Sustainability and Clean Technology: A Technological Perspective

G.U. Fayomi\textsuperscript{a}, S.E. Minib, O.S.I. Fayomib, d A. Odu
cami\textsuperscript{c}, O.O. Oyeleke\textsuperscript{a}

\textsuperscript{a}Department of Geography, University of South Africa, Johannesburg, South Africa
\textsuperscript{b}Department of Mechanical Engineering, Covenant University, Ota, Ogun state, Nigeria
\textsuperscript{c}Department of Chemical Engineering, Covenant University, Ota, Ogun state, Nigeria
\textsuperscript{d}Department of Chemical, Metallurgical and Materials Engineering, Tshwane University of Technology, Pretoria, South Africa

Corresponding author. Tel.: +2348036886783.

Abstract

Sustainability and the need to ensure sustainable development is an ever important issue in this present age and time, owing to the ever increasing demand for the earth's resources, coupled with an increase in human population, human demand for rapid industrialization and the demand for energy, these have all led to adverse negative impact on the immediate environment, as a result of the strain imposed on the environmental limits of the earth's carrying capacity. A thin line needs to be drawn, and this paper seeks to provide a comprehensive review on the subject matter of sustainability, including the different dimensions and the cross-disciplinary views on sustainability, the interdependence and inter-relationships between these dimensions, human effort in ensuring sustainability across all facets, the development of the sustainable development goals, and the challenges faced in the actualization and implementation of these goals. The achievements of the sustainable development goals were examined as well as the possible trade-offs resulting from limited resource use in the SDGs, the role of technology was also examined and how modern science and innovation can be used in driving our sustainable future.

Keywords: Sustainability; Environment; Technology; Economy; Clean

1. Introduction

The terms sustainability and sustainable development have otherwise been used interchangeably across various institutions and sectors, although both concepts are similar. A proper understanding of the inherent definitions of both concepts is necessary in order to properly discern and grasp their meaning, implications and applications. By way of distinction, sustainable development is concerned with ensuring economic growth and development associated with human related comfort, geared towards attainment of a better quality of life, relative to the environment's carrying capacity, while sustainability tends to focus more on developing an ecological balance between economic growth and the environment, with an emphasis on ecological balance, in which economic growth occurs solely within the limits of the natural resources and not at the expense of the natural environment, i.e. sustainable development focuses on the capacity of people to coexist within the confines and environmental limitations of the planet while facing the challenges of economic growth, while sustainability implies economic growth being in balance with the ecological development, while firmly taking into view the environment [1, 2]. In some other context, in differentiating between sustainability and sustainable development, it has been argued that sustainability refers to the perceived goal, of attaining homeostasis (human-environment equilibrium), while sustainable development stands and represents the methodology and process (holistic approach) taken to achieve it [3].

However, in the context of this work, both terms will be used interchangeably, sustainability also by nature, has no universally accepted definition. It has diverse definitions and interpretations that cuts across various fields and spheres of human endeavour, with as many as over 100 definitions.
encompassing fields such as ethical, political science, sociology, ecology, economics etc., however, the most widely acclaimed and accepted of these, defines sustainability as the efficient allocation and use of resources in the present without compromising the availability of the resources for future use by the next generations, i.e. the ability to meet our present needs without compromising that of future generations in satisfying their demands and needs. This is the most universally accepted definition of sustainability as obtained from the Brundtland commission’s report [4, 5].

Sustainability as a concept is naturally associated with a wide variety of initiatives such as renewable fuel sources, environmental protection, and the reduction in the emission of greenhouse gases, all as a means of maintaining balance in the ecosystem. However, this has evolved over time, and sustainability encompasses much more than this, exemplified in three fundamental dimensions, which are: economic dimension, social dimension and environmental development, these are interrelated approaches and should not be based individually, but rather as an integrated whole [6, 7] argued that discarding as little as one of the cadres of sustainable development in effect would disrupt the definition and concept of sustainability as a whole. This study delves into and explains the different approaches and elements to sustainability to better inform its perception, its interrelations, how it should be viewed, and the role of technology and the need for technology in driving and ensuring sustainability.

2. Concepts of Sustainability

Sustainable development as a concept comprises three core elements (aspects) are shown in figure 1. These are the economic, environmental and social development, these elements of sustainability are not mutually exclusive, neither are they an option between economic progress and environmental conservation, but rather, it encompasses both economic and social growth, relative to ensuring environmental balance. Therefore, these aspects are not to be viewed in isolation as they are interrelated and must be integrated together for sustainability to be generally satisfied within the context of its own definition, and these models are fused together by institution. Therefore sustainability is effectively a compromise relationship between these three aspects of development [6].

2.1. Economic Approach

The economic aspect of sustainability is built on the theory of capital convertibility, developed by Solow in 1986, and the concept of maximum income by Hicks-Lindahl. The goal is to maximize consumption and the generation of cash inflow (income), while maintaining capital which yields beneficial outputs [5]. In terms of economy, sustainability also looks to ensure adequate production of utility, goods and services on a defined and continuous basis in order to ensure manageable levels of government and external debt, in seeking to avert economic sectoral imbalances which can lead to deficiency of agricultural or industrial production [8]. Another goal of the economic sustainability is to secure an optimal amount of stock of assets or capital for use by the future generation.
2.2. Environmental/Ecological Approach

In terms of environment, sustainability seeks to ensure stability of ecosystems, i.e. biological, physical systems, and also a stable level of resource allocation in terms of natural and mineral, in order to avert cases in which natural and renewable resources are over-exploited. In short, it seeks to preserve natural resources for future generations and conservation of nature. This also factors in the maintenance health and vitality of ecosystems, biodiversity and atmospheric stability [8]. Environmental sustainability sets up and sustains the parameters and conditions, within which both nature and humanity can co-exist in productive harmony. This also sustain standard of living in ways that don’t necessarily deplete resources by ensuring future generations can sustain themselves [9].

2.3. Social Approach

Sustainability in terms of ensuring social balance must ensure adequate distributional equity of resources, the provision of social services to all cadres of society, not only that, it must also prevent social degradation; similar to how an environment suffers degradation. Social balance implies all social factors such as: culture, spirituality, customs, living conditions, traditions as well as relations between persons. It also entails provision of the basic educational and health related requirements to all classes of society, and serves as a fundamental foundation of democracy. The social aspect of sustainability ensures that the fundamental principles of existence upon which an individual is defined by is preserved, from human rights to the philosophical aspects of an individual’s behaviour and attitude [6]. For economic and environmental sustainability to be adopted, they must first be accepted on a social basis and level. Social sustainability also seeks to preserve the health and limit the vulnerability of both social and cultural systems [9].

2.4. Institution

This can be defined as the intervening agreements and strategies involved in sustainable development, a set of benchmarks and standards used in decision making with regards stages of processes, what type of actions are limited and of shat type are possible [7, 10, 11] According to [12] the application of policy with regards to sustainability (environmental, social or economic) is dependent on institution, since an effective and properly operating institution is required for sustainability in the accomplishment of social, economic and environmental goals instituted by the society.

3. Global need for Sustainability

Due to the rapid developments made by humankind in terms of scientific and technological innovations, which signalled the industrial revolution, and growth of mega-industries across the turn of 20th century which although lead to an increase in standard of living, coupled with an unprecedented economic growth rate and a rapid increase in population growth rate around the world, has led humanity to stretch and put serious strain on the natural resources and environmental limits of the earth [13]. This has been characterized by challenges such as an increase in global warming and changes in the climatic and weather conditions of the earth which has led to a destabilizing effect on the natural environment with adverse consequences such as an increase in the occurrence of natural disasters and also an increase in the sheer veracity and intensity of these disasters, all of these have led to an increase in awareness about the need to ensure sustainability both for the present and future generations to come [10,14]. This has led to a paradigm shift from exploitative industrialism, which was embodied during the industrial revolution to a more sustainable-friendly approach in which all countries are making active efforts in adopting sustainable development as a working model for driving economic change [22].

4. Role of Technology in Advancing Sustainable Development

Technology and the use of modern innovation has an plays a prominent role in advancing sustainable development, selectively looking at the goals of sustainable development, from health, to energy, economy, infrastructure, etc., all these are aspects that can be improved through the application of technological ingenuity [15], from energy generation, to agriculture, to renewable
resource systems, to energy storage, sustainability in these areas can be attained by harnessing technological advances, through solutions without negative repercussions on the environment. In terms of energy generation, traditionally, fossil fuel sources have been used as a medium for energy generation, however these fossil fuel sources also constitute considerable amounts of pollution to the ecosystem in different phases, from exploration, through refining, and even the combustion process to obtain energy, all these processes constitute considerable amounts of pollution, which are not in line with the sustainable development goals. As such, there is a need to develop alternative new forms of energy with reduced emissions or pollution neutrality, these forms of alternative energy/green technology are renewable energy and clean energy, from solutions like improved efficiency conversion systems for fossil fuels, to bio-oils and bio-fuels aimed at reducing harmful pollutants and the consumption of fossil resources, technology and innovation serves as a means of developing this renewable and clean energy, while also ensuring fair usage of available resources [16].

Another practical solution to driving sustainable development is green technology, which aims to stem the impact of climate change for future generations [21]. However, sustainability in technology use must also be evaluated to ascertain if the increases in productivity attained, are at the same time ensuring the preservation of natural environment and not depleting it

4.1. Green Technology in Environmental Sustainability

The goal of green technology is to modernize and substitute outdated practices and methods responsible for damage and depletion of natural resources with more efficient and sustainable methods, through use of renewable energy, which is energy generated from sources that are naturally replenished on a human timescale, such as wind energy, solar energy, geothermal energy, hydropower, tidal energy as opposed to use of fossil fuels which constitute the release of greenhouse gases and thus pollution and also preserve our natural resources [17]. Better forecasting allows for improved production and management of renewable resources, improved efficiency of wind turbines and PV cells allow for better harvesting of inherent energy in natural sources, the development of efficient energy storage devices such as ultra-capacitors, phase change materials etc., allow for better collection and storage capacity for energy

Other applications of green technology include the use of green buildings and e-Gain forecasting, e-Gain is a technology that utilizes weather forecasting methods to predict how a building will be affected by subsequent weather patterns, which can then be applied to reduce the excessive and unnecessary use of heat, and also reduce to energy consumption and greenhouse gas emissions, while green buildings, also referred to as sustainable buildings refers to structures that are resource efficient. Examples include: The Netherlands’ Live able wind turbine, self-sustaining buildings and cities.

4.2. Green Technology in Economic Sustainability

Green technology can be applied in business and industries to minimize environmental impacts, lean technologies and best practices can also be adopted to minimize waste and cut usage of resources thereby minimizing consumption. Technological advances finds application in all areas of an economy, from health, transport, business etc. the use of hybrid and electric cars have made a radical impact in helping cut carbon emissions while also providing jobs and new avenues for innovation and development. The use of modern advances in science has enabled the synthesis of advanced drugs in ensuring health and vitality of people, neuro-surgical operations are made possible by continuous advances in technology. Also in creation of green cities as small businesses that utilize local produce, partake in recycling operations, which helps to reduce our environmental footprint while also conserving resources altogether [18]. In other areas of food security, use of green technology in sustainable agriculture and fisheries has eliminated the need for harmful pesticides, mutative antibiotics, which has led to products that won’t affect our long term health while also preserving our natural resources [19].

4.3. Technology in Social Sustainability

The perceived impact of emerging technologies on the development of societies is felt across various parties and domains, and the proper application of these technologies requires the consideration of environmental, economic, political, cultural and social contexts and their effects.
Technology has been utilized in improving the overall standard of living of people; it is employed in analysis for better allocation of resources [20]. Other applications of technology in ensuring sustainable development include:

- Use of effective micro-cogeneration, polygeneration and load-sharing approaches and also clustering capabilities in heating networks
- New renewable energy and wastewater performance comparisons
- Power generation, use of hybrid and concentrated solar power generation systems
- Improved control strategies for energy storage applications, battery packing aging processes, super capacitors
- Improved and efficient fuel mixtures with nanoparticles additives [17].

5. Conclusions

Sustainable development as a concept is ubiquitous, and throughout history, scholars have attempted to obtain a singular definition which would satisfy all fields of study, and the inability to find such a universal definition explains the universal nature of the subject matter, as it is subject to diverse interpretations based on the field on endeavour and perception it is applied to, however, the most universally accepted definition was that defined by the Brundtland commission in which sustainability was defined as the kind of development which secures present demand and needs without inhibiting the capability of future generations to satisfy their own needs. It was also noted that sustainable development is multidimensional, and as such requires a balance of the economic, social and environmental components, integrated via the institutional system. The integrated definition of these three components gives a complete holistic view on sustainable development. In the basis of this, it was identified that technology has a leading role to play in driving and ensuring sustainable development in all areas of society, and the different applications were concisely explored, in terms of how it is developed, exploited and utilized not only in meeting human needs but ensuring ecological balance. The role of advances technology in developing renewable resource systems, cleaner energy production sources as well as more efficient energy storage devices has greatly contributed to the development of sustainable development, from the use of green technology to renewable systems (wind and solar), to the improved efficiency of conventional energy generation and management processes across various industries.

Acknowledgements

The author acknowledges Covenant University for the financial support offered for the publication of this research.

References

[1] T. Waas, J. Hugé, A. Verbruggen and T. Wright, Sustainable development: A bird’s eye view. Sustainability, 10 - (2011) 1637–1661.
[2] J. Wang, S. Ding, M. Song, W. Fan and S. Yang, Smart community evaluation for sustainable development using a combined analytical framework. Journal of Cleaner Production, 193 (2018) 158–168.
[3] B. Reyers, M. Stafford-Smith, K. H. Erb, R. J. Scholes and O. Selomane, Essential Variables help to focus Sustainable Development Goals monitoring. Current Opinion in Environmental Sustainability, 26–2, (2017) 97–105.
[4] P. P. Rogers, K. F. Jalal, and J. A. Boyd, An Introduction to Sustainable Development (Google eBook). (2008) 416.
[5] A. Pawłowski, Development Have ? Sustainable Development, 90 (2007), 81–90.
[6] Ceigis, R., & Streimikiene, D. Integration of Sustainable Development Indicators into Sustainable Development Programmes. Engineering Economics Behavioral Sciences, 216 (2005) 7–12.
[7] J. Platje, Institutional Capital as a Factor of Sustainable Development. Technological and Economic Development of Economy.
14 (2008) 144–150.

[8] J. M. Harris, Basic Principles of Sustainable Development. Global Development and Environment Institute. 4 (2000) 00-004https://doi.org/10.1016/S0959-6526(01)00061-0

[9] K. J. Bowen, N. A. Craddock-Henry, F. Koch, J. Patterson, T. Häyhä, J. Vogt and F. Barbi, Implementing the “Sustainable Development Goals”: towards addressing three key governance challenges—collective action, trade-offs, and accountability. Current Opinion in Environmental Sustainability. 26–27, (2017), 90–96.

[10] O.S. I. Fayomi, I.P. Okokpuije and M. Udo, The Role of Research in Attaining Sustainable Development Goals. In IOP Conference Series: Materials Science and Engineering 2018 Sep (Vol. 413, No. 1, p. 012002). IOP Publishing.

[11] V. Strezov, A. Evans and T. J. Evans, Assessment of the Economic, Social and Environmental Dimensions of the Indicators for Sustainable Development. Sustainable Development. 2 (2017) 242–253. https://doi.org/10.1002/sd.1649.

[12] J. D. Moyer and D. K. Bohl, Alternative pathways to human development: Assessing trade-offs and synergies in achieving the Sustainable Development Goals. Futures, 105 (2018) 199–210.

[13] W. Kates, Robert, M. Thomas, Parris and A. Leiseowitz, Anthony, What is sustainable development, Goals, Indicators, Values and practice, Environment - Science and Policy for Sustainable Development. (2016) 1–13

[14] J. R. Fitchett and R. Atun Sustainable development goals and country-specific targets. The Lancet Global Health, 2 (2014) 503. https://doi.org/10.1016/S2214-109X (14)70282-7

[15] J. Baleta, H. Mikulčić, J. J. Klemeš, K. Urbaniec and N. Duić, Integration of Energy, Water and Environmental Systems for a Sustainable Development. Journal of Cleaner Production, 215 (2019)1424–1436.

[16] G. Krajačić, N. Duić, M. Vujanović, S. Kilkış, M. A. Rosen and M. A. Al-Nimr. Sustainable development of energy, water and environment systems for future energy technologies and concepts. Energy Conversion and Management. 125 (2016) 1–14.

[17] S. Kilkis Sustainable development of energy, water and environment systems index for Southeast European cities. Journal of Cleaner Production. 130 (2016) 222–234.

[18] T. Pukšec, P. Leahy, A. Foley, N. Markovska and N. Duić, Sustainable development of energy, water and environment systems. Renewable and Sustainable Energy Reviews, 82 (2018) 1685–1690.

[19] G. G. Singh, A. M. Cisneros-Montermayor, W. Swartz, W. Cheung, J. A. Guy, T. A. Kenny and Y. Ota, A rapid assessment of co-benefits and trade-offs among Sustainable Development Goals. Marine Policy. 93 (2017) 223–231.

[20] N. Markovska, J. J. Klemes, N. Duić, Z. Guzović, B. V. Mathiesien, H. Lund and J. Yan, Sustainable development of energy, water and environment systems. Applied Energy. 135 (2014) 597–599.

[21] F. Owolabi, T. Akinwumi, D. T. Adetula, and U. Uwuigbe. "Assessment of sustainability reporting in Nigerian industrial goods sector." (2016): 383-386.
[22] U. Uwuigbe O. Teddy, O.R. Uwuigbe, O. Emmanuel, O. Asiriwuwa G.A. Eyitomi and O.S. Taiwo, Sustainability reporting and firm Performance: A bi-directional approach. Academy of Strategic Management Journal, 17 (2018)1-16.