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Fostering sustainability through scientific literacy

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ABSTRACT
Humanity is facing unprecedented sustainability challenges, including climate change, biodiversity loss, and rising social inequalities. Addressing these complex issues requires not only scientific and technological innovations but also a scientifically literate society capable of making informed decisions. Scientific literacy goes beyond rote knowledge; it involves the ability to critically evaluate information, interpret evidence, and apply knowledge to real-world contexts (National Research Council [NRC], 2006). This paper examines the contribution of scientific literacy to foster sustainability through the four pillars of sustainable development: environmental, economic, social, and human. Evidence suggests that scientific literacy strengthens individuals' capacity to adopt sustainable practices, engage in democratic decision-making, and reduce vulnerability to misinformation (UNESCO, 2021). Furthermore, it is directly linked to the achievement of the 17 Sustainable Development Goals (SDGs), influencing areas such as food security, health, renewable energy, responsible consumption, and climate action (OECD, 2017). The analysis highlights that scientific literacy is not only an educational objective but also a societal imperative that empowers communities, reduces inequalities, and supports global partnerships. By integrating sustainability themes into education and public discourse, scientific literacy serves as a pathway toward building inclusive, resilient, and sustainable futures for all.

Keywords: Scientific literacy, sustainability, sustainable development goals, Education, resilience

INTRODUCTION

Humanity is currently facing unprecedented environmental challenges, including climate change, biodiversity loss, pollution, and resource depletion. These issues are no longer abstract global concerns but have become pressing realities in daily life. For example, the choking air pollution in New Delhi during winter regularly forces school closures and increases respiratory illnesses among children (WHO, 2021). Similarly, recurring droughts in regions of Maharashtra and Rajasthan disrupt agricultural productivity, directly affecting farmers' livelihoods (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2020). Such real-life scenarios highlight that sustainability is not just an environmental agenda but a survival necessity.

Addressing these challenges requires more than scientific advancements; it demands a scientifically literate society. Scientific literacy goes beyond rote knowledge; it encompasses the ability to critically analyze scientific information, interpret data, and make informed decisions that influence sustainable practices (National Research Council [NRC], 2006). For instance, a scientifically literate citizen is better equipped to evaluate the benefits and trade-offs of renewable energy projects, understand the ecological

consequences of single-use plastics, or engage in informed debates about water conservation policies. Empirical studies suggest that fostering scientific literacy directly strengthens people's capacity to address sustainability issues. Research by Leicht et al. (2018) emphasizes that integrating sustainability themes into education enhances critical thinking and problem-solving skills necessary for global citizenship. Similarly, a study on deep-sea mining education demonstrated that engaging learners in real-world environmental problems significantly improves scientific literacy and systems thinking, empowering them to make more sustainable decisions (Rauch et al., 2022).

Thus, cultivating scientific literacy is not only an educational goal but also a societal imperative. By connecting science education to real-life sustainability challenges, individuals and communities can become active participants in building a resilient and sustainable future.

SUSTAINABLE DEVELOPMENT GOALS AND ITS PILLARS:

The ACTNOW campaign for our common future is a dedicated effort by the United Nations member states, aiming towards the sustainability of a better future for all people and the planet. Here, sustainability means meeting the needs of the present without compromising the ability of future generations to meet their own needs (United Nations, n.d.). Plastic Free Schools (2024) explain the four pillars of sustainability, which emphasize environmental, economic, social, and human dimensions to promote values and encourage viability. Figure 1 below shows the four major pillars of sustainability along with their interconnectedness.

Figure 1

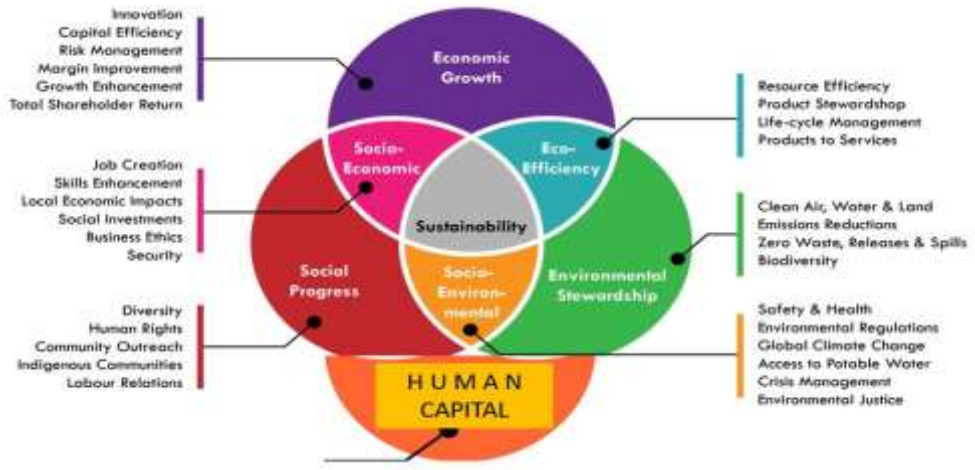

Figure 1: Four pillars of sustainable development (from Tatjana Mamula Nikolić, 2021)

This figure describes that there are four types of sustainability, which are environmental, economic, social, and human sustainability. Here human or "cultural" pillar isn't officially part of the UN's SDG framework; this concept is deeply integrated into the other three. Here, environmental sustainability focuses on the natural world, economic sustainability focuses on creating and maintaining stable and resilient economic systems, social sustainability focuses on ensuring fairness, equity, and well-being for all people, human sustainability focuses on recognizing the value of culture, tradition, and meaning-making for individuals and communities, which goes hand in hand with cultural sustainability.

Similarly, there are seventeen sustainable development goals adopted by the all United Nation members, those are accordingly: No poverty, Zero hunger, Good health and wellbeing, Quality education, Gender equality, Clean water and sanitization, Affordable and clean energy, Decent work and economic growth,

Industry innovation and infrastructure, Required inequalities, Sustainable cities and communities, Responsible consumption and protection, Climate action, Life below water, Life on land, Peace justice and strong institutions, Partnerships for the goals. Figure 2 below shows the seventeen Sustainable Development Goals (SDGs).

Figure 2

Figure-2 : Sustainable Development Goals(From) Sustainability | Strategies | International› SDGs: A challenge for sustainability policy

Here's a breakdown of the 17 SDGs arranged by the four pillars shown below in Table 1.

Table-1

ENVIRONMENTAL	ECONOMIC	SOCIAL	HUMAN
Goal 13: Climate Action **Goal 14:** Life Below Water **Goal 15:** Life on Land **Goal 6:** Clean Water and Sanitation **Goal 7:** Affordable and Clean Energy **Goal 12:** Responsible Consumption and Production	**Goal 7:** Affordable and Clean Energy **Goal 8:** Decent Work and Economic Growth **Goal 9:** Industry, Innovation and Infrastructure **Goal 12:** Responsible Consumption and Production	**Goal 1:** No Poverty **Goal 2:** Zero Hunger **Goal 3:** Good Health and Well-being **Goal 4:** Quality Education **Goal 5:** Gender Equality	**Goal 4:** Quality Education: A key aspect is promoting cultural diversity and a culture of peace and non-violence. **Goal 11:** Sustainable Cities and Communities: This includes protecting and safeguarding the world's cultural and natural heritage. **Goal 12:** Responsible Consumption and Production: This goal touches on cultural

		Goal 6: Clean Water and Sanitation **Goal 10:** Reduced Inequalities **Goal 11:** Sustainable Cities and Communities **Goal 16:** Peace, Justice and Strong Institutions	practices and traditions, such as food consumption, that are deeply ingrained in many societies. **Goal 8:** Decent Work and Economic Growth: This includes promoting sustainable tourism that creates jobs while promoting local culture and products. **Goal 16:** Peace, Justice and Strong Institutions: This pillar is essential for preserving cultural rights and preventing conflict. **Goal 17:** Partnerships for the Goals: This is a cross-cutting goal that emphasizes global collaboration. It represents the ultimate partnership of the human family to achieve a better future for everyone.

Role of Scientific Literacy in Fostering Sustainability

Scientific literacy plays a crucial role in achieving the Sustainable Development Goals (SDGs) by empowering individuals and societies to tackle complex global challenges. Here is how scientific literacy fosters and promotes the SDGs. Scientific literacy is the ability to understand, analyse, and apply scientific knowledge to make informed decisions and engage in public discourse (Sustainability Directory, 2025).

How scientific literacy fosters each pillar of sustainable development

1. Environmental pillar

Scientific literacy gives people the knowledge and skills to understand ecosystems, interpret environmental data (e.g., pollution measurements, biodiversity trends), evaluate scientific claims, and choose or support evidence-based policies and behaviours (recycling, energy conservation, biodiversity protection). This strengthens public support for environmental regulation, enables community participation in environmental monitoring (e.g., citizen science), and improves adoption of sustainable practices (UNESCO, 2021; OECD, 2017).

2. Social pillar

Scientific literacy improves health and risk-related decision-making (e.g., vaccination, sanitation), reduces vulnerability to misinformation, and empowers citizens to participate meaningfully in democratic debates about technologies and policies that affect social well-being. It supports education for sustainable development by building values and agency so communities can pursue equitable solutions (access to safe

water, health services, inclusive education). Citizen science and classroom ESD (education for sustainable development) programs link scientific understanding with social action and civic engagement. (Valladares, 2021).

3. Economic pillar

Scientific literacy builds the workforce and public foundations needed for innovation, technology adoption, and evidence-based policymaking that underpin green economic growth. Citizens and policymakers who understand scientific evidence are better able to invest in efficient infrastructure (clean energy, waste management), support R&D, and evaluate tradeoffs between short-term gains and long-term sustainability, all crucial for resilient and inclusive economies (Science for Sustainability, 2021).

4. People Pillar

Empowerment & Inclusion: A scientifically literate population can better understand health, nutrition, sanitation, and safety issues, empowering marginalized groups to make informed life choices.

Health literacy: Scientific literacy equips people to interpret medical advice, evaluate health risks, and adopt evidence-based practices (e.g., vaccination, nutrition, disease prevention), improving quality of life.

Equity in decision-making: People with scientific literacy can actively participate in dialogues about technology, climate policies, and innovations that affect communities, ensuring that decisions are inclusive and just.

Gender equality & education: Promotes access for girls and disadvantaged groups to STEM knowledge, breaking cycles of inequality and fostering social justice (Valladares, 2021).

How scientific literacy fosters each SDG

SDG 1: No Poverty

Scientific literacy empowers individuals to adopt technologies that improve agricultural yields and access to clean energy, which are crucial for economic stability in rural areas. It also helps communities understand and apply data to advocate for better social services and economic opportunities, directly combating poverty (UNESCO, 2017).

SDG 2: Zero Hunger

To achieve zero hunger, scientific literacy allows for the application of advanced agricultural techniques, such as precision farming and the use of drought-resistant crops, which increase food production and security (UN, 2021). It also helps individuals make informed decisions about food, nutrition, and safety.

SDG 3: Good Health and Well-being

Scientific literacy is fundamental to public health. It enables people to understand disease prevention, the importance of vaccination, and the scientific basis of medical treatments, which is critical for managing health crises and improving overall well-being (OECD, 2016).

SDG 4: Quality Education

Scientific literacy is a core component of quality education, promoting critical thinking and evidence-based reasoning. This skillset is essential for all citizens to navigate a complex world and contributes to the broader goals of sustainable development (UNESCO, 2017).

SDG 5: Gender Equality

Promoting scientific literacy, particularly among women and girls, helps break down gender barriers in STEM fields and ensures their full participation in developing scientific and technological solutions for a sustainable future (UN Women, 2020).

SDG 6: Clean Water and Sanitation

Scientific literacy is essential for understanding water purification processes and the management of water resources. This knowledge helps communities monitor water quality, advocate for improved infrastructure, and conserve water effectively (UN-Water, 2021).

SDG 7: Affordable and Clean Energy

Understanding the science behind renewable energy technologies, like solar and wind power, is crucial for their widespread adoption. Scientific literacy allows individuals and policymakers to make informed decisions that accelerate the transition to sustainable energy sources (IEA, 2021).

SDG 8: Decent Work and Economic Growth

A scientifically literate workforce is better prepared for jobs in high-tech and green industries. This drives innovation and creates sustainable economic growth that does not rely on environmentally harmful practices (OECD, 2016).

SDG 9: Industry, Innovation, and Infrastructure

Scientific literacy is the foundation for a society's capacity for innovation. It enables the development of new, resource-efficient technologies and resilient infrastructure, which are vital for modernizing economies and achieving sustainable development (UN, 2021).

SDG 10: Reduced Inequalities

By promoting scientific and technical education for all, especially in marginalized communities, scientific literacy helps to reduce inequalities and provides a pathway to social and economic mobility (UNESCO, 2017).

SDG 11: Sustainable Cities and Communities

Scientific literacy helps urban planners and citizens understand and apply principles of sustainable urban design, such as green infrastructure and efficient public transport, leading to healthier and more resilient cities (UN, 2021).

SDG 12: Responsible Consumption and Production

A scientifically literate consumer can understand the environmental impact of their choices, such as a product's carbon footprint and life cycle. This knowledge encourages more responsible consumption and supports sustainable production methods (UN, 2021).

SDG 13: Climate Action

Scientific literacy is essential for understanding the causes and consequences of climate change. It allows individuals to critically evaluate climate data and supports the public consensus needed for effective climate policies (IPCC, 2021).

SDG 14: Life Below Water

To protect marine ecosystems, scientific literacy is crucial for understanding issues like ocean acidification and plastic pollution. This empowers communities to advocate for and participate in marine conservation efforts (UNESCO, 2017).

SDG 15: Life on Land

Understanding the science of biodiversity and ecosystem management is key to protecting terrestrial ecosystems. Scientific literacy empowers individuals to participate in conservation and restoration projects and supports sustainable land use practices (UN, 2021).

SDG 16: Peace, Justice, and Strong Institutions

Scientific literacy fosters an informed citizenry that can hold leaders accountable for evidence-based policies on issues like public health and environmental protection. This promotes transparency and streng-

thens democratic institutions (UNESCO, 2017).

SDG 17: Partnerships for the Goals

Scientific literacy facilitates global partnerships by enabling effective communication and collaboration among researchers, policymakers, and civil society on complex scientific challenges, creating a common ground for shared progress (UN, 2021).

CONCLUSION:

Scientific literacy emerges as a cornerstone for fostering sustainability and achieving the Sustainable Development Goals (SDGs). It transcends the traditional boundaries of education by equipping individuals with the capacity to critically evaluate evidence, interpret scientific data, and make informed decisions that directly shape sustainable practices. By strengthening the four pillars of sustainability—environmental, economic, social, and human—scientific literacy empowers people to address climate change, protect biodiversity, promote social equity, and build resilient economies.

From ensuring food and water security to advancing renewable energy and reducing inequalities, the role of scientific literacy is evident across all 17 SDGs. A scientifically literate society is better positioned to challenge misinformation, advocate for evidence-based policies, and actively engage in collaborative global efforts toward sustainability. Ultimately, scientific literacy is not only an educational priority but also a societal necessity, enabling individuals and communities to become active agents of change. In this way, fostering scientific literacy contributes to building a sustainable, inclusive, and resilient future for present and future generations.

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