IEEE SA STANDARDS ASSOCIATION

IEEE planet positive 2030

Strong Sustainability by Design

PRIORITIZING ECOSYSTEM AND HUMAN FLOURISHING WITH TECHNOLOGY-BASED SOLUTIONS

METRICS/INDICATORS

An initiative supported by the IEEE Standards Association

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IEEE

Strong Sustainability by Design

This Compendium has been created by committees of the IEEE Planet Positive 2030 Initiative supported by the IEEE Standards Association (IEEE SA). The IEEE Planet Positive 2030 Initiative community is composed of several hundred participants from six continents, who are thought leaders from academia, industry, civil society, policy and government in the related technical and humanistic disciplines. At least one hundred seventy members of this community from about thirty countries have contributed directly to this Compendium and have worked to identify and find consensus on timely issues.

The Compendium's purpose is to identify specific issues and recommendations regarding sustainability and climate change challenges to achieve "Planet Positivity" by 2030, defined as the process of transforming society and infrastructure by 2030 to:

- Reduce Greenhouse Gas (GHG) emissions to 50% of 2005 GHG emissions by 2030.
- Significantly increase regeneration and resilience of the Earth's ecosystems.
- Be well on the path to achieving net zero GHG emissions by 2050 and negative GHG emissions beyond 2050.
- Continue to widely deploy appropriate technology as well as design and implement new technological solutions in support of achieving technological solutions designed and deployed to achieve "Planet Positivity."

In identifying specific issues and pragmatic recommendations, the Compendium:

- Provides a scenario-based challenge (how to achieve "Planet Positivity by 2030") as a tool to inspire readers to get engaged.
- Advances a public discussion about how to build from a "Net Zero" mentality to a "Net or Planet Positive" ("do more good," that is, doing "more" than "don't harm") societal mandate for all technology and policy.
- Continues to build a diverse and inclusive community for the IEEE Planet Positive 2030 Initiative, prioritizing the voices of indigenous and marginalized members whose insights are acutely needed to help make technology and other solutions more valuable for all. Of keen interest is how to encourage more in-depth participatory design in these processes.
- Inspires the creation of technical solutions that can be developed into technical recommendations (for example IEEE SA recommended practice for addressing sustainability, environmental stewardship and climate change challenges in professional practice, IEEE P7800™) and associated certification programs.
- Facilitates the emergence of policies and recommendations that could potentially be intraoperative between different jurisdictions (e.g., countries).

By inviting the general public to read and utilize *Strong Sustainability by Design*, the IEEE Planet Positive 2030 community provides the opportunity to bring multiple voices from the related scientific and engineering communities together with the general public to identify and find broad consensus on technology to address pressing environmental and social issues and proposed recommendations regarding development, implementations and deployment of these technologies. You are invited to Join related IEEE activities, such as standards development and initiatives across the organization.

- For further information, learn more at the IEEE Planet Positive 2030 Initiative website
- Get in touch at: PlanetPositive2030@ieee.org to get connected to and engaged with the IEEE Planet Positive 2030 community.
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If you're a journalist and would like to know more about the IEEE Planet Positive 2030 Initiative, please contact: Standards-pr@ieee.org.

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This Compendium is also not a position, or policy statement, or formal report of IEEE or any other organization with which IEEE is affiliated. It is intended to be a working reference tool created through an inclusive process by those in the relevant scientific and engineering communities prioritizing sustainability considerations in their work.

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A Note Regarding Recommendations in This Document

Strong Sustainability by Design was created in two versions ("draft" and this current edition) that were iterated over the course of two years. The IEEE Planet Positive 2030 Initiative follows a specific consensus building process where members contributing content identify specific potential issues and proposed recommendations.

Membership

IEEE Planet Positive 2030, an initiative supported by the IEEE Standards Association as part of the Industry Connections Program, Sustainable Infrastructures and Community Development program (SICDP), currently has more than four hundred experts involved, and remains eager for new voices and perspectives to join in this work.

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Request for Input Draft ("Version One") Published June 2023.
First Printing November 2024.
Printed in the United States of America.

PDF: ISBN 979-8-8557-0935-3 STDVA27090
Print: ISBN 979-8-8557-0936-0 STDPT27090

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How to cite Strong Sustainability by Design:

The IEEE Planet Positive 2030 Initiative. *Strong Sustainability by Design: Prioritizing Ecosystem and Human Flourishing with Technology-Based Solutions*. IEEE, 2024. https://sagroups.ieee.org/planetpositive2030/our-work/

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The Metrics & Indicators Committee acknowledges the Contribution of the following individuals:

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METRICS/INDICATORS

Future Vision

It is 2030.

Sustainability has become an overall institutional framework that drives the human mindset and goal setting, rather than simply being a compliance exercise. This shift informed decision-making and clear commitments (e.g., targets, action steps, and transparent relevant information sharing) brought about by globally converging regulatory changes, and by interlocking mission-driven (Mazzucato,2015, 2018) innovation-enabling programs incentivizing regenerative socioeconomic transformations at both the company and global supply chain levels.

These alterations have been duly reflected in national and globally supported accounting and reporting rules. The Industrial and Information Ages brought innovations and developments that tied individuals and communities across our world closer together but also led to direct and indirect impacts on our planet, as evidenced by data from individual, societal, company, and government programs on sustainable development outcomes. Companies from all industries across the world have now recognized the necessity for every organization, individual, and society to work together to address gaps in the achievement of sustainable development goals.

By gaining knowledge and understanding of the problems, factors, and contributions to climate change through support and collaboration among organizations, a growing number of corporations now base their operations' success on data-driven decision-making and key performance indicators (KPIs) that now reflect how the products and services they design and develop increase long-term environmental and human flourishing. Countries, companies, and communities have changed their organizational structure and socioeconomic means to be results-driven, positive, and appreciative of global sustainability goals that improve life on Earth for current populations and for future generations to come.

Prices for products and services reflect the true and relative ecological footprint cost of overall resources, so net-zero or net-positive products and services are comparatively less expensive and much more attractive. Products are incentivized to be built to be sustainable and upgradable, rather than being disposable. These products and services are of benefit to poor countries in particular, which are more sensitive to rising temperatures and extreme weather due to reliance on rain-fed agriculture as well as a lack of financing and institutional capacity to implement programs in response to climate change.

These socioeconomic, institutional, and cultural shifts would not have been possible without the development of metrics and systems to measure, monitor, and influence progress towards a net-positive, regenerative society in ways that are innovative and flexible. Standard setters and policymakers have collaborated to assist in ensuring that metrics used to identify, measure, monitor, aand report on the impacts of sustainable development and climate risks on organizations and the impact of organizations on the environment are understandable, meaningful, and consistent.

Countries have taken on board the principles as set out in the **2015 Paris Agreement goals** and by the subsequent follow-up events and mechanisms serving its implementation, including the United Nations (UN) Sustainable Development Goals (SDGs) on Diversity, Equality & Inclusion targets and parameters.

Figure 1: Planet Positive 2030 Metrics & Indicators Committee/We Support the Sustainable Development Goals
(Image: See the Sustainable Development Network of the UN)

The measures of success against the Sustainable Development Goals (SDGs) have served and continue to serve to measure our collective progress in managing our planet's valuable resources.

Countries have recognized the importance of transparency and accountability and are now reporting actions taken and progress in climate change mitigation, adaptation measures, and dedicating resources to full transformation to optimize the use of resources and impact on the entire ecosystem. This has further driven stakeholders, agencies, organizations, and companies to take the necessary actions to meet agreed targets, with failure to meet these requirements resulting in increased costs of securing debt and for reconstruction efforts required by the increasing number and disruptive effects of events constitutive of the accelerating climate crisis. The information gathered through the increasingly sophisticated prevention and monitoring processes feeds into the global inventory, which assesses the collective progress toward long-term climate goals.

The journey has begun but much more has to be done to enable this vision to become a reality. As Earth continues its journey hurtling around the sun at an average speed of 30 km/s, the clock is ticking and there is much to be done, but the connected ingenuity of the human race, augmented by an ethically deployed AI, can make us all proud to be human again.

Introduction

Metrics and indicators are essential because, as the adage says, "what gets measured gets managed." Without metrics, we have no baseline, no means to measure against standards or requirements, and no means of assessing progress. Well-defined, consistent, and practical frameworks of metrics and indicators are the foundation for capacity building toward effective monitoring and management processes, fair and objective incentive and reward systems, enforcement programs, and accountability systems. By organizing and establishing a set of metrics, this allows for data-driven decision-making in addressing issues that our planet faces.

New climate change and sustainability-oriented measurements are essential to align *systems* with transparency and accountability for the single and collective impact on individuals, organizations (e.g., government, organizations, academia, and industry, also stakeholders), societies, and total ecosystems. New infrastructure design is required to support real-time agility, to adapt to changes, and to develop these systems with increased capability considering the limits to growth (Meadows et al., 1972), while improving life quality for all humans, species, and the planet.

Metrics and indicators provide measurements that afford us better understanding of processes, tracking of results, and discovery of optimized pathways, enabled by effective application of technology to deliver scenarios and prescriptive intelligent models, both as stand-alone systems as well as being part of a larger ecosystem. The science of measurements, standardized reporting frameworks, glossaries and definitions of terms, and weighted values of both quantifiable and qualitative measures are dimensions to overall sustainability that universally affect and interplay with all organizations and living systems.

To measure and guide this transition, it is imperative to leverage digital and other technologies for a sustainable future. If used responsibly, technology can have a profoundly positive impact on the environment and global sustainability goals, while also holding accountable technology's effect on our environment.

Effective use of metrics and indicators strongly relies on consistent measurements that meet relevant standards and recommends strategies for the increased use of ethically designed advanced technologies that deliver new insights on outputs/outcomes. The recommendations further outline strategies for developing reliable data with statistically proven principles that provide scientifically proven indicators that measure impact on the wider ecosystem, thus eliminating the trade-offs in the zero-sum game.

These technological applications will be aided by interdisciplinary and transdisciplinary approaches utilizing high-dimensional statistical models supported by artificial intelligence (AI)/machine learning (ML) approaches. In short, development of holistic designs that provide quantitative/qualitative measures of ecosystem impact and that map pathways with evidence-based data will facilitate our reaching goals of shared benefit to people and the planet.

The green and digital "twin transitions" also offer the promise of leveraging digital technologies for a sustainable future. Technologies like AI, blockchain, and the Internet of Things (IoT) can be harnessed for the renewable energy transformation, improve environmental forecasting and modeling, and accelerate scientific innovation for clean technologies (Clutton-Brock et al., 2019). They can also be a cornerstone of a future circular economic paradigm (Ellen MacArthur Foundation; William McDonough; Masterton & Shine, 2022) that replaces the current linear economic model that contributes to global sustainability challenges such as the climate crisis, biodiversity degradation, and pollution (One Planet Network, 2023). Consequently, the IEEE Planet Positive 2030 initiative aims to "identify the current technological solutions that need to be deployed widely as well as technology gaps for which we need to design, innovate and deploy new technological solutions" (IEEE Planet Positive 2030).

At the same time, digital technologies can also have a negative impact on the environment and sustainability goals. This ranges from the direct environmental impact of digital infrastructure such as data centers and the energy and resource requirements of advanced technologies such as AI (OECD, 2022) to the deployment of technology for business models and economic activities that run counter to climate and sustainability targets (Lange & Santarius, 2022). As digital technologies are often regarded as a crucial element in future systems such as decentralized renewable energy networks (IEA, 2022), it is paramount that technological solutions are designed in a way that maximizes positive sustainability impacts while minimizing and mitigating negative impacts such as energy use, GHG emissions, and resource consumption (Lange & Santarius, 2022).

This is why metrics, indicators, and standards play such a significant role in conceiving and implementing true *Strong Sustainability by Design*. The example of AI systems shows how difficult an environmental impact assessment can be for advanced technology—not only are standards and metrics for the energy, water, carbon, and resource use of AI systems often missing, a holistic impact assessment would also need to include the second- and third-order effects of the application of an AI system, such as rebound effects (OECD, 2022). Common metrics and indicators, consequently, are at the center of an initiative such as IEEE Planet Positive 2030 and its purpose to "give back more to the planet with technology than is removed and not to harm the biosphere/planet" (IEEE SA Planet Positive 2030).

Issue 1: Metrics development does not universally honor nature

Background

A balance of metrics and indicators is needed to shift away from the current—2023—win/lose focus of developing a "business case" driven by classical and neoclassical economics where scarce resources need to be allocated among projects that pit profits against social goals. Instead, metrics and indicators need to enable decision-making that facilitates improved resource access and enactment that supports the full vision of prosperity aiming to improve the life quality of present and future generations (Brundtland Commission, 1987) to live in harmony with nature.

The necessary paradigmatic change towards nature-prioritized metrics is intertwined with a profound multi-institutional shift toward a non-zero-sum decision-making approach that enables identifying and implementing multiple-win solutions regarding resource allocation. Such a shift, enabling extended and upgraded (mass) cooperation, has to be intertwined with recognizing and implementing in practice the consequences of human–nature interdependence. This pattern facilitates moving away from the institutional dual primacy of a zero-sum approach and resource scarcity view that generates exploitative, dominance-seeking, competitive, and collisional socioeconomic dynamism.

From an ethical perspective, this shift indicates priority given to ethics based on virtues, care, and duties instead of utility. It logically entails a drive toward social and economic equilibriums that are not influenced by a pre-established power balance and can be, therefore, truly inclusive and fair with respect to remote and less affluent regions of the planet (Brandt, 1980).

Sustainability should become a core value of human culture rather than just a compliance exercise and, therefore, be considered a system-level goal rather than a behavioral constraint. In such a broader context, the focus on quality metrics will be to help organizations assess if their actions are achieving what they value, rather than if they are hitting compliance targets. Such a robust cultural shift can also lessen the current tendency for short-term thinking driven by perceived immediate gains/targets (Barton, 2011). Instead, it can facilitate social innovation, business models, and pursuit of technologies that aim and show long-term potential of sustainable value creation and altruistic benefits.

Recommendations

1. **Address the need for the complexity of the types of metrics and systems required to measure full environmental impacts and support the pursuit of strong sustainability goals (Daly, 1991), and address the distinct need for technological tools to support the growingly automatic measurement, monitoring, reporting, and visualization of the aggregation of transformational sustainability-oriented processes.** The proper sets and implementation dynamics of metrics and measurements should enable us to elaborate on and implement effective methodologies aiming to radically lower emissions by allowing the "technologies of nature" to work and increase the regeneration, restoration, and resilience of Earth's ecosystems.

2. **Support the development of new, genuinely net-positive businesses (Polman & Winston, 2021) that are required to promote and implement regenerative approaches** (Robinson & Cole, 2015). These businesses should be aiming to and be capable of generating profit by restoring previously triggered (environmental and social) damage, that is, by going beyond avoiding further damage. These models should facilitate personal and collective life quality improvements through fulfillment of nature-prioritized metrics instead of prioritizing mass consumption and self-serving growth.
3. **Support and encourage civil society to play a strong, active role in the elaboration and implementation of such business models by generating favorable demand patterns, legislative (including taxation) environments, and supportive public resourcing.** The civil society players have to identify and get access to proper metrics and indicators, as well as to the capacity of modeling and simulating the possible contents and impacts of the interplay among the multiple components of the required societal and institutional changes that should unfold in various fields.
4. **Encourage cultural transformation such that it can unfold through alterations in the taken-for-granted perceptions that shape the everyday life of citizens (Perez, 2002) ready for "commoning" (Bollier, 2016) and acting as "prosumers" (Toffler, 1980), and provide civil society players with the need access to proper metrics and indicators, enabling them to carry out social agency by "going after the small picture"** (Giddens, 1984). The emergence of an altered green digitalization can be mutually catalytic and constitutive of an emerging Next Society (Reichel, 2012) of a new, collaborative era—a networked knowledge-driven civil society characterized by a more global cooperative and sharing social dynamism (Toffler, 1980, 1995; Perlas, 2000; Benkler, 2006, 2011; Rifkin, 2004, 2011; Reichel, 2012). These new systems interplay with robust institutional (Giddens, 1984) alterations that can aggregate into a societal culture characterized by new dynamics of cooperation going also beyond organizational boundaries.

Further resources

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Issue 2: Sustainability reporting standards and indicators fail to measure accomplishment of sustainability goals and impact of actions taken

Background

"What gets measured, gets managed," so it is essential to measure climate and nature-based data and resources that are frequently not incorporated into most financially oriented or prioritized Corporate Social Responsibility (CSR) reporting. Our societies and organizations tend to collect data that is easily accessible and collectible as opposed to data that we may require for evidence-based decisions.

Metrics and indicators provide:

- A baseline against which progress toward sustainability goals can be benchmarked;
- Evidence of compliance with sustainability standards or requirements;
- Evidence-based results to strengthen net zero/sustainability commitments and accountability; and
- Tools to catalyze and drive the accumulation of changes into transformations facilitating the pursuit of net- and nature-positive goals and impacts.

Well-defined frameworks of metrics and indicators are the foundation for effective monitoring and capacity building, fair and objective incentive and reward systems, enforcement programs, and accountability systems. These systems need to be adapted and utilized to focus on evaluating and monitoring factors that make a difference in the pursuit of net-zero and net-positive-enabling regenerative outcomes.

The choice of metrics is also not a "one-and-done" and/or "once-and-done" exercise. Given the vast complexity and interdependence of global and socioeconomic systems, decision makers should recognize that metrics will need to be reevaluated as society moves to adopt sustainable development goals as set forth in the Paris Agreement or similar foundational goals. Unforeseen and unintended consequences need to be identified and addressed. For example, in order to provide Scope 3 (indirect) emissions disclosures, large companies will require information from suppliers, but what will be the impact on smaller organizations that don't have the means and resources to gather the needed information? Will they be excluded from the market? Are tools like the Basic Sustainability Assessment Tool (BSAT)[1] and E-Liability[2] an option for required or desired reporting? As another example, what happens if the practical measures aiming to decrease the world's dependence on beef and to increase plant-based foods lead to unfavorable shifts in biodiversity? These types of questions will require ongoing consideration.

Finally, it is also important to recognize that when metrics are used to support cost and/or value estimates that an organization intends to use for disclosure purposes or to evaluate a project, measurement methods

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must fully reflect true costs and values. For example, if a company is evaluating the potential return on investment of offering a new product line, the costs included in the evaluation should reflect all costs to develop and produce the product responsibly (in other words, in a manner that adequately considers the needs of employees and other stakeholders, reflects the true value of resources consumed, and provides for remediation of environmental harms and regenerative actions.[3] Projects should not be deemed profitable if they create problems that harm the environment, animals, or human well-being that others will need to fix. This is fundamental to accountability.

Recommendations

Sustainability oriented metrics and indicators need to measure what matters:

1. **Design metrics or systems of metrics to measure what matters.** It is important that metrics (or sets of metrics) work together to support holistic decision-making, reflect priorities, and clearly align with the outcomes being sought. To achieve this, sound indicators linking sustainable goals to the elements being measured and monitored to provide a target and associated corrective actions should be considered (Fatima, Funke, & Lago, 2024).
2. **Design metrics and indicators to be broad enough to support multidisciplinary decision-making across the range of environmental, social, and governance issues that need to be measured and monitored on a country-to-country basis**. In a particular context, this might include elements of emissions produced, resources used, biodiversity impacts, human and social impacts, and other relevant factors to better assess the holistic impact of actions. For example, in addition to environmental impacts, consideration should be given to social consequences of societal shifts, such as:
    a. Job losses in sectors being reduced and retraining that will be needed to shift jobs to sustainable industries;
    b. Inequity in access to resources that support desired changes (such as access to public transit or plant-based food alternatives); and
    c. Unintended impacts on land development or biodiversity.
3. **Reflect and incorporate how legal rights for the planet are shifting, such as the acceptance of the legal personhood of rivers (e.g., Canada, New Zealand) and other ecosystems (**Berge, 2022). These changes provide examples of the way ahead for accepting and respecting the intrinsic value of nature (Barkham, 2021).

[3] In accounting terms, this is typically referred to as Natural Capital Accounting defined by The European Commission as, " a tool to measure the changes in the stock and condition of natural capital (ecosystems) at a variety of scales and to integrate the flow and value of ecosystem services into accounting and reporting systems in a standard way."

4. **Failure to consider the full scope might lead to short-sighted decisions without due consideration of the big picture**. Therefore, the following should be observed:
    a. Metrics should identify, distinguish, and support measurements of direct (primary) and indirect (secondary, tertiary, etc.) factors that cover the entire lifespan of the product/project. This provides a more complete and realistic impact assessment to evaluate options and disclose outcomes.
    b. Metrics must reflect the tensions between human development and broader biodiversity. Robust metrics help decision makers guard against unintended consequences that improve one factor from a human perspective but harm another element. For example, green energy sources such as water turbines and windmills can significantly threaten fish and birds, and these threats also need to be measured and monitored. From a biodiversity perspective, metrics must enable decision makers to interact with and manage the wicked problems emerging from complex systems whose interplay is driving the emergent Anthropocene[4] era.
5. **Support innovation. It is essential to determine appropriate metrics and indicators that will provide the necessary scope of information.** An example of an innovative metric for a particular context is when measuring circularity[5] of a project (where its design is intended to favor reduction, reuse or recycling of materials and resources versus favoring a linear process), consider measuring the "radius of the circle." Nature evolves using small circles in tight geographic areas. In contrast, humans might find a "circular" solution, but if that means building products on one side of the globe, shipping them around the world, and then shipping the obsolete product back around the world for it to be disassembled and reused, the radius of circularity is huge and likely linear in nature and much more wasteful than a smaller radius project.
6. **Develop metrics and indicators as well as the associated data collection and handling systems such that they facilitate the much-needed implementation of more integrated reporting systems that better track progress along net-zero roadmaps and more quickly highlight areas where further action is required.** Such systems should enable more regular, reliable reports to be provided at the board level to help ensure that sustainability is at the heart of organizational strategy.
7. **Measure impact from desired behavior changes, such as individuals choosing to support organizations that prioritize the circular economy or increased awareness and popularity of plant-based food options.**
8. **Design metrics and indicators such that they support investigation of root causes and beneficial actions that both can and should be undertaken to help validate or discredit assumptions that do not measurably increase sustainability goals.**

[4] The Anthropocene era, as defined by Wikipedia, is a proposed geological epoch dating from the commencement of significant human impact on Earth's geology and ecosystems, including, but not limited to, anthropogenic climate change.

[5] "Circularity" refers here to concepts in design or statistics often referred to as Circular Design, defined by The Ellen MacArthur foundation as, "A systems solution framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution. It is based on three principles, driven by design: eliminate waste and pollution, circulate products and materials (at their highest value), and regenerate nature."

Issue 3: Operational sustainability metrics and data are not consistently accurate, reliable, and practical

Background

Metrics must reliably and accurately measure the factors that are needed to support decision-making, using the best proven, evidence-based methods available. From a practical perspective, they also need to reflect factors that can be reliably and consistently measured, rather than factors that are believed to be important but where the technology to measure the factors is not readily available or where there is no agreed-upon best-practice approach for measuring or calculating values.

Effective, evidence-based decision-making relies on the ability to evaluate data that is accurate and reliable. For example, when measuring and reporting on emissions levels, water use, or waste production of an organization or jurisdiction, it is essential that estimates be based on measurements, guesstimates and projections that are as accurate and consistent as possible.

The climate and ecosystems being measured are complex and dynamic, and more is being learned on an ongoing basis. It is, therefore, important that metrics be flexible and adaptable to changes as new measurement methodologies emerge and new standards and regulations are developed. For example, for years, a focus for climate-oriented metrics was on measuring carbon dioxide (CO_2) emissions, but current best practice suggests that GHG emissions should be measured using an enhanced GHG protocol that disaggregates measurement of relevant gasses such as methane, nitrous oxide, and CO_2, and considers their dynamic interplay.

In order for metrics to be practical, it is essential that they be defined in such a way that the necessary measurement information can be observed and collected. It does no good to define a metric if there is no reliable way to determine its value. For example, standard setters and regulators such as the United States Securities and Exchange Commission (US SEC) and the International Sustainability Standards Board (ISSB) started implementing requirements for corporations to disclose their Scope 3 emissions. While significant concerns have been raised by some stakeholders because of the challenges of accurately measuring Scope 3 emissions (Kaplan, 2021),[6] improved methodologies, technologies, and policies around these issues are bringing changes to address these needs.

Accurate, reliable, and consistent measurement and monitoring will be made more practical by employing technology and keeping up with enhancements made available by innovation. Depending on the specific application, this might include:

- Machine learning and AI technologies for data collection, interpretation, scenario modeling, prediction, and analysis (including the concept of a “digital twin”)[7];
- Immersive technologies such as virtual reality (VR) and augmented reality (AR) that facilitate simulations that allow for estimates to be determined for metrics in uncertain situations;

[6] One idea on improving Scope 3 emissions reporting can be found in the concept of “e-liability” reporting (as espoused by Robert S. Kaplan and Karthik Ramanna in Accounting for Climate Change), which utilizes traditional auditing methodologies to better balance accountability in overall supply chain reporting.

[7] Digital Twin: a concept providing digital or virtual copies of specific portions of the earth to model potential climate, weather or ecosystem scenarios based on satellite or other aggregated data.

- Data analysis and storage using computing power centers and programs [e.g., cloud computing platforms, API providers, software (e.g., green software), audience]; and
- Blockchain and decentralized systems for data provenance that support reliability.

Evaluating metrics is made more relevant by benchmarking results against those of comparable projects, organizations, or jurisdictions. For example, investors and lenders are interested in current sustainability results and future potential of corporations, and benchmarking against other similar companies helps with decision-making. More broadly, organizations gain valuable insights as to their comparative progress by benchmarking against similar organizations. This requires reliable data for benchmarking to be publicly available.

Depending on the context, necessary measurement data for benchmarking can be derived from:

- Socioeconomic models [e.g., gross domestic product (GDP), Genuine Progress Indicator (GPI), the Human Development Index (HDI); and the UN Sustainable Development Goals (SDG) Index];
- Earth observation technologies for data acquisition [e.g., National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), and the Institute for European Energy and Climate Policy (IPCC)]; and
- "Opt-in" data portals and repositories (for example, see CDP Open Data Portal and IEEE DataPort)—with suitable anonymization to protect sensitive information.
-

Benchmarking results against data repositories does come with a caveat: it is important to recognize that data gets outdated quickly in some contexts and that it often does not transfer from one context to another. This is especially important when training AI (in addition to the general awareness of the impact of potential data bias).

Recommendations

Climate and nature-based metrics need to be chosen such that they are science-based[8], objectively measurable, practical, and reliable. To achieve this:

1. **Consider the challenges and limitations of data collection/measurement and related issues when choosing metrics.** Choose metrics that are practical to measure and interpret, to support consistent application and measurement (within and between organizations and over time) in order to and objectively gauge changes and facilitate progress.
2. **Evaluate new technological innovations to take advantage of ongoing advancement in measuring, analyzing, and monitoring progress/change/status, while being mindful of the limitations of the technologies used.**

[8] The Science Based Targets Network is an established and respected organization that provides metrics along these lines, providing "a collaboration of leading global non-profits and mission driven organizations working together to equip companies as well as cities with the guidance to set science-based targets for all of Earth's systems. This will help them define a clear pathway to ensure they are doing enough across their value chain to address their impacts and dependencies on nature."

3. **Review and assess new measurement approaches, recognizing that systems and countries are complex, adaptive, and interdependent with significant uncertainty and the potential for unintended consequences (both negative and positive).**
4. **Select metrics that can be adequately documented such that they can be independently verified (both for internal confidence and to meet regulatory requirements).**
5. **Benchmark results against trusted data, both internally (to track progress) and externally (to compare results against competitors, best practice results).**
6. **Implement data collection and measurement methods that enable efficiency by allowing data to be collected once and used in multiple ways or formats in compliance with established reporting requirements (subject to privacy legislation, industry standards)**; for example, public health data with organizations such as the World Health Organization (WHO), WHO Collaborating Centers, the Centers for Disease Control and Prevention (CDC), and Training Programs in Epidemiology and Public Health Intervention Networks.

Further resources

1. Clutton-Brock, Peter, David Rolnick, Priya L. Donti, Lynn H. Kaack, Nicolas Miailhe, Raja Chatila, Marta Kwiatkowska, et al. *Climate Change & AI: Recommendations for Government Action.* Climate Change AI, Centre for AI & Climate, and the Global Partnership for Artificial Intelligence (GPAI), 2021.
2. Coalition for Digital Environmental Sustainability (CODES). *Action Plan for a Sustainable Planet in the Digital Age*. 2022.
3. Levidow, Les, and Sujatha Raman. "Sociotechnical Imaginaries of Low-Carbon Waste-Energy Futures: UK Techno-Market Fixes Displacing Public Accountability." *Social Studies of Science* 50, no. 4 (Feb. 2020).
4. Sovacool, Benjamin, Noam Bergman, Debbie Hopkins, Kirsten E. H. Jenkins, Sabine Hielscher, Andreas Goldthau, and Brent Brossmann. "Imagining Sustainable Energy and Mobility Transitions: Valence, Temporality, and Radicalism in 38 Visions of a Low-Carbon Future." *Social Studies of Science* 50, no. 4 (May 2020).

Issue 4: Lack of interconnectedness and trade-offs between society, economic development, and planetary regeneration

Background

Change will require new mindsets and deep engagement of all levels of society, industry, and communities in a systematic way that reflects the interconnectedness of all life and various, often distant, elements on Earth, which must cooperate and combine their efforts to meet these challenges and enable continuous improvement and progress toward real-world aspirations for achieving net-positive results.

A shift in mindset is needed toward a more holistic, nonlinear approach, where sustainability is inherently valued, is a core expectation, and is measured, monitored, and designed accordingly, both for compliance and to drive sustainable innovation. This shift should be supported by a focus on core values that restore dignity and respect for *all life* so that humans can be proud of humanity. Change will require deep engagement at all levels of society, industry, and communities to meet the transformational challenges humanity faces in the coming decade. Monitoring and controlling changes probably will require the capacity to shift among metrics and measurements in various settings as changes unfold, resulting in managing decision trade-offs, as well as observing changes in views and behaviors. The benefit of one decision and focus on a few metrics may in the long term lean to an imbalance in the system, affecting another metric, which may be yet to be identified. The ability to understand the interdependencies and trade-offs can be fostered through physical reminders and simulations.

Recommendations

A fundamental change in mindset is required in order to let nature work, to reestablish its self-healing capacity. Aside from—and beyond—the prevention of new harms and destructions, the human players should monitor and, if necessary, support the (sets of) natural processes that are providing feedback and that can contribute to reestablishing the balanced operation of (particular) ecosystems and their interplay.

1. **Promote experiencing interdependence and interconnectedness in practice, so that we recognize ourselves, our teams, and our societies as interacting parts, active components of the various interplaying ecosystems.** It is important to overcome the destructive perception of being capable of dominating and freely reshaping nature. Instead, we must accept that humans, countries, and their organizations are part of nature, and we must relearn to live in harmony in order to improve our quality of life. Such a fundamental shift in human perception is intertwined, fed back with profound alterations in types and compositions of the various metrics and indicators to be used. The metrics may need to be balanced across the planet, suggesting interdependencies in countries, geographies, and industries. Thus, metrics can help us identify the changes that we need to make and measure the changes and the shifts. Embedding such new perspectives in education, from preschool to universities, will play a crucial role in achieving the desired mindset change and in building awareness and lifelong learning opportunities and should also emphasize qualitative changes to understand our complex world. An example would be technical means (e.g., simulations), rather than measuring learning and behavior.

2. **Improve our educational system such that it will graduate professionals who are knowledgeable about, understand, and employ sustainability-oriented metrics and indicators through their profession.** Metrics can enable us to see the world differently and preserve these interdependencies.
3. **Help local communities measure the effectiveness of various tools to educate and encourage more socially conscientious behavior by harnessing the power of the individual.** The ability to simply focus on the physical reality that is relevant to communities is important. For example, Copenhagen's waste system is an architectural wonder that sits visibly in the middle of the city. What impact has this had on the awareness of the public and their behavioral choices? Metrics need to be able to measure success in these areas, that is, measure and monitor what is resonating with people to support different methods of using tech and education (high and low tech) to change behaviors by improving self-image, self-awareness, and so forth. At the same time, however, we need to recognize that measuring and predicting the outcomes that will result from policy changes is inherently very difficult, given the complexity of the systems and because of the added complexity that results from *human behaviors*, which human models do not fully capture.
4. **Evaluate new technologies to simulate various realistic scenarios.** These technologies allow the user to understand factors that can change future economies: geography, politics, ecology, biodiversity, and human impact. Through these simulations, the individual can gain an understanding of their own role in the ecosystem and what they can personally do to contribute to the wellness of the planet. One example of such a technology is the use of metaverse concepts (extended reality simulations of both augmented and virtual reality), where real-time tracking and alternative future scenarios can be created. These overly personalized immersive experiences at various levels of society might enable individuals and collectives to review and assess their own and others' contributions to the ecosystems of the planet, as well as enabling the understanding of how they can contribute to the future wellness of the Earth.
5. **Consider employing simulations to help test, model, predict, and validate theoretical models and the appropriateness, understanding, and/or interpretation of specific metrics that have been chosen in a given context.** Care will be needed, of course, to avoid unintended consequences by carefully assessing the psychological and physiological impacts of these immersive technologies. And with any simulation, diligence will be required to see if the metrics are sufficient, the data relevant, and the models performing as anticipated under dynamic conditions.
6. **Employ personalization (such as a visualization of the green and sustainable transformation of an individual's own neighborhood) in order to educate and provide awareness of the pathways and agency of each participant to create meaningful change in the world, which can contribute to the change of current worldviews and the mindset in some societies that tends to favor the individual at the expense of the collective good.** Such personalization can capitalize on improved collective capacity of modeling and simulating diverse scenarios and (sets of) impacts of changes. For example, the simple act of advising you of your carbon footprint when booking a flight may change consumer behavior and indirectly affect industry choices.

7. **Use transition design methods and tools extensively.** Transition design methods and tools should include alternative scenarios played out through computer simulations linked to interdependent multiple variables that combine as interlinked systems with other variables that individuals can manipulate to create realistic simulations of outcomes by changing and controlling these variables. Variables as input will be not only based on historical or current data but include qualitative variables, particularly relevant for creating long-term images of the future. For instance, variables and systems analysis may be simulated (e.g., based on the original "Limits to Growth" study by the Club of Rome in 1972 and subsequently updated since then). This computer simulation of planetary boundaries showed that the planetary system cannot support current rates of economic and population growth indefinitely and that this limit can be projected and defined and is dependent on specific resource factors such as agricultural production, population increase, hydrocarbon energy depletion, pollution, and industrial outputs, which are extrapolated into the future.
8. **Use various ways of creating scenarios and simulations for individuals to experience "different futures."** Create simulated "experiential learning." Computer (serious) gaming simulations can be another method for creating visual scenarios of the future, creating opportunities for participants to not only view and change variables but to actually experience each of the projected images of the future. These methods will be critical for creating visceral and fundamental change of mindsets and worldviews, particularly among those with significant power to make fundamental changes in society.
9. **Develop and implement reliable impact assessment tools and simulations.** At a stakeholder level, impact assessment tools that incorporate simulation methodologies can allow organizational decision makers to better predict and evaluate the impacts (positive and negative) of their strategic and operational plans. If these tools are reliable, they will help to shift the mindset and priorities of senior leadership and government functionaries by presenting consequences in a manner that is more certain and less deniable.
10. **Improve ethical use of technology.** All technologies used for scenario simulations and design shall be governed for ethical use and application through strong ethical frameworks and standards, such as the Organisation for Economic Co-operation and Development's (OECD) AI Principles, the upcoming European Union AI Act, and those under development by the IEEE Standards Association.
11. **Consider trade-offs between using technology to support sustainable development and the impact of using the technology on resource use, the environment, and people.** The technology requirements include tools that assist with training; behavior outcomes are from the individual (e.g., coaching) to the community to the organizational stakeholder's level and are integrable, comparable, and adaptable based on environmental contexts and circumstances as well as educational (empathetic) contexts across cultures, circumstances, and ecosystems. AI and immersive reality technologies are not as sustainable as we would wish them to be; hence, the trade-offs are important.
12. **Consider trade-offs such that data collection is meaningful and that associated storage is effective. In other words, consider image, video, or other document storage, where the files are stored in multiple locations—beyond the requirements for effective back-up and retrieval—and without expiry dates (exceptions are files that require deletion due to legislation)**. Do we really need all the data centers?

Issue 5: Lack of recognition of global ecological and environmental interdependence

Background

In an era when individualism favors instant perceived gratification, joining together around the globe to reach net-zero and net-positive goals provides an essential opportunity to restore dignity and respect for all life.

The recognition and acceptance of humanity's global interdependence with nature allows humans to approach the planet with the aim of being in harmony with nature rather than trying to dominate it. Respecting life and accepting that every living being/organism has intrinsic value that should be respected enables humans to seek stewardship rather than domination of nature—that is, not using it solely as a tool and resource to further humanity's own pursuits. By seeing ourselves, that is, humanity, as dependent—but active—parts of nature, we can approach harmonic relationships with the world around us. But this perspective requires overcoming the still mostly dominant, mistaken, destructive—and *self*-destructive—utilitarian perception of seeing humanity as an independent ruler that exists at a remove and freely exploits nature.

Humans are not the only species that inhabits planet Earth, but we are the species that has evolved toward an illusion of domination of the planet and control of its destiny. The responsibilities that result from acceptance of this view have not been adequately considered. The journey of the human race has been one filled with innovation, from learning how to fashion tools and making fire to inventing the wheel, the industrial revolution, and various traveling machines as well as the first computer, the world wide web, and—forthcoming—quantum computing. Until the past 200 years, at no stage did much thought appear to be given to the consequences of our actions on the planet that has greatly benefited past and current generations; instead, humans failed to consider the impact on the generations that will follow. Thankfully, this failure has at least been recognized in the UN's definition of *sustainable development*:

> *Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*
> (Brundtland Commission, 1987)

However, this definition appears to only recognize the human perspective of future generations and should be widened to better reflect biodiversity and the future sustainability of all life on this planet. This would increase alignment with the specific sustainable development goals, which do reflect broader life forms, albeit to a lesser degree. A simplistic example of the domination of the human interest is depicted when a plane is hit by a bird strike. No thought is ever given to the birds destroyed by the plane's engines. Humans were not given wings or wheels, but their ingenuity in enhancing their lifestyle has resulted in threats to other species that inhabit this planet, as can be seen by the amount of wildlife accidentally killed by vehicles on the roads and marine life sickened by industrial waste.

In accepting that interdependence together with a non-zero-sum approach should have institutional primacy, it is important to recognize also the intrinsic value of every—and any—living being. However, the current attempts to use "financialization" and the price signal to set a market value for other species are pointing us in the wrong direction, strengthening a utilitarian, exploitative, and dominance-seeking approach.

Therefore, there is a need for the human race to recognize and address the risks faced by other species. Some humans have already adopted this mindset as they seek to preserve endangered species. This can only

happen if more humans take personal responsibility for our actions. This starts with the leaders of the world. The world cannot tolerate the risk of a war that could result in an almost uninhabitable planet on which very few species would survive. This is not a political issue, but the extent to which power is in the hands of just a few individuals is of great concern, as there are no appropriate safeguards to mitigate that risk.

There is also a real risk that the future of the planet will not be determined by the many but by the few who currently dominate the technological powerhouses that, in some ways, govern our lives. There must be a world in which its resources are more equitably shared to allow many more to enjoy a better life. There also needs to be proper accountability, where individuals are held to account for their actions.

There is also the need to consider the future implications of Artificial General Intelligence (AGI) if and when that will be reached. A future with AI raises questions and concerns: Will there be a need to respect the rights of the AI robots or other AI "species"? Is such a circumstance a possibility? To what extent are these concerns relevant for the development of a sustainable future? What metrics and indicators should be monitored to help ensure that human influence in global evolution can continue to be constructive?

While these debates must be held, in the interim, technology will assist us in helping the planet by:

- Helping to appropriately mitigate risks of global warming. Doing so will not only benefit the human race but all other living things on this planet.
- Providing better data on the location of endangered species, thereby assisting in their protection (e.g., the use of infrared sensor technology with AI has assisted in monitoring the location and population of koala bears in Australia, where many have been killed by the recent increase in bushfires).
- Breaking down language barriers with more effective real-time translation.
- Providing a better understanding of the thought and communication processes of other life forms to build broader empathy.
- Assisting in true value assessments, calculations, and feedback loops of the things that are essential for life on this planet.
- Assisting in more accurately predicting incoming asteroids and other space debris that could cause serious damage to Earth, and facilitating means by which we can divert the trajectory of such threats, in the interest of all living things on this planet and others.

Recommendations

1. **Utilize new metrics that measure total impact on the entire ecosystem**. **Resolve the "hierarchy of rights" of species on planet Earth per country.** Genuine changes require overcoming attempts of financialization in order to reflect the (true market) "value" of life, living beings, and nature as we know it. There is a need to properly consider how the broader ecosystem can be prioritized over the desire for growth. This is a key matter to be resolved, since Earth and Earth's resources are finite and current human impacts on the Earth are causing much damage to the biosphere: pollution of air, soil, and water and ecosystem degradation to name a few. If current trends of human impacts on Earth continue, humans may not have a planet to inhabit in the long run. These will be complex matters to

reach agreement on, but addressing these issues can help create the appropriate legal foundations for the sustainable development of the human race and all other life-forms on this planet.

2. **Develop policies and regulations to increase transparency and accountability for total impact on environmental sustainability.** It takes time to change regulation, and, even more so, human behavior. The ultimate success of laws and regulation is to have changed human attitudes and behaviors, for example, bans on smoking in public places.
3. **Define impact in preserving and true value in using natural resources. Measure, test, and apply accurate measurements of the true cost of using natural resources and resulting true value.** Metrics and indicators must align with any new work to properly reflect true cost and value. The acceptance of the legal personhood of rivers (New Zealand, Canada) and other ecosystems provides examples of the way ahead for accepting and respecting the intrinsic value of nature. This approach leads to a paradigm shift that feeds back with overarching transformations in our system of metrics and indicators. These should reflect and contribute to a robust transformation at the organizational level, including our fundamental socio-cultural values serving as drivers of our socioeconomic activities. Because robust economic transformations also affect accountancy, other indicators must be considered in any evaluation of positive transformation.
4. **Prioritize building better datasets to assess, calculate, and monitor progress with indicators that measure total impact.**
5. **Build progress indicators that measure the consequences of human actions in a holistic way and measure the total impact of human actions from a holistic perspective, including feedback loops**. As we move towards a net-positive future, we must also guard against unintended consequences that improve one factor from a human perspective but harm another element. For example, green energy sources such as water turbines and windmills can significantly threaten fish and birds. Short-term human well-being cannot come at the cost of indiscriminate further harm to other life-forms and natural systems. This mandate must be built not only into human decision-making but also into intelligent systems that we develop to aid sustainability, particularly before they are given autonomy over their actions.
6. **Apply a regenerative circular economic approach, where possible, to prioritize reversing past harms as we build a sustainable circular economy for the future.**

Further resources

1. Barkham, Patrick. "Should Rivers Have the Same Rights As People?" *The Guardian*, 25 July 2021.
2. Bennett-Jones, Owen. "Should Animals Have the Same Rights as Humans?" BBC News, 26 May 2015.
3. Global Accounting Alliance. *A Call to Action in Response to the Nature Crisis*.
4. Wikipedia, s. v. "Animal Rights." Last modified 17 Apr. 2023.

Issue 6: Lack of socioeconomic transformation toward sustainability

Background

With strong sustainability by design and accountability as the goal, the UN SDGs form a universally recognized benchmark for transparency, reporting, and a measure of impact. SDG scores can be mapped to environmental, social, and corporate governance goals, and if well deployed and governed, can potentially facilitate and contribute to genuine regenerative socioeconomic transformations.

Effectively tackling the multiplying challenges posed by the climate crisis requires profound and robust socioeconomic transformations, decreasing global material and energy flows, while exceeding neither environmental nor social limits as described, for example, in the doughnut model (Raworth, 2018). Targeted robust and transformative systemic level changes can provide powerful and even game-changing contributions to the necessary transformations. To have real benefit, however, changes need to achieve buy-in and leverage the power of key players, such as the "Carbon Majors" that are currently the source of more than 72% of the global GHG emissions (Climate Accountability Institute).

The likelihood of genuinely transformational alterations can be significantly enhanced by building on business models that enable preservation of the planet and improve outcomes through truly sustainable and regenerative activities. Such business models must enable the owners and operators to reallocate stranded assets, frequently overcoming trillions in US dollars in market value, through truly regenerative activities.

The pathway to transformation requires the definition of goals that will serve to measure results and indicators that measure progress towards these goals. The ability to communicate these results in new and meaningful ways provides transparency and new accountability.

There is a growing awareness and popularity of ESG-related financial activities, products, (hedge) funds, advisors, ratings, and other related investment services that are important users of sustainability-related metrics and indicators along with the underlying complex models and simulations. However, there is still some confusion and lack of consistency about what the ratings are actually measuring. The investment funds often focus on the investors' risks by gauging how well an organization is addressing climate risks from the perspective of *organizational* sustainability (how likely the company is to survive or thrive)[9] (Engler, 2022). These pay less attention to whether the company is positively or negatively impacting environmental and social ecosystems. For example, MSCI's ESG ratings "aim to measure a company's management of financially relevant ESG risks and opportunities" using "a rules-based methodology to identify industry leaders and laggards according to their exposure to ESG risks and how well they manage those risks relative to peers." While this is valuable information for investors, it doesn't answer the larger questions of overall impact of the company and their commitment to ESG innovation and progress.

Use and explanation of the proper metrics, measurements, and indicators are needed to enhance awareness as well as to catalyze targeted education and knowledge dissemination among decision makers, including members of corporate governance bodies and other market and public sector players.

The reporting of quality metrics is an essential element in holding organizations accountable for setting and meeting meaningful goals and complying with regulatory requirements. Under the Sarbanes-Oxley Act in the United States, for example, chief executive officers (CEOs) and chief financial officers (CFOs) of public

[9] What is often termed as single materiality versus double materiality.

companies are required to personally certify the accuracy and completeness of annual and quarterly reports and the adequacy of internal controls with respect to these disclosures.

Recommendations

In order to effectively reduce the global material and energy flows, it is of paramount importance to systematically build and strengthen transparency, especially for corporate accountability. The enhanced transparency can establish trust in reported impact and commitment to goals and promote the effectiveness of actions being taken primarily by the economic players:

1. **As requirements evolve to include disclosure of sustainability metrics, certification exigencies should be mandated for the responsible C-suite positions so that key decision makers are publicly accountable for the information released by their organizations**. In the interim, voluntary certification should also be encouraged.
2. **Organizations should be encouraged to make the CEO directly responsible for sustainability.** For example, IKEA has combined the CEO and chief sustainability officer (CSO) positions at the country level (so country-level CEOs also hold the CSO title).
3. **The personal *remuneration* (salary and benefits) of persons in C-suite positions and individuals active on boards and governing bodies should also be connected with the environmental performance and footprint reduction of the organization(s) for which they are responsible.**
4. **Implement effective monitoring of investments.** Without effectively monitoring their genuine impacts, the large investments often described as sustainability-driven and sustainability-focused constructions can become major facilitators of destructive green washing.
5. **To effectively encourage innovation and net-positive performance (Polman & Winston, 2021), this accountability should be reflected in monetary and nonmonetary rewards for an organization's leadership team and employees at all levels to encourage and reward expected behaviors.** The board of directors can further build accountability for executives in making commitments and taking actions to achieve sustainability by incorporating the relevant performance metrics into the measures shaping their ***remuneration***.
6. **Design and implement a proper set of metrics and measurements that effectively gauges the firms' GHG emissions and carbon footprint while measuring the effect of the transformational business models and such innovative financial tools as ESG.**
7. **Provide visibility for company achievements that simultaneously facilitate enhanced regenerative and financial/profit outcomes while successfully implementing innovative business models.** This is of crucial importance.
8. **Create effective sustainability ratings and indexes. By creating community ratings or other effective sustainability indexes on ESG and performance, all stakeholders—individuals, organizations, corporations, various local peers—could receive feedback and, through transparency, the firms can be benchmarked against other stakeholders and held accountable in their community for their results.** Such transparency can promote the culture of sustainability and quality-of-life-focused public policies in communities and countries by sharing knowledge and following circular economic patterns while using locally available natural resources in networks of green communities, smart cities, and other initiatives building and capitalizing on regenerative efforts.

9. **Enable individuals and organizations by providing trusted information to make purchasing decisions.** Individuals and their self-organized teams can use their purchasing power: buying goods and services from responsible organizations and selecting net-positive products and services by using information from reliable sources such as validated consumer labeling.
10. **Grow public awareness and trust and thus encourage cultural transformation**. Convergence among the relevant metrics and standards can facilitate enhanced awareness and transparency. These, in turn, can contribute to a broadening cultural transformation that reflects and puts into daily socioeconomic practice a robust shift that promotes the genuinely regenerative paradigm (Robinson & Cole, 2015) enabling management of the multifaceted challenges of the climate crisis.
11. **Use a broadly accepted set of relevant metrics and standards to facilitate elaborative models,** carrying out simulations similar to **En-ROADS** (Climate Interactive, En-ROADS Climate Solutions Simulator) and making their findings broadly accessible and personally engaging through visualization by using tools such as dashboards, gamification, AR tools, the metaverse, and so forth.
12. **Foster growing public and individual awareness**. It can contribute to an emerging culture of care and stewardship and, in turn, catalyze both quality-of-life-focused new patterns of (mass) consumption favoring sufficiency and regenerative initiatives of economic players. This interplay can facilitate and capitalize on the emergence of positive feedback loops. An important feature of the dynamic (e.g., rolling) sets of metrics and standards serving effective accountability should be their capacity to facilitate due transformations. These should enable making visible, measurable, and controllable the aggregation of the feedback from changes contributing to these overarching transformations.
13. **Deploy and use technology effectively.** The technology requirements include tools that quantify and define engineering systems and infrastructure to consumption and environmental output levels across demographic, cultural, sustainability, educational, and socioeconomic (e.g., accountability) factors.

Issue 7: Technology does not always contribute to socioeconomic evolution towards ecosystem regeneration and sustainability goals

Background

Achieving meaningful change enabling societies and individuals to overcome the multiple crises characteristic for the Anthropocene (a proposed concept still under much discussion; Zhong, 2024) requires moving beyond mere compliance to a higher level of planetary progress and innovation. To accomplish this, a new green economy and sustainable alternatives must be inherently attractive at both individual and organizational levels. A strong sustainability in organizational context is driven by the acceptance of interdependence and a non-zero-sum approach. As these become core values, it generates a genuine potential for everyday economic activities to become regenerative. As societies shift towards recognizing the inherent benefits of sustainable living as the norm, our regular economic activities will not only fulfill genuine human needs but also contribute to the recovery from previously caused social harms and environmental destruction.

Indeed, a regenerative ecosystem, including the economy, enables conscious and active stewardship, where the restoration of previously affected elements becomes an inherent and fundamental task of economic activities by moving beyond merely avoiding harm to the environment and society (Daly, 1996; Shannon et al., 2022). However, such an approach requires radically different metrics and indicators compared to traditional sustainability. Even to overcome reliance on single and oversimplified indicators, such as growth and/or profit/profitability (Kuznets, 1962; Stiglitz et al., 2009), demands robust shift in measurement. Furthermore, the complexity of the Earth's ecosystem, as the immediate context for human socioeconomic settings, necessitates a mastery of a systemic approach. This involves considering the dynamic feedbacks among multiple factors, often generating interplaying loops. And it requires the conscious overcoming of limitations arising from the dominant logic of linearity and the related sets of metrics and indicators.

An effective organizational capacity for addressing the growing challenges of the emerging Anthropocene depends on managing a rapidly increasing volume of measured data and understanding their genuine dynamics unfolding at systemic level. To handle the expanding quantity of data that the rapidly growing number of sensors globally "pours upon us" a process-oriented approach must replace the commonly deployed variance methodology. This robust methodological challenge is intertwined with an underlying shift to process ontology bringing about significant and demanding epistemological alterations too. Following process epistemology requires powerful transformations in our, that is, people's, visions and perceptions, even in the language we use to perceive and describe reality. Rather than seeing these ontological and methodological approaches as diverse or even contradictory, we should combine them into a coordinated pluralistic view. By doing so, we can forge effective tool sets for perceiving and governing organizations and their activities, allowing us to carry out a praxis that reshapes reality (Van de Ven & Poole, 2005).

The ontological and epistemological claims emerging in connection with effectively addressing the robust challenges inherent in and generated by the multiple crises of the Anthropocene are inseparable from changes in the realm of metrics and indicators. It is crucial to acknowledge that the data required to handle the challenges of the complexity characteristic of the various feedback (sub-)systems are context-dependent. Radically altered methods and tool sets of measurements should be employed to reflect, monitor, and address multiple alterations that should aggregate into systemic—and systematic—transformations. These alterations concerning metrics and indicators are necessary for, and also constitutive of, a growingly urgent

socioeconomic shift to a genuinely regenerative systemic setting, enabling us to help ensure the survival of our civilization.

The urgent global need for a truly effective environmental science capable of understanding the Earth's ecosystem at a systemic level makes complex tasks more difficult. We are starting to realize that there are many "unknown unknowns" (Welch, 2023), even in fundamental fields such as the "operation" of the global water system, including the ocean. We must simultaneously tackle the lack of truly significant data while trying to manage a perceived data overflow that is more relative than real. We must grapple not only with *how* to measure but also with the proper identification of *what* and *when* to measure in a particular context.

Furthermore, the potential contributors to the necessary and increasingly urgent collective efforts should rely on state-of-the-art modeling and simulation capacities. These capacities can serve to build communities and reset individual and collective expectations of what is possible and worth pursuing. Such positive impacts can help the public to realize that transformations facilitating deep sustainability are fundamentally in their favor, instead of limiting or prohibiting individual life choices. Resulting demand changes can simultaneously trigger and catalyze attractive trends that both market and public players can capitalize on. Indeed, alterations in demand have robust transformational potential also for the supply side, catalyzing and shaping the emergence of an economy that aims to serve and improve harmony with nature. Its emergence and functioning require well-designed regulatory environments connected with target-oriented public funding and grants. Deploying mission-oriented public innovation management (Mazzucato, 2015, 2018) can provide a favorable framework for creating an attractive environment catalytic for progress.

Public financing, focusing on genuine moonshot projects (i.e., innovative projects with ambitious and lofty goals requiring intense collaborative efforts) carried out on Earth, can bring about significant multiplicative effects during the funding process (Mazzucato, 2015, 2018). Remunerating efforts that contribute to restoring previously generated damages can effectively motivate and incentivize long-overdue transformations. As an example, carbon removal research is both expensive and uncertain and doesn't align with typical company metrics on dashboards, resulting in underfunding. Recognizing both the need and the opportunity, Frontier Climate, a market maker facilitating funding for uncertain projects, is supporting carbon removal through an advance market commitment, pledging to purchase $925 million of permanent carbon removal between 2022 and 2030. Well-orchestrated public facilitation is required to achieve the profitability of economic activities that follow truly regenerative business models. The selection of proper sets of metrics and indicators can serve as drivers and monitoring tools for individual and corporate decision-making, shaping the daily operations of organizations in all sectors.

Developing accessible proper metrics that measure systemic impact presupposes the regular enactment of artificial intelligence, machine learning, and big data—the new technological "holy trinity." Similar state-of-the-art technology sets provide the capacity for both daily monitoring and modeling/simulation of potential ecosystem-level impacts stemming from the deployed governance patterns. However, qualitative and/or low-technology information collections for measurements and indicators should also be used to encompass aspects of the environment, communities, and societies that are not amenable to real-time, periodic, or historical data collection.

This is particularly relevant where access to remote locations, communications, or the internet is unavailable, fragmented, or unreliable, or where greater harm may result within society due to high-technology presence or intervention. It is important to think holistically and systematically about how to collect information about the entirety of planetary health. The collection and analysis of relevant datasets require integrating state-of-the-art technology with proper methodological tools, and the outcome of data processing must be freely available and consciously shared with affected stakeholders. Deploying such data-handling capacities should interplay with regulatory steps (European Union, 2018) and business strategies that drive and utilize the aggregation of local changes into the global transformations required to handle the growing challenges connected to climate change.

In the context of increasingly urgent transformations, the role of digitization and technology, in general, cannot be overstated. There is a pressing need for real-time, local, and systemic-level monitoring of emissions to rapidly influence and transform the characteristic patterns of energy production, usage, or land management, which are important sources of such emissions. More efficient energy and resource management (Shearman & Sterling, 2022) requires the proper combination of artificial intelligence, machine learning, and big data, while the widespread deployment of blockchain technologies can help improve transparency and catalyze trust (IEA, 2023).

A truly regenerative approach requires learning how to let nature carry out genuine systemic healing rather than placing high hopes on attempts similar to massive geo-engineering (IEA, 2023; IPCC, 2018). Measuring the complex feedback processes constitutive of the "routine operations" of nature, however, is a demanding task, also in the context of metrics and indicators. Sufficient and effective governance, security, data provenance, and privacy must be provided and maintained around all data and information collected for the purpose of planetary measurements and indicators. It is important that data provenance and ownership reside within the same society that the collected data represents, and that planetary monitoring does not evolve into a surveillance society. This could create additional harms to the planet and may be misused against individuals within the society.

The target-oriented enhancement of mass awareness and engagement, providing genuine empowerment and readiness to contribute to solutions, can capitalize on enhanced accessibility and effective visualization of data, using, among other tools, dashboards. The dashboard developed in accordance with IEEE Std 7010™-2020 indicates plausible links between human well-being and the impact of autonomous and intelligent systems. A similarly styled dashboard indicating the genuine impact of various attempts to decrease GHG emissions can facilitate mass awareness and contribute to self-organizing mass engagement, catalyzing demand-side changes, decreasing environmental footprints, and improving life quality. Also, serious gaming can facilitate massive voluntary contributions in multiple ways. Freely available interactive tools, similar to En-ROADS and C-ROADS developed within the MIT Sloan Sustainability Initiative (Climate Interactive, En-ROADS Climate Solutions Simulator), can be combined with the deployment of backcasting (pathfinding to nontrivial solutions by "walking back" from normative long-term positive visions) and role-playing (e.g., representing participants of the Paris climate conference and/or COP events).

For the emergence of a regenerative economy, both engineering and social technologies play a constitutive role, interplaying with innovative business models and often robust institutional alterations, including new approaches in economics and accounting. These are mutually catalytic phenomena that simultaneously presuppose and catalyze mass self-organizing, which, in turn, capitalizes on and drives robust cultural shifts. Their interplay can bring about a transformational socioeconomic dynamism, turning strong sustainability into a deeply rooted culture that reshapes daily practices far beyond formal compliance with external, formalized legal requirements. This regenerative path can emerge and sustain itself when technologies are designed and deployed following strong sustainability principles, enabling and capitalizing on enhanced harmony with nature.

Recommendations

Transforming the enactment of engineering technologies into drivers of a regenerative economy requires their conscious combination with social technologies (at multiple levels):

1. **Provide for maintenance and expansion of regulations into a complete portfolio to help prevent further environmental (and social) harms on a per-country basis**. This is of paramount importance.
2. **Verify that regulations are interoperable between jurisdictions.**

3. **Make use of rewards and penalties.** Regulatory decisions can reward or penalize market players (e.g., stakeholders, communities, and individuals) by aligning access to and costs of financing and resources with efforts and policies that genuinely contribute to preventing and addressing climate crisis-related issues. However, tools capable of enhancing profitability for regenerative efforts can be even more effective drivers of necessary systemic changes. These tools should be subsidized and incentivized by national governmental bodies, potentially leading to the growth of commercial companies and the development of new green markets.
4. **Verify that public resources, for example grants, are allocated and managed effectively.** Fragmented grants and subsidies, often triggered by powerful lobbies, frequently disperse available resources without incentivizing necessary (and overdue) transformations. Transparency in the use of such resources and achievement of sustainability is necessary for accountability and to maintain public trust. The availability of proper, effective metrics and measurements, along with publicly available capacities for truly data-driven decision-making, can be of crucial importance to effect the required changes.
5. **Select and deploy technology tools that quantify and facilitate the discovery, innovation, simulation, and implementation of engineering systems and infrastructure, considering consumption and environmental output levels across demographic, cultural, sustainability, educational, and socioeconomic factors** (e.g., accountability).
6. **Provide for the conscious development of state-of-the-art modeling and simulation capacities to meet the urgent global need for effective environmental science, capable of understanding the Earth's ecosystem at a systemic level.** This generates significant methodological challenges, connected with underlying and epistemological issues. These challenges, coupled with the importance of shifting our focus toward a regenerative ecosystem, influence and feed into the very perception and definition of metrics and indicators with the required quality and quantity of data, their sources, methods of collection, and processing.
7. **Employ visualization tools, similar to dashboards used by the International Monetary Fund (IMF), the Massachusetts Institute of Technology (MIT), and others, to increase awareness and facilitate changes in consumer demand** (e.g., IEEE Std 7010™-2020).
8. **Implement appropriate and relevant ethical governance around data collection to help ensure individual and societal privacy, ownership, and provenance are within the same society and that the planetary monitoring does not evolve into a surveillance society.** This should be in accordance with regulations, international agreements, such as the European Union's General Data Protection Regulation, and other applicable regulations as well as international standards, for example, as developed by bodies such as the IEEE Standards Association.
9. **Integrate, where appropriate, real-time data collection and analysis, quantifiable and reproducible, with low-technology and qualitative methods to provide a holistic picture of planetary health in both technology-heavy and non-technology environments.**
10. **Employ visualization tools,** for example, the open source tool **En-ROADS**, similar to dashboards used by the **International Monetary Fund** (IMF), the **Massachusetts Institute of Technology** (MIT), **C-ROADS**, and others, **to increase awareness and facilitate changes in consumer demand** (e.g., IEEE Std 7010™-2020). Other open source tools include the Basic Sustainability Assessment Tool (BSAT).
11. **Select the proper sets of metrics and indicators that can serve as drivers and monitoring tools for individual and corporate decision-making, shaping the daily operations of organizations in all sectors.**

12. **Think holistically and systematically about how to collect data and information about the entirety of planetary health, taking care not to ignore feedback loops.** The collection and analysis of relevant datasets require integrating state-of-the-art technology with proper methodological tools, and the outcome of data processing must be freely available and consciously shared with affected stakeholders. Deploying such data-handling capacities should interplay with regulatory steps (European Union, 2018) and business strategies that drive and utilize the aggregation of local changes into the global transformations required to handle the growing challenges connected to climate change.
13. **Consider using technology that is energy efficient and uses resources effectively.**

Issue 8: Metrics do not always validate compliance with standards, laws, and regulations

Background

The world is moving toward increased standards and regulatory requirements that include performance (such as maximum allowable levels of emissions), reporting and disclosure (such as reporting climate risk impacts and mitigation plans for investors), and assurance (such as standards for sustainability audits) requirements. To be enforceable, such standards need to rely on quality metrics.[10]

The development of robust standards is only meaningful if they are widely implemented, and this requires that the necessary metrics and underlying data for compliance be available and reliable. Currently, much of what gets reported are estimates, and reliable data is lacking. The precarious working conditions underpinning data labeling systems at the heart of AI developments should also be considered. Considerable effort will be needed so that metrics and measurement methods can keep pace with the standards under development, with a goal of harmonizing terminology, definitions, and metrics used to enhance consistency and understandability of reported results. This will require significant multidisciplinary collaboration among standard setters, those responsible for disclosures, and those responsible for measuring the factors and reported elements as well as auditors, rating organizations, consultants, and other market players.

Technology assists these standards by:

- Enabling more accurate capture of the underlying data (including data on emissions) with finer spatial and temporal granularity that are ultimately reported via the requirements contained in the standards;
- Facilitating more rigorous controls over the data once captured to help improve its integrity (this will assist both preparers and assurers in helping to validate the integrity and completeness of the data); and
- Facilitating greater trust in the source of products and raw materials, as well as the source and veracity of reported metrics, via the use of distributed ledger technology offering efficient data access and management in addition to immutability.

[10] See also the “Economics and Regulations” chapter for information on sustainability-related standards.

Recommendations

In order for standards and regulations to serve as a consistent means of assessing performance and facilitating accountability, compliance with such standards must be evidenced by quality metrics. To achieve this:

1. **Metrics required by regulators and standard setters should be well-defined (for example, in terms of allowable measurement approaches, expected level of granularity, etc.), consistent, and objectively measurable.**
2. **Verify that standards reflect appropriate expectations for using technology to improve accuracy, reliability, and objectivity when measuring, monitoring, and reporting on elements.** These expectations should be scalable and consider geographic (e.g., country) differences to reflect the realities of varying levels of technological maturity in different jurisdictions.
3. **Consider targeted benchmarking to help determine whether results are accurately presented when enforcing standards.** If, for example, every company in a particular jurisdiction is scoring poorly in a certain area but one company stands out as vastly better, is it doing something innovative and effective or is it greenwashing? Transparent data and effective traceability of the reported results can help determine this.
4. **Support the development of digital tools that can support a system of sustainability badges (e.g., British kitemarks) certified by trusted entities and that can further motivate and incentivize individuals and organizations to strive for progress in sustainability initiatives.** For example, digital systems could support:
    a. A sustainability rating system for companies and organizations that is similar to—and possibly combined with—credit ratings, which could ultimately integrate to better align corporate/organizational and planetary interests.
    b. Government/jurisdictional ratings that reflect environmental, social, and governance commitments and verified progress against those commitments. Such ratings could also recognize and give credit for supporting developing countries, marginalized communities, and so forth.

Further Resources

1. Gensler, Gary. "Statement on Proposed Mandatory Climate Risk Disclosures." U.S. Securities and Exchange Commission (SEC). 21 Mar. 2022.
2. International Sustainability Standards Board (website).
3. Task Force on Climate-related Financial Disclosures (TCFD) (website).

Issue 9: Lack of consistent, mandatory, enforced standards and interoperable regulations regarding sustainability measurement, reporting, and verification

Background

Standards, laws, and regulations for measuring, reporting, and independently verifying sustainability-related performance are numerous, not entirely aligned, and voluntary. Voluntary reporting can lead to de facto requirements through societal expectations and pressure, but it can also lead to inconsistency and greenwashing, either intentionally or through error and imprecise estimates.

Over the years, there has been an ever-growing number of organizations developing standards and methodologies for measuring and reporting sustainability-related metrics. The recent heightened spotlight on sustainability allows great opportunities for collaboration and progress but runs the risk of duplicating efforts, jockeying for position between organizations, and propagating inconsistencies between patchwork systems.

Seemingly with this risk in mind, many standard setters in this space are purposefully looking to converge, collaborate, and build on each other's work and, in some cases, are providing tables of concordance to show how systems align and connect. This helps users consider where standards align and where to promote different approaches so that the merits and interoperability of approaches can be assessed in a particular context.

In order for standards to be widely implemented, the necessary metrics and underlying data for compliance must be available and reliable. Broad implementation also requires coordinated action from regulators, lawmakers, the judiciary, and law enforcement. The complexity within and between these different stakeholder institutions leads to challenges such as inconsistent development and interpretation of environmental protection and regeneration mandates between jurisdictions and within any given jurisdiction (i.e., between different branches of government). There is a risk that political pressures will get in the way of progress, which has been suggested with respect to the 2022 US Supreme Court decision to limit the powers of the US Environmental Protection Agency. Similarly, major global challenges resulting from conflicts and wars threaten the will and ability of countries to take bold action toward progress and result in backsliding instead. For example, in May 2022, the G7 energy ministers had agreed to stop taxpayer-funded fossil fuel financing overseas by the end of the year, but this commitment was loosened in June of 2022, in response to the energy shortages resulting from Russia's invasion of Ukraine.

Consistent standards are also needed to require the independent verification (auditing) of reported results. The uncertainty that comes from reporting estimates and the lack of consistent globally recognized reporting standards adds to the challenge in setting high-quality assurance standards. Furthermore, there is a need that those applying the standards and providing assurance on the information reported are professionally competent to do so. As a result, there is a need for high-quality standards not only in reporting but in the provision of assurance as well. Such standards will encompass assurance, quality management, and ethics and independence.

Notwithstanding the need for consistent regulations and reporting requirements to be met by organizations and institutions, there are caveats that must also be considered:

- Requirements for hitting certain benchmarks should be sensitive to the context, such as whether the entity or organization is large or small, developed or developing, well-resourced or poorly resourced, and so forth.
- Incentivizing change needs to involve both the "carrot" of providing benefits and the "stick" of regulatory enforcement in order to shift the momentum.
- Requirements should allow for reasonable tolerances, to avoid tying the hands of organizations or institutions that are legitimately trying to improve and meet net-zero or net-positive results.

These challenges are inherently complex and further illustrate the need for global leaders to prioritize sustainable development goals over personal ambitions, short-term perceived gains, and jurisdictional differences.

Recommendations

1. **Globally recognized standards are needed to attain net-positive goals.** These standards are likely to be developed and promulgated by recognized international standards organizations, led by first-world countries, and can then be leveraged by local jurisdictional standard setters.
    a. **Standards for stakeholder reporting should not only reflect the information on how climate change and other sustainability factors are impacting the entity and how those risks are being managed and mitigated but also the impact the entity is having on the environment and social systems** and so forth. The even closer alignment and potential merger of ISSB and GRI should provide the multistakeholder sustainability reporting framework that is needed, leading to significantly improved connectivity with financial statements.
    b. Verify that assurance engagements are conducted in accordance with high-quality standards.
    c. **Use standards to guide design and development of products and services.** In addition to reporting and assurance standards, requirements for ethical decision-making are essential to guide behavior. To this end:
        i. Standards developed (and under development) by the IEEE Standards Association provide guidance on ethical design and development of products and systems including the application of technology.
        ii. International Codes of Ethics (including International Independence Standards) provide a basis for high-quality standards of professional ethics and independence, applying to both reporting activities and assurance engagements. Additionally, ongoing work in the technology space can help verify that the specific ethics implications of professional accountants utilizing technology are appropriately considered.
    d. **Standards should reflect a holistic multistakeholder approach, recognizing the interdependence of global systems, cultures, and contexts.** These standards need to be robust enough to reflect the breadth of relevant activities undertaken by organizations, stakeholders, communities, and individuals.

2. **All countries—and especially G7/G20 countries—should implement meaningful, robust legislation and regulations to achieve their stated commitments.** Reporting requirements agreed to under the Paris Agreement should be closely monitored and enforced.
3. **Standards should be enacted to require organizations to provide adequate information to consumers and / or purchasing agents for them to make purchasing decisions with sustainability criteria in mind.** For example, product labels should reflect the product's environmental, social, and/or governance impact so that consumers can evaluate cost and value more holistically and trace potential impacts of their purchasing decisions.
4. **Complying with (or exceeding the requirements of) standards should be adequately incentivized:**
    a. **Executive and senior leadership remuneration packages should adequately reflect expectations for meeting suitable sustainability metrics.**
    b. **Regulators and legislators should provide clear requirements for organizations, stakeholders, communities, and individuals with respect to standards and verify that they are enforced.** At the same time, however, there is a need to respect the realities within individual jurisdictions and be mindful of the need for flexibility and support for less resourced or less mature entities.
    c. **Governments should incentivize innovation to meet and exceed standards through tax policy, grants, and similar means.**
    d. **Governments should adequately price GHG emissions with carbon, methane, nitrous oxide, and other GHG emissions prices based on their vastly different global warming potential** (GWP).
    e. **Investors should engage with corporations and promote the need for sustainability to be embedded and take action against those companies and their boards that do not place sufficient importance on this.**
5. **As standards are developed, developers should seek out and embrace opportunities to harmonize standards and adopt the best ideas from the range of standard setters.** Collaboration must take precedence over competition. Wherever possible, common terminology should be used to avoid confusion. Consideration should be given to making requirements scalable in order to apply to organizations, communities, countries, and individuals of different size, maturity, resources, level of technology, context of operation, and so forth.
6. **Until appropriate standards become widely adopted, reporting should include sufficient detail regarding the underlying methodologies used.** Such transparency promotes the ability to apply an additive and iterative approach to achieve progress, regardless of which standards become more globally accepted. It will be important to provide for a clear transition from interim systems of measurement to the final accepted standards, including methods to determine and present comparative figures for interim results that reflect the final measurement methodologies chosen (i.e., so that an "apples-to-apples" comparison can be made between results of different periods).
7. **Standard setters should leverage technology to enhance the processes of collaboration and outreach during development to provide appropriate due process and to maximize diverse participation and acceptance and, ultimately, adoption and implementation.**
8. **Similarly, the agencies and organizations responsible for verifying, auditing, and certifying compliance with standards should employ appropriate digital methods to support and add reliability to their work, thereby building trust.**

Additional Resources

Evolving Standards Guidelines

Global Reporting Initiative (GRI):

GRI is an independent, international organization that provides widely used standards for sustainability reporting. The GRI Secretariat is headquartered in Amsterdam, the Netherlands. It has a network of regional offices to help support organizations and stakeholders worldwide.

Greenhouse Gas (GHG) Protocol:

GHG Protocol establishes comprehensive global standardized frameworks to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains, and mitigation actions.

Building on a 20-year partnership between World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), GHG Protocol works with stakeholders, industry associations, NGOs, businesses, and other organizations.

International Auditing and Assurance Standards Board (IAASB):

The IAASB is an independent standard-setting body that serves the public interest by setting high-quality international standards for auditing, quality control, review, other assurance, and related services and by facilitating the convergence of international and national standards. In doing so, the IAASB enhances the quality and uniformity of practice throughout the world and strengthens public confidence in the global auditing and assurance profession.

International Foundation for Reporting Standards (IFRS) and International Sustainability Standards Board (ISSB)

The establishment of the IFRS in 2023 issued the first International Sustainability Standards Board (ISSB) in 2023. The ISSB is an independent standard-setting body within the IFRS Foundation. IFRS Sustainability Standards are developed to enhance investor-company dialogue so that investors receive decision-useful, globally comparable sustainability-related disclosures that meet their information needs. The ISSB is supported by technical staff and a range of advisory bodies:

- Standards and frameworks
- IFRS Sustainability Disclosure Standards
- IFRS translations
- CDSB guidance and framework
- Integrated reporting
- SASB Standards
- TCFD recommendations

IEEE Standards and Publications

1. Adamson, G., J. C. Havens, and R. Chatila. "Designing a Value-Driven Future for Ethical Autonomous and Intelligent Systems." *Proceedings of the IEEE* 107, no. 3 (Mar. 2019): 518–525.
2. "IEEE Draft Model Process for Addressing Ethical Concerns During System Design." IEEE P7000™/D7 (20 April 2021): 1–83.
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7. Spiekermann, S. "From Value-Lists to Value-Based Engineering with IEEE 7000™." *2021 IEEE International Symposium on Technology and Society (ISTAS)* (2021): 1–6.

Standards Boards—Accounting

International Ethics Standards Board for Accountants (IESBA):

The IESBA is an independent standard-setting board that develops, in the public interest, high-quality ethics standards and other pronouncements for professional accountants worldwide. This includes the International Code of Ethics for Professional Accountants (including International Independence Standards), which establishes ethics requirements for professional accountants. The board also supports adoption and implementation, promotes good ethical practices globally, and fosters international debate on ethics issues faced by accountants.

International Sustainability Standards Board (ISSB):

International investors with global investment portfolios are increasingly calling for high-quality, transparent, reliable, and comparable reporting by companies on climate and other environmental, social, and governance (ESG) matters.

On November 3, 2021, the International Financial Reporting Standards (IFRS) Foundation Trustees announced the creation of a new standard-setting board—the International Sustainability Standards Board (ISSB)—to help meet this demand.

The intention is for the ISSB to deliver a comprehensive global baseline of sustainability-related disclosure standards that provide investors and other capital market participants with information about companies' sustainability-related risks and opportunities to help them make informed decisions.

The ISSB standards include a series of metrics (industry-based disclosure requirements) that cover a range of industries. These are substantively based on those of the Sustainability Accounting Standards Board (SASB), which has merged into the ISSB.

The industries covered are:

1. Consumer goods
    a. Apparel, accessories, and footwear
        i. Percentage (by weight) of raw materials third-party certified to an environmental and/or
        ii. Social sustainability standard, by standard
        iii. Number of tier one suppliers and suppliers beyond
2. Appliance Manufacturing
    a. Percentage of eligible products by revenue certified to an energy efficiency
    b. Certification
    c. Percentage of eligible products certified to an Association of Home Appliance Manufacturers (AHAM) sustainability standard
    d. Description of efforts to manage products' end-of-life impacts
    e. Annual production (number of units)
3. Extractives and mineral processing
    a. Building Products and Furnishings
        i. Total energy consumed
        ii. Percentage grid electricity
        iii. Percentage renewable
        iv. Description of efforts to manage product
4. Lifecycle impacts and meet demand for sustainable products
5. Financials
6. Food and beverage
7. Health care
8. Infrastructure
9. Renewable resources and alternative energy
10. Resource transformation
11. Services
12. Technology and communications
13. Transportation

Likewise, the GRI standards also contain various metrics.

International Federation of Accountants (IFAC):

IFAC is a global organization for the accountancy profession, comprising member and associate organizations in many different countries and jurisdictions, representing millions of professional accountants.

See, for example, Championing an Integrated Mindset: Driving Sustainability and Value Creation in which IFAC calls on businesses to integrate financial and sustainability information with an integrated mindset to make better-informed decisions that deliver long-term value creation—financial returns to investors—while taking account of value to customers, employees, suppliers, and societal interests.

Agreements/Frameworks

The Paris Agreement:

The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 parties at COP 21 in Paris, France, on December 12, 2015, and entered into force on November 4, 2016.

Its goal is to limit global warming to well below 2 °C, preferably to 1.5 °C, compared to preindustrial levels.

To achieve this long-term temperature goal, countries aim to reach global peaking of GHGs as soon as possible to achieve a climate neutral world by midcentury.

The Paris Agreement is a landmark in the multilateral climate change process because, for the first time, a binding agreement brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects.

A profile or dashboard of indicators (measuring innovation and change) should include the basics, for example:

- Ten committed outcomes
- Ten levers of change
- Aligned performance targets, indicators, and milestones

Ongoing contributions from expert teams should be undertaken to calibrate (or recalibrate) the proper sets of metrics and indicators that fit with the specific circumstances and the required outputs and outcomes. These teams must follow an interdisciplinary approach and be ready to dynamically rearrange their own composition in order to fit the concrete circumstances and the evolution of tasks in the various phases of transformation.

The Kunming-Montreal Global Biodiversity Framework (GBF) agreement

Many are calling this Biodiversity Framework the “Paris Agreement for Nature.” The following is information from the COP15 site:

> *The United Nations Biodiversity Conference (COP15) ended in Montreal, Canada, on 19 December 2022 with a landmark agreement to guide global action on nature through to 2030. Representatives from 188 governments gathered in Montreal for this important summit.*
>
> *COP resulted in the adoption of the Kunming-Montreal Global Biodiversity Framework (GBF). The GBF aims to address biodiversity loss, restore ecosystems and protect indigenous rights. The plan includes concrete measures to halt and reverse nature loss, including putting 30 percent of the planet and 30 percent of degraded ecosystems under protection by 2030. It also contains proposals to increase finance for developing countries—a major sticking point during talks.*

The stakes could not be higher: the planet is experiencing a dangerous decline in nature as a result of human activity. Up to one million plant and animal species may be threatened with extinction, many within decades.

The GBF consists of four overarching global goals to protect nature, including: halting human-induced extinction of threatened species and reducing the rate of extinction of all species tenfold by 2050; sustainable use and management of biodiversity to ensure that nature's contributions to people are valued, maintained and enhanced; fair sharing of the benefits from the utilization of genetic resources, and digital sequence information on genetic resources; and that adequate means of implementing the GBF be accessible to all Parties, particularly Least Developed Countries and Small Island Developing States.

The GBF also features 23 targets to achieve by 2030, including:

- Effective conservation and management of at least 30 percent of the world's land, coastal areas and oceans. Currently, 17 percent of land and *8 percent of marine areas are under protection
- Restoration of 30 percent of terrestrial and marine ecosystems
- Reduce to near zero the loss of areas of high biodiversity importance and high ecological integrity
- Halving global food waste
- Phasing out or reforming subsidies that harm biodiversity by at least $500 billion per year, while scaling up positive incentives for biodiversity conservation and sustainable use
- Mobilizing at least $200 billion per year from public and private sources for biodiversity-related funding
- Raising international financial flows from developed to developing countries to at least US$ 30 billion per year

Requiring transnational companies and financial institutions to monitor, assess, and transparently disclose risks and impacts on biodiversity through their operations, portfolios, supply and value chains.

**Figure taken from Protected Planet* (UNEP "COP15," 2022)

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