International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

# Progress in Science, Technology, and Innovation, and Looking Ahead to 2030 and Beyond: A Critical Review

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**Abstract**

In the era of unprecedented scientific and technological advancements, it is essential to look ahead to the future. We have examined the trends of science, technology, and innovation and applied this knowledge to identify the key areas in policy-making, increasing productivity, and achieving sustainability. In addition to creating a robust economy and an innovative society, we should invest in the next generation of scientists and technologists. This report identifies areas where further improvement can be made in teaching quality, increasing participation rates among underrepresented groups, better preparing students for their careers after graduation, and structuring programs that encourage collaboration between institutions with diverse disciplinary backgrounds. In the 21st century, scientists are working to understand the origins of our universe and how it came to be; develop new materials for medical implants; make machines that can learn by themselves; listen for signs of intelligent life beyond Earth; and increase understanding about what makes us human through advances in genetics, neuroscience, and psychology. In this report, we present an overview of progress in science, technology, and innovation and the major challenges for 2030, and highlight the areas for investment that could accelerate progress.

## Introduction

Over the past few decades, tremendous advancements in science, technology, and innovation have transformed the world. Some of the breakthroughs in science and technology that have shaped our lives include the internet, personal computing, mobile devices, biotechnology, renewable energy, artificial intelligence (AI), quantum computing, space exploration, nanotechnology and sustainability. The rapid advancement of science, technology, and innovation (STI) has become a crucial force behind socioeconomic change. The internet, personal computers, mobile technologies, biotechnology, renewable energy, artificial intelligence (AI), quantum computing, space exploration, nanotechnology, and innovations focused on sustainability have all changed human lifestyles, organizational procedures, and economic structures over the past few decades. These technological advancements interact dynamically to affect long-term sustainable development, productivity, accessibility, and capacity for innovation. The growth of digital economies and knowledge societies has been made possible by fundamental digital technologies, such as the internet, personal computers, and mobile devices, which have improved information flow, connectivity, and digital inclusion. Concurrently, advances in biotechnology and renewable energy have improved environmental sustainability, agricultural

productivity, and healthcare outcomes. More recently, it is expected that cutting-edge technologies like artificial intelligence (AI), quantum computing, nanotechnology, and advanced space exploration will act as transformative enablers, redefining future development pathways and addressing complex global challenges.

The current study conceptualized science, technology, and innovation as important independent constructs that impact various developmental outcomes, such as economic growth, social transformation, sustainability, and future-readiness, based on these viewpoints. In order to demonstrate how technological advancement catalyzed systemic change, the conceptual framework incorporates both established and emerging technologies. This process is mediated by elements like accessibility, policy support, innovation ecosystems, and sustainability orientation. This framework offers an organized perspective for comprehending the connections between technological developments and their wider societal effects.

**Literature Review:**

Richard. Li. (2018) observed that the internet has revolutionized the way we communicate, work, and access information. It has also opened up new avenues for commerce, education, and entertainment [17]. Personal Computer Global Market Report (2021) saw that the development of personal computers has made computing accessible to everyone, leading to an explosion in software development, e-commerce, and digital entertainment [14]. Whittington & Bar (2015) found that the advent of mobile devices such as smartphones and tablets has made computing even more accessible and has led to the development of new applications and services [22]. OECD International Futures Project (2030) detected that the advances in biotechnology have led to breakthroughs in medicine and agriculture, including the development of new drugs, vaccines, and genetically modified crops [13]. Charles et al. (2019) detected that the development of renewable energy sources such as solar and wind power has helped to reduce our dependence on fossil fuels and has paved the way for a more sustainable future [3]. Looking ahead to 2030 and beyond, several areas of science, technology, and innovation are likely to continue to evolve and shape our world. Stone, Peter et al. (2022) advances in artificial intelligence are expected to transform many aspects of our lives, from transportation to healthcare to education [19]. Chowdhury et al. (2020) perceived that quantum computing has the potential to revolutionize computing, enabling us to solve complex problems beyond the capabilities of classical computers [4]. Yingzhuo (2018) seemed to suggest that space exploration is expected to continue, focusing on developing new technologies for space travel and habitation and the search for extraterrestrial life [23]. Aithal & Aithal (2021) observed that nanotechnology will likely play a key role in developing new materials, electronics, and medical treatments [2]. Kornberger et al. (2021) predicted that sustainability would continue to be a key area of focus, emphasizing the development of new technologies and practices [9]. They accepted that the Sustainable Development Goals (SDGs) adopted by the United Nations in 2015 recognize the importance of science, technology, and innovation (STI) as key drivers of sustainable development. STI can contribute to achieving the SDGs by enabling the development and deployment of new technologies, improving productivity, and fostering economic growth [9]. Since 2015, there have been some notable achievements in STI that have contributed to the SDGs. For example:

a. Renewable energy technologies have become more affordable and accessible, leading to increased deployment and use of clean energy sources.

b. Advances in agricultural technologies helped to improve yields and reduce food waste, contributing to food security.
c. Digital technologies have increased access to information, education, and healthcare services.
d. There have been significant discoveries in medical research, such as the innovation of new vaccines, which have helped to address global health challenges.

STI has seen various positive, encouraging advancements since 2015, but much more needs to be done to meet the SDGs. Addressing the gaps will require increased investments in R&D, greater technology transfer and diffusion, and policies that promote greater inclusion and equality in science and technology [8] [18].


**Figure 1: 17 Sustainable Development Goals**

Source:www.un.org/sustainabledevelopment;www.undp.org/content/undp/es/home/sustainable-development-goals; www.who.int/topics/sustainable-development-goals/test/sdg-banner.jpg

**Research Gap**

There is a significant lack of integrative frameworks that comprehensively analyze the combined impact of conventional and emerging technologies on sustainable socio-economic development, despite a wealth of literature detailing individual technological developments and their sector-specific effects. Most of the current research takes a disjointed approach, focused on individual technologies or isolated results, thus ignoring the interrelated and cumulative effects of several innovations working concurrently. Also, future-focused viewpoints that connect present technological trends with long-term sustainability and development objectives have received little empirical attention. To minimize this gap, the current study offers a thorough conceptual framework that integrates various technological fields to more fully explain how they work together to shape societal change both now and in the future.

**Gaps in STI Progress:**

There are also significant gaps in STI progress that need to be addressed to achieve the SDGs:

a. There is still a significant digital divide, with many people in developing countries lacking access to the internet and other digital technologies.
b. While there have been advances in renewable energy, fossil fuels still dominate the energy mix, and progress on reducing greenhouse gas emissions has been slow.
c. Research and development (R&D) investments remain concentrated in a few countries, and many developing countries lack the resources and capacity to invest in R&D.
d. Gender disparities in science and technology remain a significant challenge, with women underrepresented in STEM fields and technology companies.

**Proposition:**

The propositions of harnessing STI for the SDGs by 2030 and beyond are the following:

Harnessing science, technology, and innovation (STI) for the Sustainable Development Goals (SDGs) requires a long-term vision and sustained commitment to research and development, technological innovation, and collaboration between different categories of stakeholders. By 2030 and beyond, the following areas could be prioritized to enhance the contribution of STI to the SDGs:

**Investment in R&D:**

Surana, Singh & Sagar (2020) and Prieto-Jiménez et al. (2021) observed that increased investment in research and development (R&D) can significantly accelerate the advancements in vital areas, like renewable energy, sustainable agriculture, and health technologies [21] [16]. Therefore, greater R&D funding by countries and organizations is essential to initiate technological innovation and support the effective achievement of the Sustainable Development Goals (SDGs).

**Proposition 1:**

*The attainment of the Sustainable Development Goals (SDGs) is accelerated by increased investment in research and development (R&D), which has a positive impact on technological innovation in renewable energy, sustainable agriculture, and health technologies.*

**Technology transfer and diffusion:**

With the development of new technologies, it should be ensured that they are transferred to developing countries and diffused to communities that need them most. This requires collaboration between governments, the private sector, and civil society to disseminate the sharing of knowledge, expertise, and resources. The COVID-19 pandemic has disrupted the global education system, and as a result, governments in almost every nation have temporarily suspended traditional face-to-face learning. The faculty members had to change the teaching process to a face-to-face method, and were replaced by an online device, such as laptops, computers, or mobile phones, through which classes and examinations needed to be conducted [5, 15].

**Proposition 2:**

*Effective collaboration among governments, the private sector, and civil society facilitates the transfer and diffusion of digital technologies to developing countries, which in turn enables continuity and adaptation of higher education teaching and learning during crises such as the COVID-19 pandemic.*

**Innovation ecosystems:**

Miles, Ozcan & Alexander (2016) found that to promote innovation, the country's prerequisite is to develop robust innovative ecosystems that provide the necessary infrastructure, human resources, and financial support for researchers and entrepreneurs. Innovation hubs, incubators, and accelerators can help foster collaboration and create an environment that supports innovation [12].

**Proposition 3:**

*The development of strong national innovation ecosystems, supported by supportive infrastructure, skilled human capital, financial resources, and institutional mechanisms such as innovation hubs, incubators, and accelerators, positively enhances the capacity to promote innovation and entrepreneurial growth of a country.*

**Inclusivity and equality:**

To harness the full potential of STI for the SDGs, there is a need to ensure that science and technology are inclusive and accessible to everyone. This means promoting gender equality in science and technology, ensuring that people in developing countries can access digital technologies, and addressing other forms of inequality and discrimination.

**Proposition 4:**

*Inclusive and equitable access to science, technology, and innovation through gender equality, digital inclusion in developing countries, and the reduction of structural inequalities is a critical enabler for effectively harnessing STI to achieve the Sustainable Development Goals.*

**Monitoring and evaluation:**

Adu-Gyamfi et al. (2022) confirmed that STIs are instrumental to the SDGs; it is important to establish clear monitoring and evaluation frameworks that track progress towards the goals. It requires data and indicators that could help to measure the impact of STIs on sustainable development.

However, achieving the SDGs through STI requires a long-term and collaborative approach that involves governments, the private sector, civil society, and other stakeholders. By prioritizing investment in R&D, technology transfer and diffusion, innovation ecosystems, inclusivity and equality, and monitoring and evaluation, we can maximize the influence of STI on sustainable development [1].

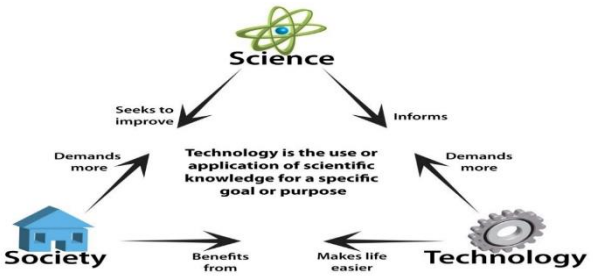


**Figure 2: The Relationship between Science, Technology, and Society**

Source: Ihueze, Christopher Chukwutoo & Okpala, Charles & Okafor, Christian & Okonkwo, Ugochukwu. (2015). Harnessing

**Proposition 5:**

*The Sustainable Development Goals (SDGs) are greatly aided by science, technology, and innovation (STI); however, the success of STI depends on the development of strong frameworks for monitoring and evaluation, ongoing investment in R&D, efficient technology transfer and diffusion, inclusive innovation ecosystems, and long-term multi-stakeholder cooperation between governments, the private sector, and civil society.*

**Proposals for key STI milestones**

Proposals for key STI milestones, performance targets, high-impact techs, and scientific breakthroughs, and proposals for science and tech policy and cooperation until 2030 and beyond are indispensable to ensure that science, technology, and innovation (STI) are harnessed effectively to achieve the Sustainable Development Goals (SDGs) [20]. Some possible proposals are:


**Figure 3: Integration of National, STI, and SDG Plans and Key Actors**

Key STI milestones and performance targets:

a. Increase global R&D spending to 3% of GDP by 2030, with at least 1% dedicated to basic research.
b. Double the share of renewable energy in the global energy mix by 2030.
c. Increase agricultural productivity by 70% by 2030.
d. Develop and deploy new health technologies that can address emerging health threats.
e. Increase the number of women and underrepresented groups in STEM fields and technology companies [6, 7].

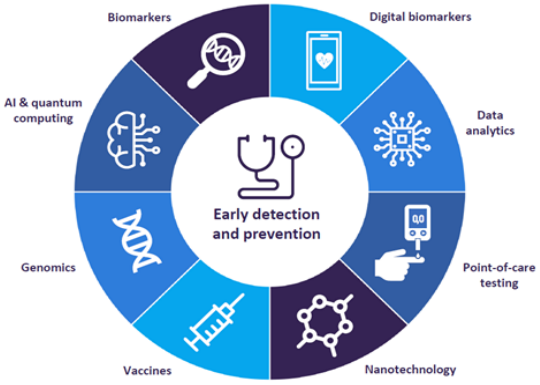


**Figure 4: To gain more insights into the top future technologies and their impact on the healthcare sector in 2030**

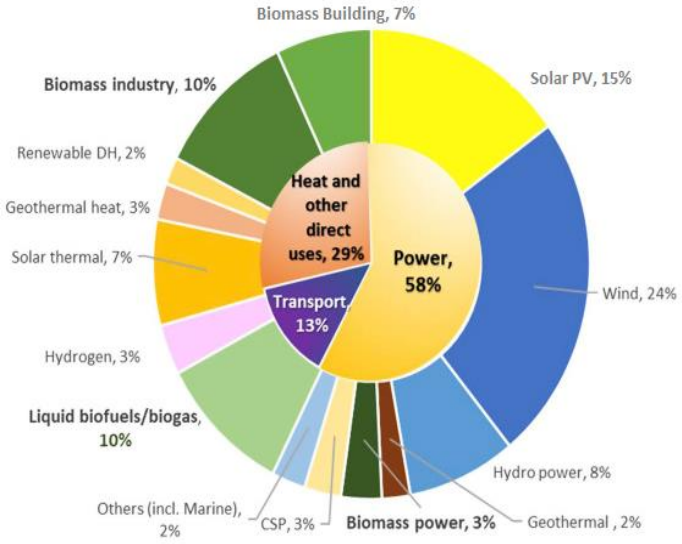


**Figure 5: Breakdown of the renewables use in total final energy consumption terms, RE map 2050.**


**Figure 6: Scheme of the multi, intra, and interdisciplinary nature of Food Security.**

**High-impact techs and scientific breakthroughs:**

a. Develop advanced energy storage technologies that could make renewable energy sources more reliable and affordable.
b. Develop new materials with unique properties that could be used in different applications, from medicine to energy.
c. Develop and deploy precision agriculture technologies that could improve crop yields and reduce waste.
d. Develop new vaccines and treatments for infectious diseases and non-communicable diseases.
e. Develop artificial intelligence and machine learning technologies that can help address a wide range of global challenges [4][10].

**Science and tech policy and cooperation:**

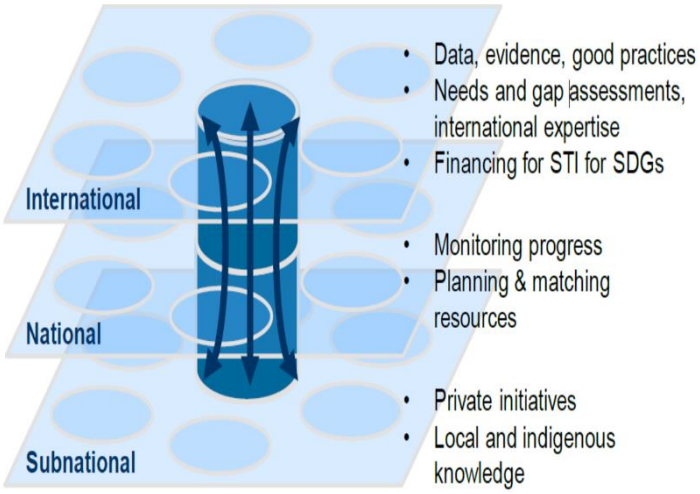


**Figure 7: Three levels of STI for SDG Roadmaps**

a. Foster international collaboration on research and development to accelerate progress towards the SDGs.
b. Increase investment in science and technology education and training to build a strong STEM workforce.
c. Promote open access to scientific research and data to facilitate knowledge sharing and collaboration.
d. Create incentives for private sector investment in sustainable development technologies and innovation.
e. Ensure that science and technology policies are inclusive and address equity issues [15][12].

## Conclusion

The Sustainable Development Goals (SDGs) provide a framework for global action to create a more sustainable future for all. Beyond 2030, it is crucial to build on the progress already made toward achieving the SDGs and continue working toward a more equitable, resilient, and sustainable world.

To achieve the goals, it might be necessary to focus on creating more sustainable and inclusive economies that prioritise social and environmental well-being. This will require investing in clean energy, sustainable agriculture, and circular economies, among other areas. It will also require promoting economic growth that benefits everyone, not just a few.

Additionally, we need to prioritize social development, including education, healthcare, and social protection. Addressing poverty and inequality will require targeted policies that empower marginalized groups and promote social inclusion.

To accomplish these objectives, we must promote science, technology, and innovation. This includes investing in research and development, promoting technology transfer and diffusion, and creating innovative ecosystems supporting entrepreneurship and collaboration.

Achieving the SDGs beyond 2030 will require continued commitment, collaboration, and innovation from governments, the private sector, civil society, and other stakeholders. By working together towards a shared vision of a sustainable future, we can create a more resilient, equitable, and sustainable world for future generations.

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