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Evaluating Frameworks Used to Define and Structure Sustainability Indicators: A UNESCO-Based Perspective on Indicator Development

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ABSTRACT

This literature review examines the frameworks and methodological approaches developed by UNESCO and its affiliated researchers to define and organize sustainability indicators. As sustainability challenges grow more complex, the need for indicators that are both measurable and context-sensitive has become increasingly important. UNESCO has played a significant role in translating global sustainability objectives into practical implementation at the local level. Drawing on 19 publications from 2007 to 2025, this review traces the evolution of UNESCO's approaches to methodological development in sustainability indicators. It highlights major trends, ongoing debates, and gaps within the literature. The findings reveal a transition from standalone indicators toward more integrated, participatory, and SDG-aligned systems. Despite this progress, persistent challenges include balancing global comparability with local relevance, adequately capturing intangible cultural dimensions, and ensuring inclusive stakeholder engagement.

Keywords: *Unesco, Sustainability Indicators, Indicator Frameworks, Sustainable Development Goals, Participatory Governance, Adaptive Management.*

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1.0 Introduction

Sustainability indicators have become essential tools for measuring progress toward sustainable development. As environmental, social, and economic systems grow increasingly interconnected, robust frameworks for defining and structuring indicators are necessary to inform policy decisions and track changes over time (Verbruggen & Kuik, 2020). UNESCO occupies a distinctive position in the global sustainability landscape through its mandate encompassing education, science, culture, and communication. Global Geoparks, Biosphere Reserves, and World Heritage sites are part of its "living laboratories" network where sustainability principles can be tested and demonstrated (Sugiura, Khan, & Rachmawati, 2017). With the establishment of the Sustainable Development Goals (SDGs) in 2015, indicator frameworks become more important than just

academic research.

Few efforts have been made towards the creation of methods for sustainability indicators definition, and Kay's paper (1991) provides a good review of what has been achieved so far. The comprehensive evaluation of drawbacks of simple approaches to the study of ecological features has been undertaken (Kay and Schneider 1994), and the application of indicators has been also studied (Ruitenbeek 1991). One of the strategies applied has been the appraisal of environment friendly resources (Parikh and Ghosh 1991, United Nations 1992, 1993, 1994). No matter how these resources and their impacts are evaluated, it is clear that there should be a set of certain variables to be considered in designing the indicators.

Now UNESCO is trying to set up the ESSD indicators in south and southeast Asian regions. This is taking place after consultation and cooperation with all UN organizations which are really working for the regional growth. A cooperation meeting is organized by a UN organization, ESCAP (Economic and Social Commission for Asia and the Pacific), which operates for Asia and the Pacific region with its headquarters located in Bangkok. ESCAP set up ICED (Inter-agency Committee on Environment and Development) in 1990.

The ICED has set up a working group, to design a framework of ESSD indicators. These indicators are meant to provide a structured way to evaluate how well development initiatives address environmental challenges. In order to establish ESSD indicators, UNESCO began evaluating the actual actions conducted by UN agencies in Indonesia (Harger and Soeriaatmadja 1991). The agencies were asked to propose general ESSD indicators after reviewing their positions on Agenda 21, to create a standardized set of measures that could be used to evaluate outcomes in terms of environmental sustainability, social equity, and development effectiveness. These indicators had to cover every aspect of activities carried out in developing nations and be generally valid. Due to the difficulty of the task and the inability to eliminate overlap, the procedure is far from complete. UNESCO would greatly appreciate any suggestions for improving the final list of ESSD indicators.

Sustainability indicators are measurable variables providing information about the state, trend, or performance of systems relevant to sustainable development. The Scientific Committee on Problems of the Environment (UNESCO Digital Library, 2002–2010) defines them as "reliable tools for decision making" requiring careful structuring for validity and relevance. The Pressure-State-Impact-Response (PSIR) framework (Verbruggen & Kuik, 2020) distinguishes between:

- Pressure indicators: Human activities affecting sustainability.
- State indicators: Current conditions of systems.
- Impact indicators: Effects of pressures on system states.
- Response indicators: Policy and management actions.

Indicators Enable:

- Monitoring and Assessment: Tracking progress toward goals.
- Decision Support: Evidence for policy formulation.
- Communication: Translating complex concepts for stakeholders.

2.0 Research Objectives

- To analyze UNESCO’s sustainability indicator frameworks with emphasis on their conceptual foundations and methodological design.
- To trace the development of these frameworks over time, highlighting major shifts, trends, and debates.
- To evaluate their effectiveness across diverse contexts, identifying recurring patterns as well as existing gaps and limitations.

3.0 Scope and Research Methodology

This evaluation looks at 19 publications (2002–2025) from the given research summary, including institutional publications from UNESCO, peer-reviewed articles, and policy guidelines. The CRAAP test was used to assess the sources, and thematic, chronological, and methodological analyses were conducted.

4.0 Discussion & Analysis

Sustainability models for UN Sustainable Development Goals

In this regard, the 2030 Agenda that incorporates SDGs and 169 global goals is aimed at a more

holistic view to the world which should be a better and sustainable one. Head of States, Head of Government, and High Representatives from 193 countries were engaged in the development of SDGs in September 2015 (UN Nations, 2015).

When we discuss the different stages of policy-making in general as refer to global targets by 2030, as stated in Agenda Framework 2016 by UNESCO. From that timeline, there will be an increase in a number of methodologies, guidelines, assessments, and studies on this subject reference.

The United Nations' provided Sustainable Development Goals (SDGs), a global framework for achieving sustainable development by 2030 and defines as, "unified and inseparable, universally developed and applicable, measurements and levels of development and respecting national policies and significances by taking into account several national realities." Goals are clear, ambitious, and worldwide, and each government has the authority to establish its own limits and policies based on its unique situation. (2020, UN Nations).

Sustainable development comprises of three sustainability domains (environmental, social and economic), but several alternatives exist. Some propose that the three components are merely not really connected and not relevant and balanced. (Knight K, 2014), others suggest that they are interdependent (Elkington, J, 1999) or that they are very much connected to each other (Ostrom, E., 2009). These models usually link economic development to the environment with different areas of interest and collaborations, and some are referred to as conflict models. These differing perspectives are indicative and multifaceted, addressing intricate.

Consequently, the tripartite definition of sustainable development brought a complicated idea that aimed to give the public domain and policy discourse a more thorough representation of the complexity of issues and possible solutions.

Development and Application of Sustainability Indicators with Local Communities

In order to make our society sustainable, we need instruments that can track and assess the advancement of various objectives, such as social, environmental, and economic. It has been stated that recently, the implementation of "sustainability indicators" have become crucial components of both national and international policy. However, Community participation in sustainability data collection is unlikely without direct, localized benefits. King and Freebairn (2003). Many local communities then generally concur that they should be involved and participate at all levels of indicator development and collection. (Corbiere-Nicollier et al., 2003, for example). To put it briefly, the statement recommends that indicators be relevant to the local community and that methods be used to gather, develop, and apply data in the most efficient and active way possible in order to encourage active participation from the local community. Additionally, these indicators must change as conditions and circumstances do. (Tinning and Carruthers, 2003).

Sustainability indicators are going ahead for not only measuring sustainable progress within local context. They can set up a process that helps to increase the overall understanding of social, environmental and physical issues in the community na s helps to facilitate and guide the policy makers to take step forward.

Methodological Paradigms

The literature related to development of sustainability indicators falls into major approaches. (Bell and Morse, 2001)

1. Expert led / Top Down
2. Community base / Bottom up

The first approach deals with the scientific assumptions and research findings to explicitly measure indicators quantitatively, it is very common in many fields and it more deals with quantifying the complexities of systems that are very dynamic in nature but lake some perceptions.

The second approach is based on a bottom-up strategy that addresses community involvement from the bottom up (Bell and Morse, 2001). This type of research gives more emphasis on the importance of local scenarios establishes linkage and prioritizes goals related to sustainable development. The best solution is to adopt both approaches to carry out research in quantitative and qualitative manners and the combination is diverse and deals with local circumstances with an expert approach as well. Then it becomes an integrated learning process for every stakeholder.

Table 01

Examples of methodological frameworks for developing and applying sustainability indicators at a local scale

Selected Examples	Brief Description
Bottom-Up	
Soft Systems Analysis (Checkland, 1981)	Builds on systems thinking and experiential learning to develop indicators as part of a participatory learning process to enhance sustainability with stakeholders.
Sustainable Livelihoods Analysis (Scoones, 1998)	Develops indicators of livelihood sustainability that can monitor changes in natural, physical, human, social and financial capital based on entitlements theory.
Classification Hierarchy Framework (Bellows, 1995)	Identifies indicators by incrementally increasing the resolution of the system component being assessed, e.g., element = soil; property = productivity; descriptor = soil fertility; indicator = % organic matter
Classification Hierarchy Framework (Bellows, 1995)	Develops indicators to represent four conditions for a sustainable society to identify sustainability problems, visions and strategies.
The Natural Step (TNS, 2004)	Develops indicators to represent four conditions for a sustainable society to identify sustainability problems, visions and strategies.
Top-Down	
Panarchy Theory and Adaptive Management (Gunderson and Holling, 2002)	Based on a model that assesses how ecosystems respond to disturbance, the Panarchy framework suggests that key indicators fall into one of three categories: wealth, connectivity, diversity. Wealthy, connected and simple systems are most vulnerable to disturbances.
Orientation Theory (Bossel, 2001)	Develops indicators to represent system "orientators" (existence, effectiveness, freedom of action, security, adaptability, coexistence and psychological needs) to assess system viability and performance.
Pressure-State-Response (PSR, DSR and DPSIR) (OECD, 1993)	Identifies environmental indicators based on human pressures on the environment, the environmental states this leads to and societal responses to change for a series of environmental themes. Later versions replaced pressure with driving forces (which can be both positive and negative, unlike pressures which are negative) (DSR) and included environmental impacts (DPSIR).
Framework for Evaluating Sustainable Land Management (Dumanski etal., 1991)	A systematic procedure for developing indicators and thresholds of sustainability to maintain environmental, economic and social opportunities with present and future generations while maintaining and enhancing the quality of the land.
Well-being Assessment (Prescott-Allen, 2001)	Uses four indices to measure human and ecosystem well-being: a human well-being index, an ecosystem well-being index, a combined ecosystem and human well-being index, and a fourth index quantifying the impact of improvements in human well-being on ecosystem health.
Thematic Indicator Development (UNCSD, 2001)	Identifies indicators in each of the following sectors or themes: environmental, economic, social and institutional, often subdividing these into policy issues.

Using adaptive learning to design and apply sustainability indicators in partnership with local communities

Building a sustainable society requires tools that can track progress and motivate action across social, environmental, and economic objectives. Because of this, selecting and analysing "sustainability indicators" has become essential to both domestic and global policy in recent years. Sustainability indicators are now the subject of so much scholarly and policy literature that Kingetal (2000) refers to it as “an industry on its own” (p. 631). According to Carruthers and Tinning (2003), for instance, there are increasing concerns that indicators are not useful and that "millions of dollars and much time... has been wasted in preparing national, state, and local indicator reports that gather dust on the shelf." (Booher and Innes, 1999). This problem can be partially attributed to the scale of indicators because most of the present-day indicators are built around the notion of sustainability that is understood from the top-down perspective using the data on the national level (Riley, 2001). This problem might lead to overlooking important aspects of sustainable development that matter locally and ignoring the problems that emerge at the local level. For instance, one of the most widely used Environmental Sustainability Index (Global Leaders, 2005), which assess a nation’s progress toward sustainable development. National ranking in the index is assessed through a number of criteria that have been shortlisted by some of American scholars according to their knowledge of sustainability. This is against Local Agenda 21 – local participation in any process of planning and encouragement of the legislators to allow the locals to determine the notion of sustainability.

The next issue is that communities are less likely to engage in monitoring the indicators of sustainability unless the monitoring process leads to actions that provide immediate benefits to the community (Freebairn and King, 2003). Consequently, it has become a common belief that local communities should be involved throughout the planning and implementation of the project, as well as the choice, monitoring, plus collection of indicators (for example, Corbiere-Nicollier et al., 2003). That means that not only the indicators have to be appropriate for the community but also the process of data collection and analysis has to be easy enough for non-experts.

Additionally, as circumstances change and communities become more involved, indicators must change over time. As a result, indicators of sustainability are much more than just progress indicators. They can assist guide development and policy activities, strengthen community capacity, and start a process to raise public awareness of social and environmental issues. The interactive methods that are popular among post-modern scholars may have certain disadvantages, though. Community control is useless for sustainability if residents continue to hold the similar dogmas and approaches that have directed to the untenable stances that exist now. Since growth-hungry local agencies are just as capable of allowing urban sprawl as national governments, the demands of sustainable development may not be satisfied by shifting authority from central governments to municipal institutions, thereby returning power to communities. It is necessary to strike a balance between neighbourhood and higher level initiatives. The goal of this essay is to assist in striking this balance. This will be accomplished by critically analysing existing top-down and bottom-up frameworks for the development and application of sustainability indicators at the local level. There is a process that leverages the different strengths of published methodological approaches after methodically assessing their advantages and disadvantages through the analysis of a variety of case study examples.

The two basic methodology based approaches exist in literature about sustainability indicators are Community based (Bottom Up) and Expert-led (top-down) Bell and Morse (2001). The first draws its epistemic basis from scientific conclusions and based on quantitative values or indicators. Although techniques that are based on Experts opinion lead to measure the complexity of the systems based on these indicators but lacks in highlighting the complex and varied opinions of the local stakeholder in our case the local community. The second ideology that based on community viewpoints majority refer to controversy by Bell and Morse (2001). According to King and Freebaim (2003) had highly supported the community based approach as this really helps out to identifies the importance of local context need which in other steps helps to set priorities and formulate objectives on real grounds. Sustainability always is a learning way out for both communities and scholars. In order

to get valid viewpoints on home-grown issues, it is argued that social actors need to be actively involved in the research process in order to generate solutions and atleast take steps to find the best results (Pretty, 1995). Table 1 illustrates an overview of the research done in the area of sustainability indicators and shows how the contexts projected can be classified into Community based (Bottom Up) and Expert-led (top-down) approaches with both having their own pros and cons.

Top-down strategies usually produce indicators that are carefully collected, analysed by experts, and statistically assessed for significance. This process identifies trends over time and across locations that a more casual observation could miss.

Table 02

Two methodological paradigms for developing and applying sustainability indicators at local scales and how each method approaches four basic steps

Methodological Paradigm	Step 01 Establish Context	Step 02 Establish sustainability goals and strategies	Step 03 Identify, Evaluate and Select Indicators	Step 03 Collect data to monitor progress
Top–down	Typically land use or environmental system boundaries define the context in which indicators are developed, such as a watershed or agricultural system.	Natural scientists identify key ecological conditions that they feel must be maintained to ensure system integrity.	Based on expert knowledge, researchers identify indicators that are widely accepted in the scientific community and select the most appropriate indicators using a list of pre-set evaluation criteria.	Indicators are used by experts to collect quantitative data which they analyse to monitor environmental change.
Bottom-Up	Context is established through local community consultation that identifies strengths, weaknesses, opportunities and threats for specific systems.	Multi-stakeholder processes identify sometimes competing visions, end-state goals and scenarios for sustainability.	Communities identify potential indicators, evaluate them against their own (potentially weighted) criteria and select indicators they can use.	Indicators are used by communities to collect quantitative or qualitative data that they can analyse to monitor progress towards their sustainability goals.

However, local communities are frequently not engaged by this kind of approach. Bottom-up indicators are typically derived by methodically comprehending limited observations of the humanity and environment, and they are based on an understanding of local context. This suggestion helps to improve learning capacity at community level and comprehension in addition to being a good source of indicators. Indicators created solely through participatory methods run the risk of not being able to reliably or accurately track sustainability. Although it is easy to see these two methods as essentially distinct, there is growing recognition and scholarly discussion about the necessity of creating novel hybrid approaches to comprehend various knowledge opinions (Twyman and Thomas, 2004) (Nygren, 1999); (Batterbury et al., 1997). Presently no agreement on the best way to accomplish this method integration, and our analysis is intended to contribute to these continuing discussions.

An adaptive learning method for the creation and use of sustainability indicators:

It is important to integrate. The empirical results from all over the world prove that there are positive outcomes from involvement of local community in monitoring sustainability measures. The indicators established came out to be as accurate (and at times more precise than) the indicators established by experts (Dougill et al., 2006); Reed, 2005; Fraser, 2002; Stuart-Hill et al., 2003). Yet the expertise of an expert might supplement the local wisdom in a couple of key ways. Even though qualitative indicators generated as part of participatory research encourage community action and learning (like working with the Kalahari pastoralists and "sneaker index"), one cannot guarantee their accuracy and reliability. Through empirical testing of indicators established through participating community helps reservation the ownership of community opinions which in order improve the overall wellbeing of society in term of precision, sensitivity and trustworthiness. Additionally, research may be able to establish quantitative dawns that enhance utility of indicators to improve sustainability. Both scholars and community people can benefit from this kind of fusion of quantitative and qualitative methodologies. When presented in a form that community members can understand, empirical findings can benefit people to have ownership of indicators they have suggested.

Researchers can gain more insight into the indicators they have examined by hearing how the community responds to these findings. For instance, after completing an empirical evaluation of sustainability indicators that Kalahari pastoralists had initially selected and shortlisted, Reed (2005) presented the results of focused group of the communities he selected for research. Both the experts and local community identified their social, economic and environmental needs in dissemination of results to propose best indicators of sustainability that will come up with rapidly growing environmental challenge. Communities and researchers in comparable social, economic, and environmental situations can benefit from knowledge sharing through the dissemination of research at wider spatial dimensions. This is particularly crucial when the environment is rapidly changing and information that is available do not be able to provide better adjustment opportunities for the community.

Despite the fact that the Basarwa from the Kalahari region are in an excellent position to be aware of the changes brought about by climate change to the environment, it is not clear to what extent this knowledge relating to the ecosystem, such as location of plants during different seasons, migration of animals, and hunting paths among others, would be beneficial if these conditions are altering rapidly. In that situation, the local information will have to complement by views of scholars that contribute in terms of predicting and managing the new environmental conditions.

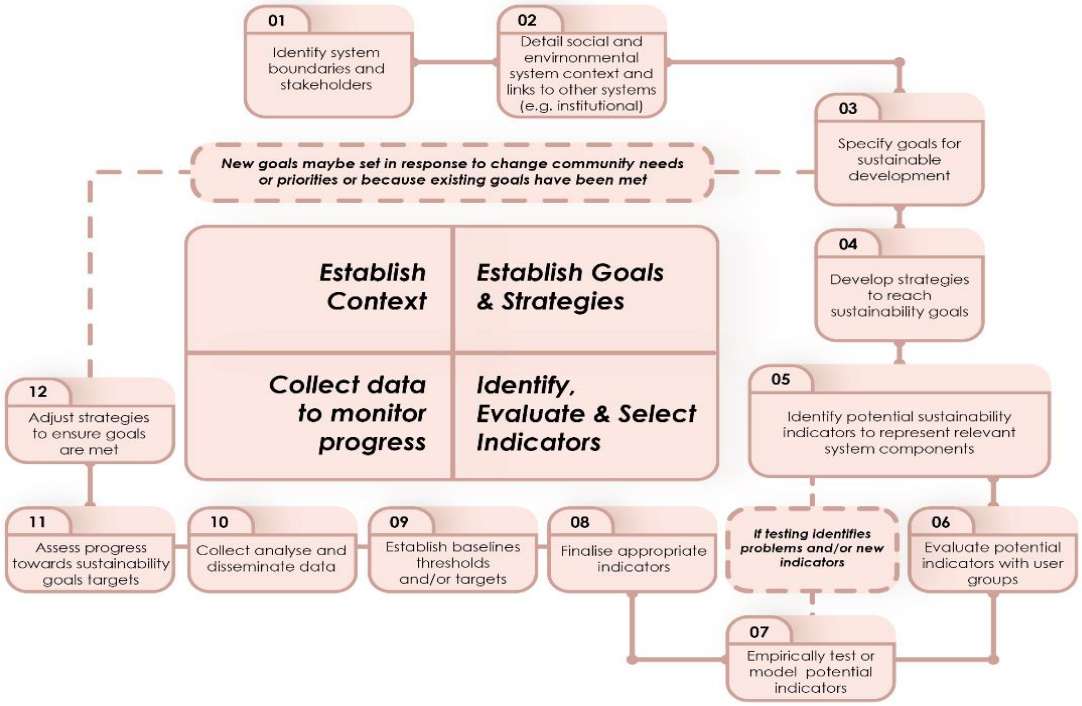

Fig 02 *Adaptive learning process for sustainability indicator development and application.*

Challenges to Sustainability Indicators

The key challenge for policymakers is in forecasting the directions of future developments of society and the economy taking into account often contradictory needs for growth of economy progress of community, political stability and sustainable environment. Bad decision making could exacerbate the problem, create crisis situations and lead to serious consequences. The enhancement of the quality of the decision-making foundation and the integration of numerous issues with clear signs for the busy decision-maker is of the utmost importance. As modern technologies of

information lead to the increasing quantity of knowledge while not increasing our capacities to perceive it, we need tools which could aggregate and comprehend information to facilitate its acuity and additional analysis. That is the role of the indicator. An indicator may be defined as a number, a sign, an image or even colour representing a feature or a tendency in a complicated system or an object. In the past, statistical bureaus computed most of the indicators used by decision-makers such as complete indices (gross national product or GNP) or percentage (unemployment rate). Chapter 40 of Agenda 21 declares that "indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems". This statement admits that "commonly used indicators do not provide adequate indications of sustainability". (UNCED 1992). Even though idea of sustainable development has advanced significantly over the past 12 years, Agenda 21's challenge has not been adequately addressed. Although a number of indicator sets have been put together, none of them have been widely used, and integrating them to support self-regulating sustainability remains a noteworthy contest. Sustainable development initiatives and programs is still the creation of indicators (OECD 2004). In order to help those who must use indicators immediately and to provide some insight into the future, the main focus of this book is the evaluation of current indicators. Research needs are identified, knowledge gaps are revealed, and successes and failures are examined. Additionally, a few novel strategies are proposed. In three areas—policy relevance, methodological frontiers, and conceptual challenges—this book examines the evolution of sustainability indicators. Even though major difficulties identified are application of indicators community level, there are various projects accrued out for finding the evaluation process. The only generalisation that can likely be made regarding indicators or indices that are used or recommended is that there isn't a perfect indicator that fully captures all the necessary features. The trades off are always present; the objective is to make them transparent and to recognize and steer clear of significant obstacles rather than to totally eliminate them. As a result, there isn't a single set of recommended indicators; instead, there are several methods that might be suitable for different applications.

It is particularly important to describe the fears in such a way that is applicable to strategy because these indicators are at the intersection diverse domains. For developing effective indicators, they have to be relevant or prominent to decision makers, legitimate in the eyes of stakeholders and users, and credible (scientifically valid). The awareness that a policy instrument is necessary to handle a specific issue is the first step in the policy's life cycle. It then proceeds further at various stages in first at development phase than the implementing stage later it will be adopted after careful evaluation, this all develop a clear mechanism. At different phases of the policy life cycle, indicators must meet different information needs. One use would be early warning, pointing out a policy gap for a current issue or drawing attention to a negative trend that could be a sign of a brand-new, developing concern. Outlooks and effect assessments, the creation of new policy proposals, and monitoring at all al stages to help implement policy all make use of additional indicators. Indicator set design requires flexibility throughout the policy life cycle. While some of the indicator set's indicators might need to be changed for optimum policy relevance, more of them stay related for a longer period of time.

Equity and Democracy an essential ethical component of sustainable development is the idea that every person has a right to a fair portion of the advantages this planet provides. Access to all aspects of development is facilitated by democratic processes. The following are some of these rights:

- The availability of land and natural resources, clean drinking water, sanitary facilities, energy, shelter, infrastructure etc is referred to as the biophysical environment.
- To guarantee active engagement in society at the individual level, this means having access to the sociocultural system and a steady minimum wage. Equal access to economic benefits nonmarket economies within the parameters of the national economy should be part of this. Barriers to Sustainability Indicators employment, volunteer community service, compassionate labour, and related activities). This implies that markets and funding (i.e., non-discriminatory credit conditions) are open to all potential producers. Globally speaking, this entails eliminating trade restrictions and obsolete

debt that affluent cultures have imposed to keep people from engaging in the global economy.

- This includes decision making, knowledge exchange and easy access to information. Some of the elements include: participatory politics, social security systems which are non-discriminatory, the legal right to participation, equal access to justice, and legal assurance of access to resources.

Identifying Methodological Challenges

Determining the Sustainable Development Subdomains: Increasing Openness in Indicators Development in defining sustainable development, it becomes clear that all life on Earth is dependent on biophysical support system of the planet. The condition of our planet and ecosystems is affected by the complex interaction of social, economic and political factors; in many cases, the condition of the planet and ecosystems is almost completely, if not entirely, determined by the activities of humans, past and present. The present research is an example of the first kind of discussion, while the second one must receive more attention in the future if sustainable development indicators are to become widespread in people's thoughts. As an indicator of sustainable development, the SD index can attract public attention and serve as a good tool for communicating the ideas of sustainable development. However, this index can hide the essential problem of sustainable development, namely the understanding and assessment of the trade-offs between achieving high levels of well-being of humans and keeping and restoring the integrity of ecosystems.

EEA Frameworks for Environmental Assessment and Indicators

In the last decade, the European Environment Agency (EEA) has provided assessment of almost all environmental problems in Europe. Evaluations and indicators reflect the connections between emerging environmental issues. Longer time perspectives, more scenario analyses and models, and larger European Union (EU) with socially, economically, and geographically more diverse countries should be considered in assessments. New and more difficult challenges point out the process and assumptions of the development of knowledge. We still believe that broader peer review can be an important step towards improvement and generalization of those frameworks to more complex and persistent environmental problems. Why are frameworks needed? They are needed to develop a process to kind of collecting data which later on developed in more refined form of knowledge which is very important to understand the sustainability issues and to resolve them in finding the best solutions using frameworks for information analysis and structuring. However, practice shows that existing information does not always get incorporated in policies: "Policy theories" or "policy frames" imply those principles. Disagreeable information would be ignored if it contradicts those policy theories (Veld, 2004).

5.0 Findings

Key Debates & Contradictions

STANDARDIZATIONVERSUSCONTEXTUALADAPTATION:

- For standardization: Enables comparison, global monitoring, learning across contexts, and common frameworks for cooperation (Sandoval- Hernández et al., 2021).
- For adaptation: Better reflects local challenges, engages stakeholders, and informs local decisions (OECD Expert, 2021).
- Synthesis approaches: Standardized core indicators with contextual supplementation (UNESCO, 2019); modular frameworks allowing sector-specific adaptation (Walker et al., 2025).

Technical Neutrality Versus Political Shaping:

- Technical perspective: Emphasizes methodological rigor and validity (UNESCO Digital Library, 2002–2010).
- Political perspective: Demonstrates indicators are shaped by political processes and powerful stakeholders, with local contexts often overlooked (Gorur et al., 2025).

Quantitative Versus Qualitative Measurement:

- Quantitative approaches: Enable statistical analysis and cross-context comparison (Sandoval-Hernández et al., 2021).
- Qualitative approaches: Capture dimensions resisting quantification (El Faouri & Sibley, 2024).
- Mixed-methods integration: Increasingly common in contemporary frameworks (UNESCO, 2019).

Top-down Versus Participatory Development:

- Top-down: Ensures technical rigor and international alignment but may lack local legitimacy.
- Participatory: Essential for meaningful indicators but may sacrifice comparability (Tilbury, 2007; Giaretta et al., 2024).

Identified Gaps

Theoretical gaps	• Integration of scientific, traditional, and local knowledge. • Dynamics of how indicator systems should evolve over time. • Relations in indicator development and equitable process design.
Methodological gaps	• Robust methods for integrating qualitative & quantitative data. • Validation methodologies. • Longitudinal research on indicator system performance.
Empirical gaps	• Implementation studies examining actual framework use. • Comparative research across sites, countries, and frameworks. • Impact assessment linking indicators to outcomes.
Practical gaps	• Data infrastructure development in resource-constrained contexts. • Practical methods for stakeholder engagement design

6.0 Conclusion & Recommendations

UNESCO's sustainability indicator frameworks have evolved from domain-specific measurement tools toward integrated, transdisciplinary systems emphasizing governance, participation, and learning. Thematic diversity across designated sites, education, and culture reveals common principles including attention to multiple dimensions, stakeholder participation, and contextual adaptation. Contemporary frameworks demonstrate sophisticated attention to methodological issues,

integration of qualitative and quantitative data, and recognition of political dimensions.

For Indicator Developers:

- Embed indicators within governance frameworks specifying use.
- Design participatory processes including diverse stakeholders.
- Balance standardization and adaptation through core-plus-supplemental approaches.
- Integrate multiple knowledge systems systematically.
- Plan for evolution as understanding and conditions change.

For Policy-Makers:

- Invest in data infrastructure and capacity building.
- Recognize political dimensions through transparent processes.
- Use indicators for learning rather than merely compliance.

For Researchers:

- Conduct implementation research examining actual practice.
- Develop validation methodologies for sustainability indicators.
- Investigate power dynamics in indicator development.

UNESCO's contributions to the development of sustainability indicators show that effective measurement depends not only on technical robustness but also on governance structures, stakeholder participation, and contextual sensitivity. As sustainability challenges become more complex, indicator frameworks must continue to evolve toward greater integration, adaptability, and inclusiveness. The frameworks reviewed in this study offer a strong foundation for this ongoing development while also highlighting the gaps and future work that still need to be addressed.

Conflict of Interest

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