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Reimagining Sustainable Development and Economic Performance Indicators: A Human-Centric Maslow–Bossel Blueprint

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Abstract: Reflecting the shift from purely quantitative economic growth to broader socio-environmental sustainability, this study proposes a framework for assessing sustainable development (SD) by integrating Maslow's hierarchy of needs with Bossel's classification system. As economic development increasingly emphasizes sustainability, numerous organizations and agencies, including the United Nations, have developed indicators to measure sustainable progress. However, subjective dimensions of SD, grounded in individual values and needs, remain underexplored. This study operationalizes Maslow's "pyramid of needs" alongside Bossel's system to establish an "SD pyramid", distinguishing dimensions and indicators that capture social, economic, and environmental complexity. By mapping human needs onto the Sustainable Development Goals (SDGs), this study contributes to delineating (i) the research areas uncovered (or partly covered) with relevant indicators, (ii) a significant lack or partial shortage of pertinent information, and (iii) a combination of a few basic indicators summarizing the necessary information into a unique measure of SD. The outcomes offer a foundation for a quali-quantitative assessment of SD, enhancing the monitoring tools focusing on subjective and contextual needs.

Keywords: sustainable development; performance indicators; sustainability metrics; Maslow's hierarchy; Bossel's classification; economic sustainability; socio-environmental complexity; policy targets; SDGs

1. Introduction

Over recent decades, the concept of sustainable development (SD) (Shi et al. 2019; Vardopoulos and Karytsas 2019) has acquired considerable relevance within the debate

of the economic growth and competitiveness of national and regional production systems, becoming a crucial issue in societies grounded in the principles of justice and equity (Guo et al. 2022; Kiseľáková et al. 2019). To this end, the environmental component plays an essential role in eliminating, or, at least, containing, the negative externalities of socioeconomic dynamics on environment quality and ecosystem services (Paprotny 2021; Kapsalis et al. 2019). While the concept of SD mainly focuses on ecological issues (Hariram et al. 2023), especially regarding the management of natural resources and biodiversity (e.g., Zorpas 2014), the notion of SD embraces multiple dimensions of well-being (Cortesi et al. 2022; Vardopoulos et al. 2024a) and territorial justice (Demeterova et al. 2020; Nickayin et al. 2023), which extend to the economic, environmental, and social frameworks of a particular place, community, or production system (Sarvajayakesavalu 2015; Lehtonen 2004).

This notion transcends a purely economic prosperity model strictly associated with monetary indicators like Gross Domestic Product (GDP) growth and capital accumulation (Alaimo and Maggino 2020; Fritz and Koch 2014). The intrinsic development of a given location in non-economic terms is also a measure of economic progress (Lyytimäki et al. 2020; North 1955) and should further incorporate qualitative dimensions, enhancing the social, cultural, and moral well-being of residents (and visitors/tourists) to optimize the quality of life (Li et al. 2020; Wiesli et al. 2021). Several scholars argue that economic growth and environmental sustainability are often seen as competing goals, especially when technological progress or substitution abilities in capital usage are limited (Klaassen and Opschoor 1991; Tsangaris et al. 2024).

Nevertheless, the transition to SD remains essential, underscoring the joint significance of SD's three pillars, namely environment, society, and economy, as they collectively foster synergy and cooperation among different knowledge sectors (Purvis et al. 2019; Jovanović et al. 2023). Studies examining the inter-relations between the economic, social, political, and environmental aspects of SD consistently reveal (explicitly or implicitly) that the Sustainable Development Goals (SDGs) are interdependent and should be pursued in an integrated manner (van Zanten and van Tulder 2021; Fonseca et al. 2020). Increasingly, empirical research scrutinizes whether SDGs operate synergistically or present trade-offs in practice (Luca Salvati and Carlucci 2014; Fonseca et al. 2020).

Sustainable economic growth has been described as an oxymoron within the context of finite resources (El Chami 2021; Callenbach 2014). Economic growth, therefore, should ideally coexist with environmental sustainability, where the reduced exploitation rate of natural resources and lower consumption levels—achieved through "sustainability" policies and practices—may ultimately curb economic growth (Zhang et al. 2022; Hariram et al. 2023). Conversely, initiatives that stimulate economic growth can potentially hinder SD, at least from a classical standpoint (Galindo-Martín et al. 2020; Yin 2019). Development pathways are, thus, linked to improving life quality, regarded as a qualitative precondition for well-being that transcends the boundaries of economic systems (Mouratidis 2021; Cibulka and Giljum 2020).

From an SD perspective, "well-being" can be understood as a specific state of human existence shaped by subjective perceptions, actual environmental conditions, and the interrelationships among all material and immaterial elements within a system (Brulé 2022; Cortesi et al. 2022). To identify connections between well-being and the socioeconomic context, an operational approach is required, one that quantifies and contextualizes the available data (Nagy-Pénzes et al. 2020; Silva et al. 2021).

The ongoing development of a comprehensive, comparable, and unified dashboard of Sustainable Development Indicators (SDIs) aligned with the SDGs has resulted in two major United Nations (UN) initiatives. These initiatives are strong candidates for providing a coherent representation of SD through shared frameworks, relevant conceptual approaches, documented methodologies, and, thus, suitable indicators. Initially, in 2007, the UN, with support from independent scholars, proposed an operational framework that included 50 primary and 46 secondary indicators for monitoring SD. Less than a decade

later, in 2015, the institution introduced more advanced approaches, outlining multiple indicators that gauge the progress toward achieving the 17 SDGs (Klopp and Petretta 2017; Giangrande et al. 2019).

While numerous academic contributions have developed indicator systems that evaluate SD from an objective perspective (Loizia et al. 2021; Sateriano et al. 2024; Vardopoulos et al. 2021), subjective analyses—particularly those reflecting individual perceptions—remain underexplored and offer fertile ground for new interdisciplinary insights. Building on this premise, the present study examines the intrinsic relationship between SDGs and SDIs, illustrating the potential for subjective classifications of "needs" to enrich and refine SDIs within the broader framework of the UN's SDGs. Specifically, the operational use of Maslow's hierarchy of needs (Maslow 1943) alongside an original classification system by Bossel (1999) is proposed to collectively define the relevant indicators and condense them into simplified, non-redundant measures of SD, with particular emphasis on their connection with human needs. As previous studies have only partially addressed this connection, this analysis seeks to advance both theoretical and practical understanding, aiming to contribute—preliminarily and conceptually—to a more subjective and individualized evaluation of SD.

This work emphasizes the notion of "subjective needs" as the foundation of any SD path rooted in individual values, aspirations, and necessities. The two approaches—Maslow and Bossel, as elaborated later in this contribution—facilitate the creation of an "SD pyramid", which differentiates specific analytical dimensions and relevant indicators. By presenting examples of indicator classification based on Maslow's and Bossel's frameworks and qualitative criteria, this system enables an exploration of the contributions of various social, economic, and environmental complexities to SD from an individual perspective. The intensity and spatial direction of changes over time in the selected indicators, as well as their placement within this pyramid, are particularly relevant aspects warranting continuous evaluation (Shaker 2015; Wilson et al. 2007). Moreover, this innovative approach strengthens and adds scientific depth to more traditional, objective methodologies, establishing a conceptual linkage between an objective and aggregated (quantitative indicator-based) evaluation of SD and a more subjective and disaggregated perspective grounded in individual needs and qualitative indicators (Fotopoulou et al. 2022; Luan et al. 2017).

This article is organized into five standard sections, which are further divided into thematic sub-sections. Section 2 presents a state-of-the-art examination, addressing the operational concept of SD and the ongoing academic discourse surrounding the SDGs and SDIs (Sections 2.1 and 2.2). Section 3 outlines the theoretical and practical aspects of the proposed approach, including the rationale behind specific examples and applications to global UN indicator dashboards (Section 3.1). This is followed by separate introductions to Maslow's theory (Section 3.2), its natural linkages with the concept of SD (Section 3.3), potential applications to the UN's SDGs (Section 3.4), and Bossel's operational framework for indicator classification (Section 3.5). Section 4 provides specific examples and practical results arising from integrating these conceptual frameworks with the UN's SDGs. Section 5 concludes the article with an extended discussion on the originality and innovation of this approach, its anticipated limitations, and pathways for future research focused on integrating objective and subjective dimensions in assessing SD progress.

2. State-of-the-Art Examination

The concept of SD, as defined in the seminal Bruntland report (1987), has evolved significantly, incorporating various socioeconomic, environmental, and policy dimensions that aim to foster a balanced global society (Díaz-López et al. 2021). The fundamental pillars—society, environment, and economy—form the backbone of SD and are reflected in the 17 goals outlined by the United Nations in its 2030 Agenda. In response to the increasing complexity of SD, a wide array of indicator systems has been developed, providing both granular and composite measures of SD progress (Schoenaker et al. 2015; Huan et al. 2021).

For example, the Human Development Index (HDI) encapsulates a multi-faceted view of human well-being by measuring life expectancy, education, and per capita gross national income (Ghislandi et al. 2019). The HDI, with its simplicity, has inspired derivative indicators like the Inequality-adjusted HDI (IHDI), the Gender Development Index (GDI), and the Gender Inequality Index (GII) (Land 2015). These adaptations account for disparities, such as gender inequality and poverty, which affect SD paths (Nilsson and Larsen 2020). Additionally, the Multidimensional Poverty Index (MPI) captures the deprivations that individuals face across several dimensions, further highlighting the need for holistic SD metrics (Alkire and Sumner 2013; Alkire et al. 2022). In the environmental sphere, notable indicators include the Ecological Footprint (EF), which assesses the area required to sustain resource consumption, and the Environmental Performance Index (EPI), which focuses on ecosystem health and human environmental safety (Strezov et al. 2017). Indicators like the City Development Index (CDI) and the City Prosperity Index (CPI) extend SD evaluations to urban settings, addressing the specific sustainability challenges of metropolitan areas (Wong 2015).

As these frameworks expand, the development of composite indexes—such as the Measure of Economic Welfare (MEW) and the Genuine Progress Indicator (GPI)—has gained prominence, allowing for more comprehensive comparisons across regions and socioeconomic contexts (Zambon et al. 2017). These indexes, while valuable, often necessitate adaptation to the specific socioeconomic and environmental contexts of the areas under evaluation, thus limiting their generalizability on a global scale.

2.1. Operational Notion of "Sustainable Development" and Key Indicators

Indicators have evolved to represent a broad spectrum of sustainability measures (Hueting and Reijnders 2004). Systems such as the HDI emphasize human development, while indexes like the Environmental Performance Index (EPI) focus on environmental outcomes (Liu et al. 2017). Collectively, they allow for inter-country and inter-regional comparisons of sustainability progress (Liu et al. 2017). Despite their advantages, (these) indicators often fall short of capturing the intricate interactions across SD dimensions, such as the synergy or trade-offs between economic growth and environmental sustainability (Bali Swain and Yang-Wallentin 2020).

Recent studies advocate for a multidimensional approach to SD evaluation, employing tools such as the AHP (Analytic Hierarchy Process) (Vardopoulos et al. 2021) and fuzzy logic (Vardopoulos 2019) to capture the inter-relations among the SD pillars: social, environmental, and economic. These tools offer a sophisticated means of assessing SD across scales, highlighting the contextual relevance of indicators to local and regional sustainability efforts (Carlsen and Bruggemann 2022).

Generally speaking, these indicators have been adopted for specific socioeconomic (or territorial) conditions, e.g., at a sectoral or national level, thus preventing a possible generalization to broader contexts.

2.2. Maslow's Pyramid and Sustainable Development Indicators

Maslow's hierarchy of needs has been adapted in SD studies to frame human well-being as a central pillar of sustainability (Yawson et al. 2009). Traditionally structured as a pyramid progressing from basic physiological needs to self-actualization, Maslow's framework serves as a lens for evaluating human development within sustainable practices.

In recent years, Maslow's hierarchy has been applied to SD frameworks as a tool for categorizing indicators within human-centered SD. The progression of needs—from physiological to self-actualization—has been particularly useful in evaluating human-centric SD goals, such as poverty reduction (SDG 1) and well-being (SDG 3). At higher levels, Maslow's hierarchy aids in assessing the goals related to social stability and governance, such as SDG 16 (peace, justice, and strong institutions). This hierarchical structure effectively aligns with SD, facilitating the inclusion of qualitative dimensions such as social well-being and individual self-fulfillment within sustainability evaluations.

As SD indicators evolve, a systems-oriented approach enables the integration of both objective and subjective measures. Bossel's systems-thinking framework, which emphasizes interconnected societal and environmental systems, offers a holistic model for designing SD indicators. By classifying indicators according to criteria like adaptability, security, and compatibility, Bossel's framework facilitates the development of SD indicators that reflect complex social–environmental interactions. This approach provides an operational basis for assessing SD comprehensively, acknowledging both individual and systemic factors that contribute to sustainability (Bossel 1999).

3. Methodology

Identifying effective methods to measure and compare SD across regions and countries is essential for jointly assessing the environmental, social, and economic performances of specific locations, both historically and in the present, and for designing impactful interventions for the future (Rosati and Faria 2019). Over the years, significant initiatives have been led by the Organization for Economic Cooperation and Development (OECD), the World Bank, and the United Nations Commission. A key milestone was the Rio+20 Conference, where a comprehensive framework for SD was established, addressing specific environmental concerns and socioeconomic topics such as poverty, sustainable cities, employment, education, and inequality (Panagiotopoulos et al. 2022; Díaz-López et al. 2021). In 2015, the United Nations formalized 17 SDGs within "Agenda 2030", aiming to establish a global SD trajectory through a collective global effort by 2030 (Mindrinos and Panagiotopoulos 2023; Koundouri et al. 2024) (Figure 1).

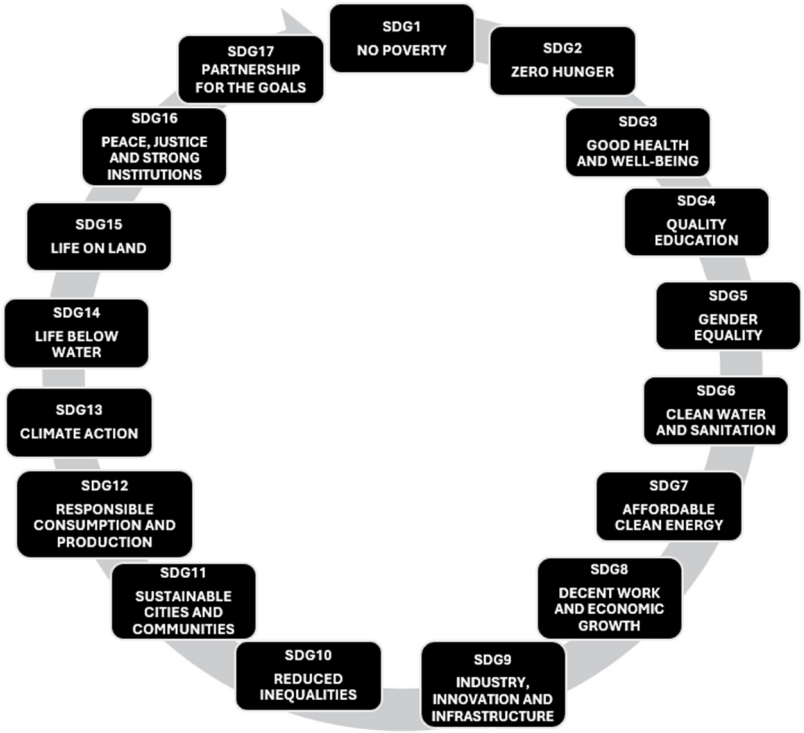

Figure 1. United Nations Agenda 2030: the 17 Sustainable Development Goals.

3.1. Definition and Measurement of Sustainable Development Goals (Agenda 2030)

The SDGs are intended to reinforce and achieve the targets set by leaders from 189 UN countries in the Millennium Development Agenda of 2000 (Vandemoortele 2011; Suresh and Johnson 2015). Agenda 2000 established eight Millennium Development Goals (MDGs) to be achieved by 2015, focusing on critical issues such as reducing extreme poverty and hunger, combating violence against women, and safeguarding health and the environment (Sachs 2012; Lomazzi et al. 2014) (Figure 2). The development and

implementation of the SDGs occurred in a markedly different context than that of the MDGs. Unlike the MDGs, which were formulated by a group of experts at the UN headquarters (Unterhalter and Dorward 2013), the SDGs emerged from extensive consultations within individual countries and through face-to-face meetings (Caballero 2019). Technically speaking, the MDGs consisted of 8 goals, 21 targets, and 63 individual indicators (Jacob 2017), with none explicitly addressing human rights. In contrast, the SDGs include seven explicit targets for people with disabilities, six for individuals in vulnerable contexts, and two goals addressing discrimination, among others (Dada et al. 2023). Additionally, while the MDGs primarily focused on developing countries funded by developed nations (J. Sachs and McArthur 2005), the SDGs apply universally to both developed and developing countries, jointly committed to achieving the established goals (Ali et al. 2023). The SDGs center on five core themes, known as the "five P's": people, planet, prosperity, peace, and partnership (Dulume 2019; Tremblay et al. 2020). These themes encapsulate the key issues of the 2030 UN Development Agenda and are associated with multiple SDGs to foster a healthier and more prosperous world (Costa et al. 2021; Fonseca et al. 2020) (Figure 3).

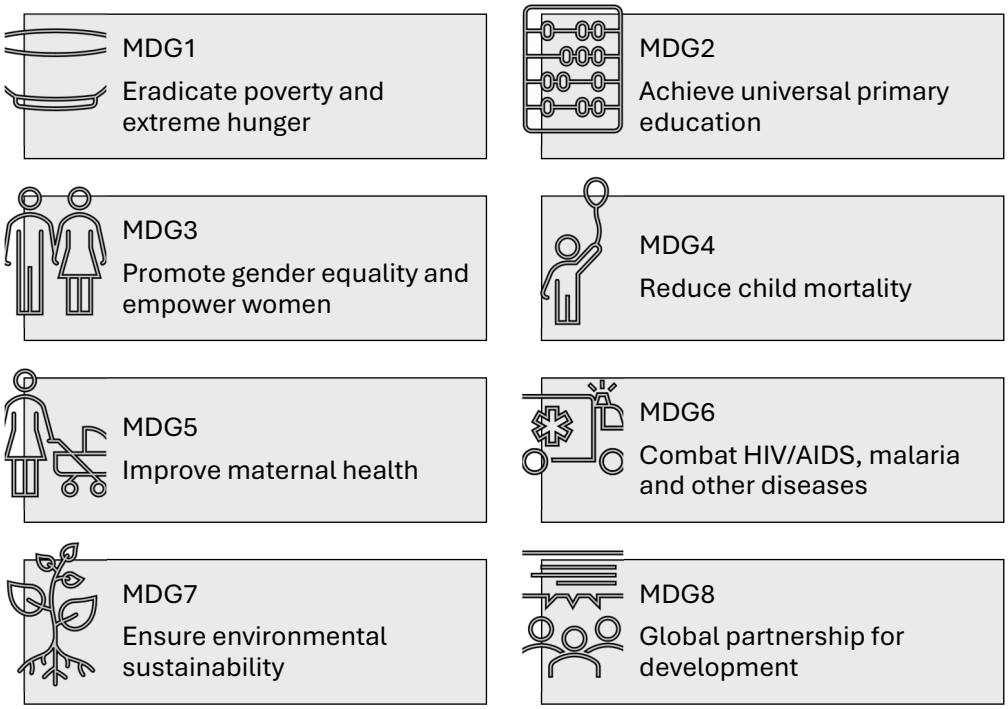

Figure 2. A graphical representation of the MDGs of United Nations Agenda 2000.

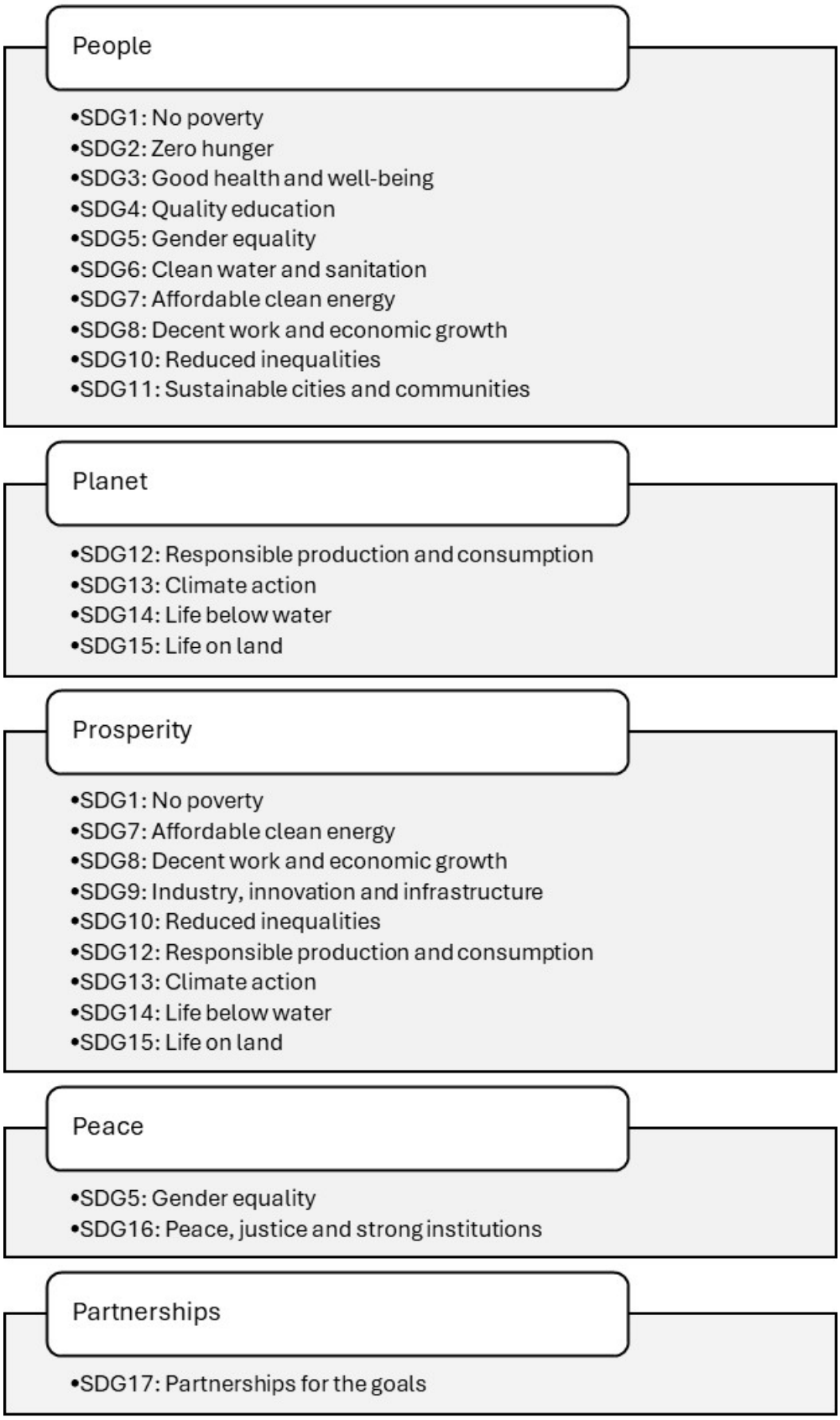

Figure 3. The five keys ('P') of SD and the explicit linkage with SDGs.

The first 'P', people, emphasizes the importance of individuals within societies and is connected to key issues like social inclusion and reducing disparities, such as those based on gender. This dimension encompasses targets related to eradicating poverty and hunger (SDG1 and SDG2) (Pérez-Peña et al. 2021; Galabada 2022), achieving better health outcomes (SDG3) (Mikuła et al. 2024), providing quality education (SDG4) (Khan et al. 2022; Eliades et al. 2022), and improving access to clean water and sanitation (SDG6) (Martínez-Córdoba et al. 2020; Tsani et al. 2020). The goals aim to enhance well-being and equality for all, irrespective of social class, gender, nationality, or living conditions (SDG5 and SDG10) (Horton 2015; Fonseca et al. 2020). Additionally, an improved living environment implies access to decent work (SDG8) (Bieszk-Stolorz and Dmytrów 2023; Kavouras et al. 2022), clean energy (SDG7) (Tsangas et al. 2023; Vardopoulos et al. 2023a), and the development of sustainable cities and communities (SDG11) (Stefanou and Miitoula 2024; Vardopoulos et al. 2023b).

The second 'P', planet, focuses on protecting natural environments and enacting measures to address climate change. This includes policies aimed at promoting responsible consumption and production (SDG12) (Zorpas 2020b; Kritikou et al. 2021), climate action (SDG13) (Thapa et al. 2023; Sardianou et al. 2023), the conservation of oceans and marine resources (SDG14) (Xue et al. 2023; Gourgiotis et al. 2024), and efforts to combat land degradation (SDG15) (Maialetti et al. 2024a, 2024, 2024c; Halbac-Cotoara-Zamfir et al. 2020).

The third 'P', prosperity, is intrinsically linked to economic growth (SDG8) (Nickayin et al. 2022; Vardopoulos et al. 2024d) and includes social and environmental sustainability (Ali et al. 2023; Sateriano et al. 2024), ensuring benefits for all individuals without discrimination (SDG10) (Cojocaru et al. 2022; Mațcu-Zaharia et al. 2024). This objective also focuses on providing clean energy (SDG7) (Barone et al. 2021; Vardopoulos et al. 2023a) and promoting industrial innovation and infrastructure development (SDG9) (Vardopoulos et al. 2020, 2024c), aiming to preserve and create wealth for future generations (Abrudan et al. 2021).

The fourth 'P', peace, seeks to establish a global society free from conflict and violence through principles of universal justice and by promoting strong and accountable institutions (SDG16) (Baranyi et al. 2021). Achieving peace involves eradicating or at least mitigating violence against women and children, as well as all forms of violence (SDG5) (García-Moreno and Amin 2016). A peaceful society is fundamental for social cohesion and SD (Fry and Elliott 2017).

Effective progress toward the 17 goals requires collaborative efforts among governments, academia, and institutions to advance SD, as highlighted in the fifth 'P', partnership (SDG17) (Cruz 2023; Bulmer and Yáñez-Araque 2023).

As pointed out in the previous section, the academic literature discussing clear and universally adopted approaches to continuously monitor progress towards the achievement of the SDGs remains limited despite the critical importance of this issue (Ricciolini et al. 2022). Quantitative analyses are also constrained by the extensive scope of the topic, which involves multiple levels and scales of application—national, regional, and global—and by the lack of a standardized lexicon, complicating comparisons across different studies and implementations (Bishop et al. 2016). The need for a new framework to address these challenges, along with technical support using novel tools for conducting ex ante, in itinere, and ex post evaluations of progress toward sustainability across the economic, social, and environmental pillars, has been emphasized (Gusmão Caiado et al. 2018; Scrase and Sheate 2002). Additionally, any mis-specification or omission of variables in an assessment model may lead to biased results and evaluations (Aksoy and Bayram Arlı 2020; Kubiszewski et al. 2022).

Within this framework, support systems play a crucial role in providing essential information, enhancing decision-making processes, and selecting (and measuring) activities that genuinely advance SD pathways (Schmidt-Traub et al. 2017). Numerous studies have been conducted by institutions across various countries (Firoiu et al. 2019). Among them, it has been argued that the current indicators related to SDG10 fall short in quantifying the progress in reducing within-country disparities (Winkler and Satterthwaite 2017), while

a comprehensive analysis of the commonly used indicators highlights both advantages and critical issues (Barbier and Burgess 2019). In Canada, sustainability progress was evaluated using an approach grounded in the "no one left behind" principle, excluding non-relevant targets, focusing on the available data, and employing proxies to address missing information (McArthur and Rasmussen 2019). Meanwhile, Australia's progress toward SD has been monitored through selected SDGs (Allen et al. 2020). To highlight differences in evaluation methods for tracking target achievement, a comparison of three distinct approaches used by the Sustainable Development Solutions Network (SDSN), the Economic and Social Commission for Asia and the Pacific (UNESCAP), and the Organization for Economic Cooperation and Development (OECD) has also been conducted (Bidarbakhtnia 2020).

An alternative set of indicators, partly inspired by the aforementioned approaches, includes composite indexes of SD (Zhou et al. 2012). These indexes are often used to quantify complex, multidimensional concepts—such as economic, social, and environmental aspects of sustainability—and facilitate straightforward, intuitive comparisons across different regions and territories (Bonnet et al. 2021). When well designed and managed, they enable the handling of vast amounts of data from individual indicators with minimal loss of informational detail (Delli Paoli and Addeo 2019). For instance, a composite index based on SDG9 was developed to monitor industrialization progress across 128 global economies from 2000 to 2016, addressing key sustainability aspects such as social inclusiveness and environmental impact (Kynčlová et al. 2020). Similarly, a set of composite indexes has been applied to evaluate sustainable city initiatives in Spain, with outcomes influenced by the compensability levels in the aggregation of individual indicators (Lo-Iacono-Ferreira et al. 2022). Given the breadth of SDG targets and indicators, aggregation plays a crucial role in evaluating and monitoring sustainability progress. However, the selection and operationalization of indicators continue to present significant challenges. Experts emphasize the need for a clear conceptual framework and specific references to ensure indicator relevance and effectiveness, underscoring the enduring value of foundational guidance provided in earlier work (Hák et al. 2016; Lancker and Nijkamp 2000).

3.2. Maslow's Theory and the Operational Use of "Pyramid" Tools

Maslow developed a theory on human needs satisfaction, proposing that while each person is unique, all individuals share fundamental needs whose fulfillment enables the attainment of well-being (Maslow 1943). Maslow's framework categorizes human needs within a hierarchical structure, indicating their progressive priority (Mathes 1981). He represented this hierarchy as a pyramid, where the base comprises the most instinctive and essential needs, such as physiological needs for food, health, and safety (Bridgman et al. 2019). The higher levels encompass "emotional" and "social affirmation" needs, reflecting an existential state that surpasses basic requirements (Montag et al. 2020). Although the concept of "need" is often associated with the individual or subjective domain, well-being is ultimately achieved within a broader socio-environmental context (Kenrick et al. 2010).

Each individual needs to adjust their expectations and behaviors to align with the social norms, resource availability, and environmental constraints of their community (Forsyth 2013; Vasseur et al. 2022). This adjustment reflects a stratified expression of social (Perry et al. 2021), demographic (Luca Salvati et al. 2019), cultural (Cardenas 2011), institutional/political (Doukas et al. 2023), economic (Yamin et al. 2019), and ecological (Everard et al. 2016) factors that may restrict personal desires within the "carrying capacity" of the socio-environmental system (Cardenas 2011; Yamin et al. 2019). Within this complex system, an optimal balance can be achieved by incorporating specific knowledge of landscapes, environments, ecosystems, and ecological conditions into the socioeconomic evaluation of "needs", alongside implementing collective, rather than individualistic, strategies aimed at enhancing well-being (van den Bosch and Sang 2017). Human needs should be realistically achievable within a framework of "fair", "sustainable", and, above all, "long-lasting" well-being (Khraisha 2020). Consequently, individual well-being is inherently

influenced by physical and social environments, and achieving the stages of Maslow's hierarchy (progressively represented in succession) is only feasible within an adequately "holistically healthy" territorial context (Repetti 1987).

To this end, the objective quality of a given territory should be connected with the subjective aspects of well-being (Costanza et al. 2007). Several indexes have been developed to express both the territorial dimension, in terms of a territory's health or degradation, and the social and individual dimensions of well-being (Tomaselli et al. 2021; Perchinunno et al. 2020). The environmental–territorial dimension can be analyzed through objective indexes, such as the Environmentally Sensitive Areas Index (ESAI) (Luca Salvati et al. 2015), or thematic indexes that measure factors like the prevalence of illegal buildings (Luca Salvati et al. 2013), the demographic makeup of unauthorized real estate units (Vinci et al. 2023), the rate and spatial patterns of urbanization in areas under landscape protection, the erosion of rural and semi-natural spaces due to urban sprawl (Vardopoulos et al. 2024b), the decline of rural areas due to land abandonment (Doukas et al. 2022), the presence of green spaces in urban settings (Bianconi et al. 2018), and the severity of air (Kougea and Koundouri 2011), water (Frontistis 2021), and soil pollution (Zorpas 2020a). Indicators for these dimensions are often derived from sample surveys, official statistics on aspects of daily life, or interviews with key informants representing a cross-section of society, conducted across various scales from aggregated (national and regional) to disaggregated (local communities, municipalities, neighborhoods, and individuals) levels.

3.3. The Evolution of Maslow's "Theory of Needs" and Sustainable Development

The Brundtland Report's definition of SD encourages individuals to meet their own needs without compromising the needs of future generations (Kuhlman and Farrington 2010). Within this framework, constraints such as the current state of technology, environmental conditions, and social structures play crucial roles in shaping sustainable economic growth (Lans Bovenberg and Smulders 1995; Rojas et al. 2023). Ensuring that essential needs are met across populations remains a guiding principle for government policies aimed at equitable resource distribution, supporting both affluent and disadvantaged nations in reducing poverty (Udo and Jansson 2009; King 1998). Additionally, wealthier countries are encouraged to adopt eco-friendly policies and invest in innovations that promote the sustainable use of resources, addressing climate change while prioritizing intergenerational equity (Ahmad and Wu 2022).

Maslow's 1943 "Theory of Needs" provides a socio-political model useful for analyzing the SDGs both qualitatively and quantitatively. Traditionally, Maslow's model categorizes human needs in a hierarchical structure, starting from basic physiological needs and ascending through safety, love and belonging, esteem, and, ultimately, self-actualization (Mathes 1981). The theory was expanded in 1971 to include three additional levels: cognitive needs, aesthetic needs, and self-transcendence (Koltko-Rivera 2006; Kenrick et al. 2010). However, contemporary critiques highlight that Maslow's original model is somewhat static and does not fully account for the dynamic needs of modern societies, particularly with the emergence of new social, environmental, and digital dimensions that shape human well-being (Taneva 2023; Harvard 2010).

In response to these critiques, a refined classification has been proposed that integrates digital advancements and social shifts into Maslow's hierarchy. For instance, digital connectivity is now recognized as a fundamental component of both safety and belonging (Benson and Dundis 2003), with the potential to influence esteem needs as well. In the digital age, access to information and online networks supports individual security (digital safety and data privacy), fulfills social needs (online social connections and communities), and even contributes to self-esteem (social media engagement and virtual recognition) (Cao et al. 2013; Ghatak and Singh 2019). This expanded model reflects the increasingly interconnected nature of digital needs within Maslow's hierarchy, illustrating how digital

access influences well-being on multiple levels and aligning with the SDGs that focus on equality and inclusive access (Yildiz 2021).

Accordingly, the following updated classification addresses both traditional and contemporary needs, integrating digital aspects that are central to 21st-century lifestyles (Griskevicius et al. 2006) (Figure 4):

- Physical and psychological needs: this base level encompasses nutrition, healthcare, sleep quality, and physical activity, forming the foundation of individual health and well-being.
- Safety needs: beyond physical security, financial stability, and health, modern safety needs now include digital safety—encompassing data privacy, cybersecurity, and the safe use of digital technologies—which are critical in today's digital society.
- Need for belonging: social connections, family, and romantic relationships are joined by digital communities and social media, which fulfill a growing aspect of individuals' need to connect with others in virtual spaces.
- Need for esteem: traditional esteem needs related to achievement and recognition now include online validation, such as social media engagement, which has become an influential factor in self-perception and confidence.
- Cognitive needs: knowledge, curiosity, and understanding remain key, but modern information access, such as digital learning platforms and online resources, is crucial in meeting these needs today.
- Aesthetic needs: the appreciation of beauty, enhanced by digital access to art and nature through virtual media, aligns with contemporary expressions of aesthetic fulfillment.
- Self-actualization needs: creativity, personal fulfillment, and meaning continue to define this level, with the internet providing expanded avenues for creative exploration, career development, and lifelong learning.
- Self-transcendence needs: the pinnacle of the pyramid, focusing on self-transcendence, is enriched by the digital era, allowing individuals to form global connections and engage in collaborative projects that transcend personal identity and contribute to broader societal goals, aligning with the SDGs related to global partnerships and social inclusion.

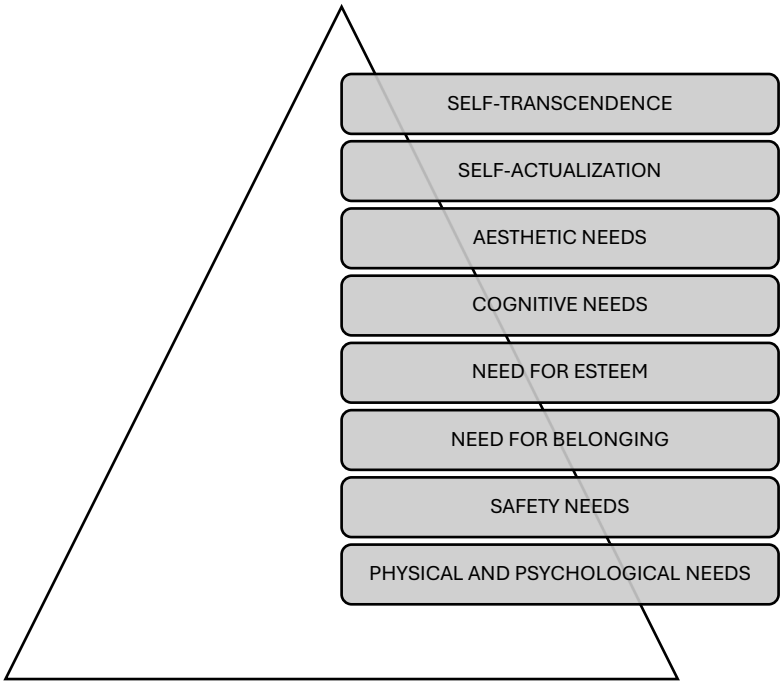

Figure 4. The pyramidal hierarchy of needs as envisaged in Maslow's theory.

3.4. The Intimate Linkage Between Maslow's "Pyramid of Needs" and Agenda 2030 SDGs

The Brundtland report's definition of SD highlights the connection between Maslow's theory of human needs and the Agenda 2030 SDGs (Cheshmehzangi and Zou 2024; Zhai et al. 2023). Fundamental needs like nutrition are critical to achieving the SDGs, impacting healthcare, education, and women's empowerment (Wells et al. 2020). Addressing nutrition helps break poverty cycles, as sound policies improve community well-being in both developed and developing countries (Aliyu et al. 2021). In wealthier nations, dietary choices consider environmental impacts, aiding climate mitigation (Ribeiro Hoffmann et al. 2024). Sustainable fishing practices also align with the "life below water" SDG, supporting water quality and sanitation improvements (Atkinson and Cools 2017). Nutrition interlinks with multiple SDGs: sustainable diets affect climate change (Koliaki et al. 2024), biodiversity (Belgacem et al. 2021), and water quality (Tompa et al. 2022); quality nutrition enhances health and productivity (Alt et al. 2022; Grimani et al. 2019); and proper diets improve well-being and women's empowerment, leading to reduced poverty and inequalities (Huang et al. 2023).

Education, a cognitive need from Maslow's later model, is a fundamental right and a driver of economic development, healthcare, and social empowerment ("Education" 1964). It reduces inequalities (SDG10) (Cojocaru et al. 2022) and supports poverty reduction (SDG1). Education also impacts health (SDG3) (Fonseca et al. 2024), as knowledge helps manage diseases and fosters strong institutions (SDG16) for peace and reduced unemployment (SDG8) (Mehmetaj and Xhindi 2022).

3.5. Bossel's Theory to Design Sustainable Development Indicators

Operationally, SD is defined as a developmental pathway that fully aligns with sustainability criteria (Wojtkowiak and Cyplik 2020). The concept is inherently dynamic, as it must adapt to social transformations in culture, technology, and economic expectations while often reflecting an unpredictable evolutionary process (Wibeck et al. 2019; Vardopoulos et al. 2023b). Evaluating progress, along with its actual or anticipated impacts, requires a comprehensive set of indicators that describe the state of the environments and systems shaping society (Ramos 2019; Pappas et al. 2021). The pursuit of effective SD indicators has been ongoing across various levels of social organization, from local communities to the global scale (Salvati et al. 2008; Vardopoulos et al. 2018). Within scientific discourse, scholars contend that no single indicator can capture the full scope of SD; instead, multiple indicators are necessary to encompass all relevant dimensions in any specific application (Luca Salvati and Zitti 2009; Ferrara et al. 2012).

Historically, indicator selection was conducted by specialists in fields such as economics, ecology, sociology, and engineering (Inglezakis and Zorpas 2014; Pissourios 2013). This approach often resulted in discipline-biased indicators that emphasized field-specific aspects while overlooking essential broader features (Heckman et al. 1998). To address these limitations, Bossel (1999) proposed a robust research framework, defining SD as an evolutionary process of interacting systems within a shared environment, where each system self-organizes to meet the unique challenges of its surroundings. The intricate network of interacting systems can be recursively decomposed into individual systems, each influencing its own trajectory and that of others (Hjorth and Bagheri 2006; Ostrom 2009). The performance of each specific system, along with its interaction mechanisms with others, should be assessed using one or more indicators (Reed et al. 2005). The design of these indicators begins with identifying essential systems and subsystems, thereby establishing the structure and characteristics of an "ideal" system (Reed et al. 2005). Next, statistical methods are applied to aggregate and condense the selected indicators while preserving crucial information.

In this framework, the selected indicators are assumed to fully capture each system's fundamental interests according to six core criteria aligned with Bossel's framework and guided by Maslow's hierarchy of needs: (i) existence, (ii) effectiveness, (iii) freedom of action, (iv) safety, (v) adaptability, and (vi) psychological coexistence (for systems involving

human elements). Using these criteria, a comprehensive and minimal set of indicators has been developed to provide insights into all aspects of viability and sustainability (Table 1).

Table 1. A recursive scheme to design viable indicators of SD (own elaboration on Bossel (1999) and incorporating additional indication from Maslow's theory).

Basic Dimension	Viability of Affecting System	Contribution to Affected System
Existence	Is the system compatible with and can it exist in its particular environment?	Does the system contribute its part to the existence of the affected system?
Effectiveness	Is it effective and efficient?	Does it contribute to the efficient and effective operation of the total system?
Freedom of action	Does it have the necessary freedom to respond and react as needed?	Does it contribute to the freedom of action of the total system?
Security	Is it secure, safe, and stable?	Does it contribute to the security, safety, and Stability of the total system?
Adaptability	Can it adapt to new challenges?	Does it contribute to the flexibility and adaptability of the total system?
Coexistence	Is it compatible with interacting subsystems?	Does it contribute to the compatibility of the total system with its partner systems?
Psychological needs (for specific systems)	Is it compatible with psychological needs and culture?	Does it contribute to the psychological well-being of people?

The systems-oriented approach appears effective in defining a comprehensive set of indicators for SD, as it leverages existing datasets while minimizing the risk of overlooking essential aspects or overemphasizing minor ones (Reed et al. 2005). This approach is particularly valuable when evaluating sustainability under time and budget constraints. Generally, selecting supplementary indicators to validate existing ones is advisable, especially for large-scale projects, as it enables the development of relevant indicators for new or less-experienced practitioners (Bagheri and Hjorth 2007). The systems-oriented approach has significant potential to influence the selection and application of SD indicators across various domains, including technical, institutional, and public sectors (Barbier and Burgess 2017). This method provides an overarching framework and guidelines for designing a complete, reliable set of indicators, focusing data collection on essential information and, thus, facilitating the exchange of foundational knowledge and practical experiences among agencies and via digital platforms (Bradley Guy and Kibert 1998). Moreover, this approach enhances the capacity of the public, administrations, and businesses to accurately interpret and apply the selected SD indicators.

Overall, the systems-oriented approach has proven to be a valuable and systematic tool for selecting SDIs, improving the efficiency of sustainability assessments, and facilitating the practical application of indicators across various contexts (Pokorný and Palacká 2023). It provides a robust foundation for comparative approaches that encompass all essential aspects of SD (van Zanten and van Tulder 2021).

4. Results

As discussed in previous sections, SD fundamentally involves meeting the needs of both present and future generations (Kuhlman and Farrington 2010). To achieve this, these needs must be accurately identified and quantified using indicators or composite indexes (Mindrinos and Panagiotopoulos 2023; Inglezakis and Zorpas 2014). While prior work has often focused on organizations and institutions, sustainability originates at the individual level (Doukas and Vardopoulos 2023). Based on this foundational premise, sustainability in a rapidly changing world must advance in tandem with SD (Bossel 1999). Ongoing transformations in economic, social, and environmental spheres may challenge

the adaptability and resilience of the global system. Achieving the SDGs requires provisions across three primary areas—economy, society, and environment—and within six operational subsystems of human life, addressing the needs of individuals and society as a whole, from basic to secondary needs (J. D. Sachs et al. 2019).

Profiling SDIs According to Maslow's Pyramid and Bossel's Theory

The sustainability of the overall system depends on the functionality and viability of each of its subsystems. Maintaining this condition requires designing effective indicators that provide insights into each subsystem's contribution to the sustainability of the global system. Table 2 aligns the standard models of Bossel (1999), Maslow (1943), and the UN 2030 Agenda, operationally highlighting correspondences between fundamental human needs and SDGs. While these examples represent only a fraction of the many linkages among deeply interconnected processes, the connections reveal that they support a deeper understanding of the relationships among various aspects of SD and human needs—at physical, social, and psychological levels. They also illustrate the link between efforts to achieve SDGs and the effective fulfillment of both fundamental and higher human needs, individually and collectively.

Table 2. An exemplified classification of SDGs based on Bossel's and Maslow's operational schemes.

Bossel (1999)		**Maslow (1943)**	**2030 UN AGENDA**
HUMAN SYSTEM	Individual development	Physical and psychological needs Safety needs Cognitive needs Need for esteem Self-transcendence	SDG1: No poverty SDG2: Zero hunger SDG3: Good health and well being SDG4: Quality education SDG5: Gender equality SDG10: Reduced inequalities SDG12: Responsible production and consumption
	Social system		
	Government	Safety needs Need for esteem Self-transcendence	SDG16: Peace, justice and strong institutions SDG17: Partnerships for the goals
SUPPORTSYSTEM	Infrastructure	Physical and psychological needs Need for belonging Need for esteem Aesthetic needs	SDG9: Industry, innovation and infrastructure SDG11: Sustainable cities and communities
	Economic system	Physical and psychological needs Self-actualization	SDG8: Decent work and economic growth SDG9: Industry, innovation and infrastructure SDG11: Sustainable cities and communities
NATURAL SYSTEM	Resources and environment	Physical and psychological needs	SDG6: Clean water and sanitation SDG7: Affordable clean energy SDG13: Climate action SDG14: Life below water SDG15: Life on land

The first operational area, associated with the "human system", emphasizes the strong interconnection between the SDGs and fundamental human needs, aligning with the lower and middle tiers of Maslow's pyramid and broadly encompassing the dimensions of "individual development", "social systems", and "governance". In this context, physical and psychological needs, safety, self-esteem, and self-transcendence correlate closely with various SDGs, including poverty reduction (SDG1), hunger eradication (SDG2), and health promotion (SDG3). The "governance" dimension underscores the importance of societal stability in fulfilling these essential needs. Accordingly, safety and self-transcendence needs

are logically linked to SDGs that promote peace, justice, and strong institutions (SDG16), as well as global partnerships (SDG17).

The second area pertains to the support system, which includes "infrastructure" and the "economic system", recognizing that high-quality infrastructure meets not only physical needs but also social and psychological ones. Infrastructure addresses physical and psychological needs, belonging, esteem, and aesthetic requirements and aligns with SDGs focused on sustainable infrastructure (SDG9) and sustainable communities (SDG11). The economic system supports self-actualization by fostering economic growth, decent work (SDG8), welfare, and individual development.

The third area involves natural systems, being closely connected with "resources", the "environment", and "ecosystems", highlighting the critical role of a healthy environment in overall well-being. In this context, physical and psychological needs are intrinsically linked to SDGs that focus on sustainable resource management, including clean water (SDG6), affordable clean energy (SDG7), and environmental conservation (SDGs 13, 14, and 15).

Based on the key systematization in specific dimensions and the explicit linkage with the UN's SDGs, as reported in Table 2, a final effort was made in Table 3 to make more explicit and, thus, fully operational, Bossel and Maslow's scheme into statistical themes (dimensions) corresponding with defined indicators routinely derived from official statistics. In the case of the table, we considered a representative production of subjective indicators for a continental area (European Union) primarily based on a comparative, high-quality sampling design valid in all member countries and carried out under a representative sample of the residents interviewed, using a defined and stable questionnaire that investigates a vast number of self-perceived aspects of sustainable development and quality of life. The indicators proposed in the table were produced and released coherently every year, generally since the early 2000s, and covering Europe at a particularly refined scale (basically, macro-regional and/or regional level) over a sufficiently long time interval (generally since the early 2000s). While improvable in several directions—when they are made available from official statistics—the ensemble of subjective indicators illustrated in Table 3 may represent a particularly vast, stable, and robust set of variables, forming a composite evaluation of sustainable development, fully adhering to the principles of Bossel and Maslow and anchored on fully comparable, standardized, and reliable input information based on Eurostat EU-SILC, the European System of Statistics (both census and sampling frame) on income and living conditions. A coherent scrutiny of such indicators over both time and space may offer a particularly rich evaluation of sustainable development advancements in a vast set of territories, with different socioeconomic characteristics, in Europe, and provide an explicit indicators dashboard that can be updated regularly and with no effort from official statistics (Eurostat website). Finally, computation on such indicator dashboards may allow for the construction of one (or more) composite indexes of sustainable development using—likely for the first time in the academic literature—a fully subjective perspective *à la* Maslow–Bossel.

Table 3. An exemplified assessment of Bossel and Maslow's operational scheme (see Table 2) considering practical indicators derived from Eurostat official statistics covering the whole of Europe at the macro-regional and/or regional level over a sufficiently long time interval (generally since the early 2000s).

Bossel (1999)		Maslow (1943)	Theme	Indicators
HUMAN SYSTEM	Individual development	Physical and psychological needs Safety needs Cognitive needs Need for esteem Self-transcendence	Overall experience of life (life satisfaction and affects)	Overall life satisfaction by sex, age, and educational attainment Persons being happy in the last 4 weeks by sex, age, educational attainment, and frequency
	Social system		Social interactions (relations with people, activities for people, social support, and social cohesion)	Persons getting together with family and relatives or friends by income quintile, household composition, degree of urbanization, and frequency Persons having contact with family and relatives or friends by income quintile, household composition, degree of urbanization, and frequency Persons having someone to ask for help by sex, age, and educational attainment Persons having someone to discuss personal matters by sex, age, and educational attainment
	Government	Safety needs Need for esteem Self-transcendence	Physical safety Social interactions (relations with people, activities for people, social support, and social cohesion) Governance and basic rights	Police-recorded offenses by offense category Crime, violence, or vandalism in the area Trust in others by sex, age, and educational attainment Level of trust in institutions by sex, age, educational attainment, and domain Gender pay/employment gap Persons participating in formal/informal voluntary activities or active citizenship by income quintile, household composition, and degree of urbanization
SUPPORT SYSTEM	Infrastructure	Physical and psychological needs Need for belonging Need for esteem Aesthetic needs	Quantity of, quality of, and access to leisure Educational attainment, self-reported skills, lifelong learning, and opportunities for education Access to healthcare	Persons not participating in cultural or sport activities in the last 12 months by sex, age, educational attainment, activity type, and reasons Early leavers from education and training by sex and labor status Individuals' levels of digital skills Self-reported unmet needs for medical examination by sex, age, main reason declared, and educational attainment level
	Economic system	Physical and psychological needs Self-actualization	Economic security (wealth and debts)	Inability to face unexpected financial expenses Arrears (mortgage or rent, utility bills, or hire purchase) Labor transitions by employment status Participation rate in education and training
NATURAL SYSTEM	Resources and environment	Physical and psychological needs	Natural and living environment (pollution, landscape, and built environment)	Pollution, grime, or other environmental problems Noise from neighbors or from the street Satisfaction of landscape by sex, age, educational attainment, and domain

5. Discussion

While academic contributions have developed various indicator systems, primarily evaluating SD from an objective standpoint (Krank et al. 2013; Eustachio et al. 2019), the subjective analysis of SD advancements—particularly from an individualistic perspective—remains underexplored and potentially open to interdisciplinary contributions. Building on this premise, the present study examines the intrinsic relationship between SDGs and SDIs by offering selected examples of a subjective classification of "needs" (e.g., Maslow's pyramid of needs) to enrich and refine SDIs within the broader context of the UN's SDGs, in alignment with a logical classification framework such as Bossel's. Specifically, this study proposes an operational application of Maslow's "pyramid of needs" alongside Bossel's classification system to define relevant indicators and condense their information into simplified, non-redundant measures of SD, with a special emphasis on the connection between SD and human needs. This linkage, which has only been partially addressed in previous research (Fu et al. 2020; Mindrinos and Panagiotopoulos 2023; Yawson et al. 2009), is explored here in both theory and practice to contribute—preliminarily and conceptually—to a more subjective and individual evaluation of SD.

In practice, this work centers on the concept of "subjective needs", viewed as the foundation of any SD path rooted in individual values, aspirations, and necessities (Jolibert et al. 2014). The two approaches—Maslow's hierarchy and Bossel's framework—are mutually intertwined and operationally integrated to create an "SD pyramid", differentiating specific analytical dimensions and, where possible, relevant indicators (Van Opstal and Hugé 2013). By offering specific examples of indicator classification according to Maslow's and Bossel's frameworks and their qualitative criteria, this system facilitates an examination of how various social, economic, and environmental complexities contribute to SD from an individual perspective (Peet 2004; Eustachio et al. 2019). The intensity and spatial trajectory of changes in the selected indicators, along with their placement within the pyramid, represent key aspects warranting continuous assessment (van Niekerk 2020). Furthermore, this approach enriches traditional, objective methods, establishing a conceptual link between an objective, aggregated evaluation of SD (i.e., using quantitative indicators) and a more subjective, disaggregated perspective focused on individual needs and qualitative indicators (van Zanten and van Tulder 2021).

More specifically, integrating Maslow's and Bossel's frameworks into a unified classification system of SDGs and SDIs, approached from the perspective of "human needs" (i.e., a purely individualistic perspective), helps to identify (i) research areas that lack comprehensive SDIs, (ii) significant gaps or partial shortages in pertinent information, and (iii) a set of essential indicators that condense necessary information into unique measures of SD. The findings of this approach aim to strengthen a quali-quantitative assessment of the subjective dimension of SD and the underlying data necessary for such statistical monitoring and reporting.

Improvements in research design should, for instance, facilitate a targeted comparison across regions and countries, potentially delineating the socio-environmental distinctiveness of diverse territorial contexts, a foundation for understanding the intrinsic disparities in SD levels across territories. A notable aspect of our approach, however, lies in its capacity to address all facets of SD, including those typically challenging to examine from a subjective perspective. For instance, ecological quality—a crucial but often complex dimension of SD to assess (e.g., Maialetti et al. 2024a)—can be investigated subjectively alongside the interplay between specific socioeconomic attributes and quality of life. This approach enables a meaningful integration with a traditionally objective dimension of SD (i.e., the inherent characteristics of a given socioeconomic context) as well as a hybrid (objective–subjective) dimension, such as quality of life (Alaimo and Maggino 2020).

In this perspective, incorporating Maslow's theory emphasizes the essential role of the environment in achieving satisfactory levels of happiness, being closely tied to the fulfillment of basic human needs (Pimentel et al. 2024). Recognizing the existence and significance of this relationship in evaluating SD within a specific location allows for the con-

ceptualization of an "SD" function based on relevant socioeconomic characteristics and the associated quality of life (Przybyłowski et al. 2022; Wojewódzka-Wiewiórska et al. 2019). This approach offers a framework for addressing the genuine needs of individuals, thereby supporting the attainment of a satisfactory quality of life within a given territorial context and under specific socioeconomic constraints (Rojas et al. 2023). The integration of mixed quali-quantitative indicators of SD is, thus, central to this methodology. Additionally, subjective approaches that focus on individual perspectives on SD may enhance the informational value of quantitative indicators by highlighting the dimensions more effectively assessed through personal judgment and subjective evaluations rather than through conventional statistical measures (Burford et al. 2013).

From a practical standpoint, this approach holds particular value in cases where official statistics remain limited, incomplete, or insufficient for translating SDGs into fully quantitative SDIs at the desired spatial resolution and temporal scale for meaningful diachronic comparisons (Caudill et al. 2024). In both advanced and emerging economies, it is recognized that while official statistics are relatively harmonized globally—at least for a core set of indicators—there remains a need for enhancement and further consolidation to quantitatively capture the full scope of phenomena and processes outlined in the 17 UN SDGs (Campbell et al. 2020). A subjective approach can offer valuable supplementary insights, enabling the collection of information that may not be readily obtained from official statistics alone (Peet 2004).

From a theoretical standpoint, distinguishing between the human system, support system, and natural system through Maslow's framework enables a clearer understanding of the interactions between societal components and the environment (Maximova et al. 2023). Relevant measures for each of these subsystems could support the continuous monitoring of SD within a given location while also identifying future challenges, thus promoting a holistic approach to sustainability (Eustachio et al. 2019). As outlined in Section 4, the 17 SDGs can be mapped across Maslow's hierarchical levels of human needs (Fonseca et al. 2020). This mapping, as illustrated in Table 2, reveals that all of Maslow's identified needs are also addressed by the SDGs (Rojas et al. 2023). Among these, physiological needs are the most represented, being associated with at least 11 targets. Esteem and safety needs are each cited in four instances, while self-realization, aesthetic, and transcendental needs appear twice each. Self-actualization needs, however, are only referenced once.

The approach outlined herein, operationalized in Table 2, indicates that certain needs—particularly those related to spiritual and transcendental aspects—are nearly absent in the current classification. This gap may warrant a more in-depth analysis of motivational needs and their influence on sustainability, as understanding human motivations is essential for formulating effective policies (Bandhu et al. 2024). Furthermore, this observation underscores the value of applying a general framework, such as Maslow's pyramid of individual needs, to identify potential conceptual gaps in the SDGs and their related indicators, especially considering that the SDGs aim for a holistic definition of SD (Custodio et al. 2023). Future studies should reinforce the empirical basis for the theoretical approach proposed in this research. Validating this framework with real data and normative indicators would be a promising research direction, enhancing its relevance to the SD field. Operational models, involving comprehensive SD indicator dashboards derived from a UN SDGs perspective and demonstrating practical classification applications, would reduce the speculative nature of this proposal and facilitate empirical case studies.

Analyzing the interaction between human needs and their immediate environments reveals both individual and community dynamics (Stern 1993). This study is based on the premise that human development and environmental quality are deeply interconnected, influencing sustainability outcomes (Punit and Singh 2023). Recognizing specific strengths and challenges within a given area helps align human needs with ecological requirements, thus enhancing planning, development, and social policies (Hoffmann 2022). Human well-being fundamentally relies on a healthy environment, which is essential for personal growth and quality of life (Betley et al. 2023). Accessible green spaces, clean water, and

public services serve as foundational elements of collective welfare (Ramaswami 2020). Advancing this perspective calls for research exploring the relationship between quality of life and critical economic, social, and environmental indicators, with frameworks like Maslow's pyramid offering valuable insights. Simplifying SDG indicators into consolidated dashboards can facilitate effective monitoring and a balanced approach to local and global policy objectives, reflecting each region's unique needs (Horan 2020).

6. Conclusions

In pursuit of a more holistic and systematic approach to measuring SD from both objective and subjective perspectives, the "SD pyramid" proposed in this study offers a valuable framework for classifying indicators that comprehensively assess SD and highlight the interdependencies between individual human needs and broader SDGs. By mapping human needs onto the SDGs, this study demonstrates the intrinsic compatibility between fundamental human needs and SDIs. From a normative perspective, this interdisciplinary approach provides a fresh lens on SD by incorporating human needs on both individual and societal levels, which can be especially informative for decision makers at local and international levels, particularly in urban and environmental policy contexts. From a positive perspective, the proposed framework offers a detailed view of SD by linking it to the dimension of human needs as structured by Maslow's hierarchy and Bossel's classification system.

The findings underscore the critical role of human well-being as a cornerstone of SD, revealing that an effective sustainability strategy must accommodate various levels of human need while prioritizing ecological balance. Practical applications of this framework suggest pathways for policymakers to better address localized socio-environmental contexts and socioeconomic disparities. Additionally, by proposing a structured integration of objective and subjective indicators, this study advocates for a balanced approach to global sustainability metrics that can address the gaps in existing quantitative-only evaluations.

The proposed Maslow–Bossel framework can be effectively applied to real-world policies by guiding the design and evaluation of sustainable urban development programs. For instance, in urban resilience planning, the framework facilitates the alignment of human needs, such as safety and belonging, with the objectives of the SDGs. In practice, this approach can be employed to structure policies addressing affordable housing, public safety, and access to green spaces by integrating indicators that reflect both subjective well-being and objective environmental performance. For example, the framework can inform urban infrastructure projects by ensuring that the provision of clean water and sanitation (SDG 6), alongside sustainable cities and communities (SDG 11), also addresses the psychological and social needs of residents, such as their sense of security and community inclusion. This dual focus enhances the ability of policymakers to design interventions that are both practically viable and holistically aligned with sustainability principles. By embedding this integrative perspective into policy frameworks, stakeholders can ensure that development efforts are not only environmentally sustainable but also responsive to the nuanced needs of diverse populations.

To further operationalize the framework, policymakers could leverage its principles in real-world initiatives such as national sustainability strategies, regional urban planning policies, and global adaptation mechanisms like those recently discussed at COP29 in Baku, Azerbaijan. Specifically, aligning the Maslow–Bossel framework with the reporting requirements of, inter alia, the Nationally Determined Contributions and Biennial Transparency Reports could provide a structured method for tracking progress on adaptation and resilience. For example, incorporating subjective well-being indicators into adaptation strategies would enable a more inclusive approach that captures diverse socioeconomic contexts, particularly those of vulnerable populations, such as women and indigenous communities. Additionally, the proposed composite indicators could be utilized in participatory research settings to bridge the gap between global sustainability metrics and localized decision-making processes. By embedding these applications into

existing policy frameworks, the Maslow–Bossel framework has the potential to drive both practical and transformative changes in sustainable development initiatives at multiple governance levels.

Future research should focus on validating this framework with empirical data across different regions, aiming to refine the indicators and enhance the interpretive power of the proposed "SD pyramid". As SD continues to evolve, frameworks that recognize the interplay between individual needs and systemic sustainability goals will be essential to achieving comprehensive and equitable progress on a global scale.

Integrating a basic classification of human needs, as proposed by Maslow, with the complexities of the SDGs—and further contextualizing this through Bossel's approach—illustrates how sustainability objectives align with various levels of the hierarchy of needs, particularly from physiological safety to self-realization. Reorganizing and expanding the academic discourse on SDIs to include, or at least complement, a subjective and individual perspective represents a particularly relevant contribution of this study to sustainability science.

This study ultimately provides a valuable roadmap for policymakers, researchers, and stakeholders striving to harmonize economic growth, ecological responsibility, and social equity within SD initiatives.

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