators employed in assessing the 'Regional Empowerment for Japan's Growth of Tsukuba' is regarded high in light of the coverage of various facets of the WB, the credibility as an assessment tool, and the policy relevance. However, the contrasting view on WB recognised by the residents and policymakers appears as a constraint of its practical use. Meanwhile, the potential usability of subjective indicators in monitoring the 'CIVIC program' is fairly limited, particularly because such indicators play merely a guiding role in the initiative. To a feasible implementation of municipal SDGs, developing an established initiative/action plan and gaining the stakeholders' (in a broader sense) knowledge are alternative key factors over using subjective indicators.

Meanwhile, this study addresses several limitations. First, the data from the semi-structured interview and the questionnaire relied on a relatively small sample size, and the survey participants would have a positive bias to the survey subjects. Hence, the latent factors identified in both analyses could differ in the case that a study selects the larger sample groups from a more random demographic group. Second, research of subjective indicators in other municipalities should provide different results, thus insights

into its usability in practice, given that selecting subjective indicators and how WB is recognised in a municipal sustainable development and prioritized in public policy are fairly context-dependent. Accordingly, further study that overcomes those limitations will provide additional insights and contribution to the development of this study field and practice of indicator-based assessment of sustainable development, including SDGs.

Diverse factors recognised in operationalizing sustainable development in municipalities have an impact on constructing the residents' WB (Mapar et al., 2020; Szaboova et al., 2021). Similarly, WB is not only articulated in Goal 3, but underlies across all goals (Allen et al., 2017). Objective indicators, which often overlooked measuring intangible targets such as WB in sustainable development have been employed in numerous cases of sustainability assessment (Kajikawa, 2008; Moran et al., 2008; Warhurst, 2002). In this regard, incorporating indicators that specifically measure individual and collective WB into a 'conventional' indicator system is a key to comprehensive sustainability assessment. In particular, the use in a municipal-level practice helps address local needs, values, and priorities in the assessment outcomes. Therefore, this assists in guiding public policy and initiatives to a better pathway toward sustainable municipal development.

Declaration of Conflict of Interest: The author declares no conflict of interest is involved in this study.

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Appendix 1. A matrix of cooccurrence of sub-codes derived from the textual data, examining the usability of subjective indicators in in assessing policies in the Regional Empowerment for Japan's Growth of Tsukuba.

Code System	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
(A)Credibility¥Accurate measurement of targets	0	19	21	18	10	17	15	13	7	2	15	13	6	13	11	11	7	15	20	13	21	4	19	7	3	4	17
(B)Credibility¥Enhancing policy output	19	0	19	15	6	13	12	11	7	3	12	9	7	9	9	12	8	12	17	17	15	0	7	0	0	0	8
(C)Credibility¥Informing policy outcome	21	19	0	17	12	16	16	14	0	0	16	13	10	14	12	15	3	14	19	10	18	0	10	0	0	0	11
(D)Credibility¥ Policy validation	18	15	17	0	5	13	10	9	9	4	10	12	7	7	13	12	10	12	17	17	17	4	12	7	3	4	10
(E)Credibility¥Methodology Solidity	10	6	12	5	0	6	6	4	3	0	6	7	2	7	12	8	0	2	3	2	13	5	11	11	5	5	7
(F)Relevance¥Capturing issues of concern (major policy goal)	17	13	16	13	6	0	10	8	7	2	10	11	7	10	15	12	10	11	16	16	17	5	15	12	5	4	11
(G)Relevance¥Capturing issues of concern (individual policy targets)	15	12	16	10	6	10	0	8	0	0	10	8	5	8	9	11	0	6	9	5	12	0	5	0	0	0	6

(H)Relevance¥Aimed at targeted audience	13	11	14	9	4	8	8	0	3	0	8	5	3	5	6	8	3	6	13	12	10	0	3	0	0	0	4
(I)Relevance¥Resonance with local context	7	7	0	9	3	7	0	3	0	7	0	9	7	2	14	11	12	10	14	18	14	11	17	18	10	9	12
(J)Relevance¥Selecting appropriate indicators to policy targets and goals	2	3	0	4	0	2	0	0	7	0	0	3	2	0	5	4	7	5	10	13	5	4	8	7	3	4	5
(K)Relevance¥Relation between policy targets and major policy goal	15	12	16	10	6	10	10	8	0	0	0	8	4	8	9	10	0	6	9	5	12	0	5	0	0	0	6
(L)Data Reliability¥Rigor of data value	13	9	13	12	7	11	8	5	9	3	8	0	5	8	14	10	11	10	15	17	17	7	13	14	6	5	8
(M)Data Reliability¥Sensitivity to time series	6	7	10	7	2	7	5	3	7	2	4	5	0	0	6	9	8	7	12	14	8	0	0	0	0	0	0
(N)Data Reliability¥Comparability with other entities	13	9	14	7	7	10	8	5	2	0	8	8	0	0	10	0	0	4	4	0	13	6	16	13	5	4	12
(O)Data Reliability¥Complementarity with quantitative data	11	9	12	13	12	15	9	6	14	5	9	14	6	10	0	11	12	11	14	18	21	10	16	17	9	8	11

(P)Data Reliability¥Representing latent factors	11	12	15	12	8	12	11	8	11	4	10	10	9	0	11	0	12	12	17	19	13	0	0	0	0	0	0
(Q)Flexibility¥Sensitivity to social change	7	8	3	10	0	10	0	3	12	7	0	11	8	0	12	12	0	10	15	18	12	8	16	16	9	8	9
(R)Flexibility¥Revising indicator descriptions and targets	15	12	14	12	2	11	6	6	10	5	6	10	7	4	11	12	10	0	15	17	15	5	11	8	4	5	8
(S)Flexibility¥Involving multiple stakeholders' view in the measurement	20	17	19	17	3	16	9	13	14	10	9	15	12	4	14	17	15	15	0	22	20	8	13	9	8	9	11
(T)Flexibility¥Allowing bottom-up feedback	13	17	10	17	2	16	5	12	18	13	5	17	14	0	18	19	18	17	22	0	21	12	16	15	11	12	12
(U)Flexibility¥Capturing complexity	21	15	18	17	13	17	12	10	14	5	12	17	8	13	21	13	12	15	20	21	0	10	21	17	9	8	17
(V)Well-Being¥Enhancement	4	0	0	4	5	5	0	0	11	4	0	7	0	6	10	0	8	5	8	12	10	0	16	17	9	8	11
(W)Well-Being¥Resident perception	19	7	10	12	11	15	5	3	17	8	5	13	0	16	16	0	16	11	13	16	21	16	0	23	15	14	20
(X)Well-Being¥Policy maker intention	7	0	0	7	11	12	0	0	18	7	0	14	0	13	17	0	16	8	9	15	17	17	23	0	16	15	18
(Y)Well-Being¥Generation as policy outcome	3	0	0	3	5	5	0	0	10	3	0	6	0	5	9	0	9	4	8	11	9	9	15	16	0	7	10

(Z)Well-Being¥Relation to policytargets and goals	4	0	0	4	5	4	0	0	9	4	0	5	0	4	8	0	8	5	9	12	8	8	14	15	7	0	9
(AA)Well-Being¥Captured by indicators	17	8	11	10	7	11	6	4	12	5	6	8	0	12	11	0	9	8	11	12	17	11	20	18	10	9	0

Appendix 2. A matrix of cooccurrence of sub-codes derived from the textual data, examining the potential usability of subjective indicators in assessing the CIVIC program.

Code System	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
(A)Use of indicators¥Subjective indicators	0	7	9	9	9	0	7	8	5	9	10	0	10	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(B)Use of indicators¥Objective indicators	7	0	8	8	8	0	6	7	5	9	9	0	10	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(C)Use of indicators¥Time frame	9	8	0	10	10	0	8	9	7	11	11	0	12	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(D)Use of indicators¥Existing indicators	9	8	10	0	10	0	8	8	4	8	6	0	7	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(E)Use of indicators¥Selecting appropriate	9	8	10	10	0	6	24	21	17	26	24	5	25	15	18	11	15	18	9	5	15	8	7	5	8	11	13	0	0	0	0	0	6

indicators to action goals																																		
(F)Use of indicators¥Referring to international SDG indicators in monitoring the municipal action plan	0	0	0	0	6	0	7	7	5	7	7	5	10	0	4	5	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(G)Action Relevance and Integrity¥Envisioning municipal SDG goal	7	6	8	8	24	7	0	21	17	29	28	6	23	18	20	14	17	19	11	11	7	14	11	10	12	14	15	11	8	8	6	9	13	
(H)Action Relevance and Integrity¥Creating a relevant action plan	8	7	9	8	21	7	21	0	14	23	21	6	22	13	14	7	13	14	7	2	12	5	4	2	5	8	10	0	0	0	0	0	3	

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(I)Action Relevance and Integrity¥Creating concrete action programs	5	5	7	4	17	5	17	14	0	19	17	4	18	9	14	7	12	14	6	2	12	5	4	2	5	8	10	0	0	0	0	0	3
(J)Action Relevance and Integrity¥Identifying local challenges related to SDG agenda	9	9	11	8	26	7	29	23	19	0	31	6	24	19	22	16	17	21	11	11	17	14	11	10	12	14	15	15	12	12	10	13	13
(K)Action Relevance and Integrity¥Interpreting SDGs resonating with the local context	10	9	11	6	24	7	28	21	17	31	0	6	24	18	24	15	16	20	8	10	16	13	10	9	11	13	14	15	12	13	10	13	13
(L)Action Relevance and	0	0	0	0	5	5	6	6	4	6	6	0	9	0	3	4	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Indicator																																	
Integrity¥Resonating SDG targets with the comprehensive local policy																																	
(M)Action Relevance and Integrity¥Resonating SDG goals with the comprehensive local policy	10	10	12	7	25	10	23	22	18	24	24	9	0	10	10	9	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(N)Action Relevance and Integrity¥Implementing policy and actions aiming at SDGs	6	6	8	5	15	0	18	13	9	19	18	0	10	0	18	8	15	14	8	9	15	12	9	8	10	12	13	15	12	13	10	13	12
(O)Multi-stakeholder Governance¥Cooperation with	0	0	0	0	18	4	20	14	14	22	24	3	10	18	0	18	22	22	16	16	21	19	16	15	20	19	19	15	12	13	10	13	22

other departments of the municipal administration																																	
(P)Multi-stakeholder Governance¥Existence of cross-cutting decision making	0	0	0	0	11	5	14	7	7	16	15	4	9	8	18	0	17	17	9	9	15	12	9	8	10	12	13	12	9	9	7	10	11
(Q)Multi-stakeholder Governance¥Need of expertise or specialized know-how	0	0	0	0	15	0	17	13	12	17	16	0	0	15	22	7	0	22	26	16	22	29	16	15	17	19	20	13	8	9	8	11	17
(R)Multi-stakeholder Governance¥Existence of the core actor	0	0	0	0	18	4	19	14	14	21	20	3	10	4	22	27	22	0	16	15	21	18	15	14	16	18	19	1	6	7	6	9	16
(S)Multi-stakeholder	0	0	0	0	9	0	11	7	6	11	8	0	0	8	16	9	16	16	0	10	16	13	30	9	10	13	14	0	0	0	0	0	8

Governance¥Action management through different administrative layers																																	
(T)Inclusive Development¥Stakeholders diversity	0	0	0	0	5	0	11	2	2	11	10	0	0	9	16	9	16	15	10	0	16	13	10	9	11	13	14	15	2	2	0	13	12
(U)Inclusive Development¥Collaboration between the municipal administration and stakeholders	0	0	0	0	15	0	17	12	12	17	16	0	0	15	21	15	22	21	16	16	0	19	16	15	17	19	20	20	15	16	15	18	17
(V)Inclusive Development¥Securing places to implement action	0	0	0	0	8	0	14	5	5	14	13	0	0	12	19	12	19	18	13	13	19	0	13	12	14	16	17	18	15	15	13	16	15
(W)Inclusive Development¥Long term engagement	0	0	0	0	7	0	11	4	4	11	10	0	0	9	16	9	16	15	10	10	16	13	0	9	11	13	14	15	2	2	0	13	12

(X)Inclusive Development¥Initiatives from stakeholders	0	0	0	0	5	0	10	2	2	10	9	0	0	8	15	8	15	14	9	9	15	12	9	0	10	12	13	14	11	11	9	12	11
(Y)Inclusive Development¥horizontal interaction or exchange among stakeholders	0	0	0	0	8	0	12	5	5	12	11	0	0	10	20	10	17	16	0	11	17	14	11	10	0	14	15	17	14	15	12	15	14
(Z)Inclusive Development¥Role of individual participants	0	0	0	0	11	0	14	8	8	14	13	0	0	12	19	12	19	18	13	13	19	16	13	12	14	0	17	18	15	15	13	16	15
(AA)Inclusive Development¥Role of organisational participants	0	0	0	0	13	0	15	10	10	15	14	0	0	13	19	13	20	19	14	14	20	17	14	13	15	17	0	18	13	14	13	16	15
(AB)Capacity building¥Gaining basic knowledge of SDGs	0	0	0	0	0	0	11	0	0	15	15	0	0	15	15	12	13	11	0	15	20	18	15	14	17	18	18	0	19	20	17	20	19

(AC)Capacity building¥Introducing learning programs	0	0	0	0	0	0	8	0	0	12	12	0	0	12	12	9	8	6	0	12	15	15	12	11	14	15	13	19	0	17	14	17	16
(AD)Capacity building¥Variation of learning programs	0	0	0	0	0	0	8	0	0	12	13	0	0	13	13	9	9	7	0	12	16	15	12	11	15	15	14	20	17	0	15	18	17
(AE)Capacity building¥Availability of experts for the learning programs	0	0	0	0	0	0	6	0	0	10	10	0	0	10	10	7	8	6	0	10	15	13	10	9	12	13	13	17	14	15	0	15	14
(AF)Capacity building¥Understanding of the complexity of SDGs	0	0	0	0	0	0	9	0	0	13	13	0	0	13	13	10	11	9	0	13	18	16	13	12	15	16	16	20	17	18	15	0	17
(AG)Capacity building¥Voluntary learning	0	0	0	0	6	0	13	3	3	13	13	0	0	12	22	11	17	16	8	12	17	15	12	11	14	15	15	19	16	17	14	17	0

Appendix

Authorship of the articles

Article Number	Article Information	Relative importance of contribution	Quality of publication medium	Status	Weighting Factor
1	Hatakeyama. T. (2018). "Sustainable development indicators: Conceptual frameworks of comparative indicators sets for local administrations in Japan". *Sustainable Development*, 26 (6), 683-690. DOI: 10.1002/sd.1738.	Single authorship	International, peer-reviewed journal; H-index: 58	Published	1.0
2	Hatakeyama, T. (2021). "The significance of measuring well-being in assessing local sustainable development: An examination of distinctive indicator systems". *Journal of Sustainable Development*, 14(3), 58-77. DOI:10.5539/jsd.v14n3p58	Single authorship	International, peer-reviewed journal; H-index: 33	Published	1.0
3	Hatakeyama, T. (2022 under review). "Subjective Indicators of Well-being and Municipal Sustainable Development: A Case Study of Tsukuba, Japan". *Sustainability: Science, Practice and Policy*	Single authorship	International, peer-reviewed journal; H-index: 20	Submitted	1.0

I avouch that all information given in this appendix is true in each instance and overall.