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A review on environmental-friendly energy multidisciplinary exposition from goals to action

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ABSTRACT

The world over-reliance on fossil fuels as a source of energy has led to a tremendous increase in environmental and climate change distresses. It has negatively impacted the ecosystem such that, if not checked, it will lead to dire consequences to the current population and jeopardize future generations' well-being. The natural capital, being finite, can only sustain the world for several years. This paper analyses how technical, technological, economic, social, institutional, and political dimensions interact with sustainability. It also proposes the best approach to achieving sustainability goals proposed by the United Nations (UN). This empiric analysis paper relies on the literature review not analytical models. It comes up that there is no single methodology that will maintain sustainability requirements by 2030 independence, and every effort toward suitability needs specific measures of a unique nature. A multifaceted approach is ideal. It will take individuals, corporates, civil societies, non-state organizations, and governments to sustain sustainability significantly. All the above-listed dimensions influence environmental sustainability making it imperative to use relevant approaches in pursuing energy and environmental sustainability. Besides, cross-sector and intergovernmental methodologies are vital in achieving sustainable development. Therefore, this study focused on sustainability pillars expositions from lessons learned and examples, including political leadership, governance, policy, legislation, etc. That can influence sustainable development dimensions in achieving overall energy and environmental sustainability objectives. So, sustainability needs to be a global top priority list and executed as a matter of urgency.

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1. Introduction

According to the world energy foundation, sustainability has become the most popular word in environmental conversations and is applicable in many disciplines, as mentioned above. What was its origin? Renewable energies are not sufficient until they are sustainable. What does it mean? It originates from the German word "Nachhaltigkeit," which means "sustained yield." In the mid-19th century, it translated to mean not harvesting more than the forest produces [1]. The ecosystem's ability to supply its essential functions while retaining biodiversity over time is called ecological sustainability. The dependence on fossil fuels and the overuse of natural resources increased until the 1980s, when the word sustainability began to imply the relationship between human activities and the environment [2]. Therefore, sustainable development is the advancements that meet today's needs without compromising the ability to meet future needs [3]. Many states have renewed their energies towards sustainability; let's take a case study of Turkey. The government has considered an energy-efficiency law and tax benefits to promote biofuels. In Turkey, renewable energy resources make the second largest contributor to domestic energy production after coal, mainly hydro, biomass, solar, and geothermal [4]. The idea of sustainability has risen to a global norm with many governments, organizations, and individuals pursuing its realization. Globally, an increase in social responsibilities in the monitoring of ecological and social impact is apparent. Many scientific researchers have pursued meteorology, oceanography, economics, engineering, anthropology, science, and technology. In addition, several governments, non-governmental organizations, and social movements are actively playing their role. However, unsustainable dynamics are still apparent in many jurisdictions. In this chronicle, we assert that sustainability is a complex phenomenon related to different practices, times, actors, and places [5]. Therefore, it covers various approaches and perspectives.

Energy sustainability is the provision of energy services to all people in a way that does not compromise the environment and well-being of humankind at present and does not impact future generations as well. Energy supply causes environmental concerns like ozone depletion, air pollution, deforestation, and radioactivity. These effects and degradation of the environment negatively impact humanity. Carbon dioxide is a byproduct of fossil fuel

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combustion and is released into the atmosphere. Therefore, energy, environment, and sustainable development are closely related, and wholesome address is essential [6]. In the past, researchers are focused on geophysical and social pressures to shift from fossil fuels to renewable and sustainable energy sources. Also, the factors at play have been put into consideration and examined. It concludes a multifaceted approach is ideal for achieving the green objectives due to the complexity of energy and environmental sustainability within technical, technological, economic, social, institutional, and political dimensions.

Energy finds use in all life facets, making it possible for the ecosystem, human civilizations, and life to exist. Therefore, the standard of living of any nation is a function of energy in some way that supplies naturally and is finite (fossil resources) or available infinitely like renewable energy resources [6]. For a successful energy management practice, integration of different operational phases factors like utilities and government policies, social psychology, economic concepts are exigence to understand the market barriers to energy efficiency. A transition towards a circular economy has been accelerated by depletion of resources and deterioration of the environment. From an economic point of view, wastes are mostly seen as resources, and several directives on the waste streams have been delivered in the last years [7].

The most critical environmental problems are acid rain, ozone depletion and global warming. The ecosystem services perspective can further develop environmental sustainability, reinforcing the value pertaining to non-monetary ecological qualities and functions. Therefore, to maintain and advance human well-being, environmental sustainability objectives must be considered. This can be done by considering ecosystem services as a fundamental component of human well-being [8]. Various environmental sustainability indicators are reported in the literature [4,9–11]:

- Gross Domestic Product (GDP)
- Human Development Index (HDI)
- Environmental Sustainability Index (ESI)
- Dashboard of Sustainability (DS)
- Well-being Index (WI)
- Ecological Footprint (EF)
- Living Planet Index (LPI)
- Direct Material Consumption (DMC)

Apparently, there are many influencing factors on environmental sustainability, e.g., geographical factors, theater conditions, nature parameters, etc. For example, the most challenging issue on environmental matters in the Iceland area is the loss of vegetation through wind erosion [12]. As a result, it becomes a challenge to grow vegetables on sites again and progress environmental sustainability. In addition, the growing sector of metal production, especially aluminum production, has led to more carbon dioxide emissions to the environment. Road transport has also largely contributed to carbon dioxide emissions. Furthermore, as the Iceland economy heavily relies on fishing, the fishing vessels combust fossil fuels that negatively affect the environment, like increased ecosystem toxicity on biodiversity. The solution to this is fueling the intensive fishing plants with renewably generated electricity in the place of fossil fuel combustion [12].

Exergy is the result of the interactions of substances under consideration and the common reference substances in the natural environment [13]. Using mathematical models, exergy is used to overcome problems related to environment and ecosystem; it is also used to understand and explain important traits of ecosystems. The process of translating ecological indicators and terms to thermodynamics uses exergy being the measure of the distance from chemical equilibrium. When environment and ecology are integrated with exergy, they provide a fresh approach to improving ecological and environmental management and give significant potential to perform this function [13]. Eco-exergy can be a suitable indicator to indicate how an ecosystem is developed and track its performance against objectives. Industrial ecology is used to provide principles being used as a tool of change. The principles in this industrial ecology are industrial symbiosis, technological food webs, closed industrial ecosystems, and industrial metabolism.

Authors in [6], on sustainability, energy, and development, proposed twenty-six sustainable energy indicators for cities divided into environmental, economic, social, territorial, and political dimensions. According to this study, it is critical to measure development in a city and formulate criteria for monitoring progress towards sustainability. The selection of energy fuels, production technologies, and delivery modes impacts the economic, social, and environmental spheres. Therefore, it is apparent that policymakers should measure current and future effects of energy use on health, society, water, air, and soil to ensure their sustainability. Energy is an impetus to social and economic welfare, eradicating poverty, and improving living standards. However, it originates from fossil fuels, which are considered environmentally unsustainable. There is always a risk or waste during energy conversion, even if translation technologies are employed, and the pollutants, when emitted, cause detrimental health and environmental effects. Energy is essential in sustainable development. Efficient energy supply is a prerequisite for economic growth. Besides, ecological and human disasters are closely tied to energy supply. It focuses on equity, which promotes universal energy access. Oil, which is the primary energy source in cities, is non-renewable and causes environmental pollution. Renewable energy sources like biomass, sunlight, hydropower, and wind, are environmentally friendly, which calls for local, regional, and global ecological re-thinking. Since measuring sustainability is an amalgam of many indicators, finding their quantitative measurement is daunting, but they can be expressed in biophysical terms. Authors in [14], reviewed renewable energy sources, sustainability issues,

and climate change mitigation, asserted a persistent increase in energy demand for social and economic development, welfare, and health, but the earth is static. The greatest challenge is to secure energy requirements and curb its contribution to climate change and global warming. Increased use of renewable energy is paramount in reversing climate change and meeting future generation's energy demands. The study focused on available opportunities to utilize renewable energy, energy security and access, social and economic development, decrease in environmental and health effects, and climate change mitigation. The challenges associated with exploring renewable energy include daily carbon emission, market failure, lack of knowledge, and inaccessibility to raw resources for future renewable reserves. The study proposed policy changes in case of deploying may achieve the goal of renewable energy. Marc A. Rosen [15] reported influencing factors on energy sustainability, including harnessing sustainable energy sources, utilizing energy carriers, increasing efficiency, reducing the environment's impact, and promoting socioeconomic acceptability. Socioeconomic factors include affordability, equity, land use, lifestyle, and aesthetics.

Further, advanced tools like exergy analysis can improve efficiency and life cycle analysis for environment analysis. Marc A. Rosen seeks to examine key factors that, if implemented, will achieve energy sustainability in a global context and emphasize the technical aspects. The critical elements identified in this release are significantly advantageous; they can help identify, develop, and implement strategies that will lead to a societal shift towards overall sustainability. Authors in [16] proposed an interdisciplinary framework for regulating lasting energy system changes and focuses on socio-technical transitions and new institutionalism concepts. The pursuit of mitigating climate change depends on the transformation of how energy is produced and utilized, and the alteration needs an enabling environment. This study reports that political, contingent, and institutions govern and mediate between sustainable change and forces for continuity, and policy and governance are, therefore, critical in achieving a viable change agenda.

2. Technical sustainability

In most civilizations, the levels of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) exceed the normal. Profound changes have occurred in addition to the atmospheric concentration. The variations include global climate change, increased surface temperature, decreased ocean PH, shift in precipitation patterns, and sea levels. The changes occur due to the burning of fossil fuels, deforestation, and agriculture [17]. The world would have to transform energy systems into sustainable options quickly. The main contributors' gases to the greenhouse gas emissions are [18]:

- Carbon Dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)
- Chlorofluorocarbons (CFCs)
- Hydrofluorocarbons (HFCs)
- Hydrochlorofluorocarbons (HCFCs)
- Perfluorocarbons (PFCs)
- Sulfur Hexafluoride (SF_6)

Fossil fuels are carbon-based and readily found on the earth's surface. The power arises from the decomposition of plant and animal remains, which takes millions of years. It is the most popular energy source because of the ease with which it is transported and the high concentration of energy it offers. However, the use of fossil fuels is not sustainable. Petroleum is limited in supply. If fossil energy in the subsurface gets depleted, the world's energy demand will be unmet. The number of reserves, however large it may be or innovation of extraction technologies, have a finite end and can only last several years. Another drawback of using fossil fuel arises because 42% of the world's oil originates from the Organization of Petroleum Exporting Countries (OPEC) [19]. Some producing states are politically volatile and have links to terrorist networks; therefore, it gives them financial power to execute terror. Besides, fossil fuel use is detrimental to human health and the environment. For instance, coal-fired power plants emit particulate matter and mercury, which causes respiratory illness and death, especially among the elderly and children [20]. Also, burning fuel leads to climate change. Greenhouse gas carbon dioxide is a byproduct of burning fuel, and its increasingly accumulating in the atmosphere. The accumulation causes sea level rise, melting glaciers and sea ice, increasing the frequency of heatwaves, and leading to extreme weather conditions and droughts [21]. Lastly, burning diesel and coal produce sulfur dioxide gas, which is corrosive and suffocating in nature. Petrol also gives nitrogen oxides, which dissolve in water to form acid rain, harming plants, animals, and monuments [22]. The welfare of future generations is at stake if the world does not act swiftly.

Half of the world's land finds its use in agricultural practices [23]. Agriculture has exerted pressure on biodiversity, and several displaced species are potentially facing a risk of extinction. Food production accounts for one-quarter of the global greenhouse gas emissions. Agricultural food production, post farm processing, and distribution contribute to emissions. Nitrous oxide released by fertilizers and manures contributes to the accumulation of CO_2 in the atmosphere.

Moreover, deforestation for agricultural purposes reduces vegetation, which recycles CO_2. Barriers to significant energy transitions are tenable [23]. A balance in the use of land for energy-related activities, agriculture, and recreation is paramount. This tradeoff is often challenged by technologies that use large pieces of land, electricity,

wind turbines, and bioenergy. Besides, some people consider renewable energy technologies detrimental to the environment; however, damaging environmental aesthetics is not suitable for well-being and sustainability. These forms of fuels are considered clean and environmental-friendly [24]. Besides, they provide environmental protection, a pollution-free environment, economic benefits, and energy security.

3. Technological sustainability

The emergency of formation and communication technologies (ICTs) in energy and environmental resource management has aroused interest among scientific researchers. Similarly, it has sparked a debate among policymakers who strive to promote green technologies to mitigate carbon emissions [25]. Some of the sectors that technology is influencing include energy, public infrastructure, water, agriculture, manufacturing, economics, and waste management. The world must create more energy-efficient societies that use resources responsibly and organize the industrial process to recycle waste. Therefore, technology is the pathway to sustainability. Energy and environmental sustainability heavily depend on technologies' evolution to reduce fossil fuel use or use them in a less-polluting manner. For instance, sustainability depends on renewable energy innovations, public acceptance, and safety on nuclear power [26]. Green or clean technology describes new processes, practices, and applications that substantially replace existing technologies to decrease environmental risks and ecological scarcities. This segment discusses green technology's different perspectives on the sectors mentioned earlier to phase out fossil fuels. All told, there are some challenges towards green energy technologies deployment as [27]:

Developing countries find it expensive to fund the costly research and development of green technologies. Basic needs become a priority as technology becomes a luxury need.

- Stiff and stereotypical government policies and conservative culture of thinking also challenge the implementation of technology.
- Lack of knowledge and appreciation of the benefits of green technology on the environment and well-being.
- Incompatibility of infrastructure and lack of extra support in harnessing green technology is another innovation challenge.
- Non-productive environmental impact evaluation processes.
- The benefits of green technology in the current and future generations are overwhelming.

4. Economic sustainability

The economist assumes that natural resources are limited and focus on resource allocation has met the reality of the finite nature of natural capital. A belief that technological advancements would replenish the earth has hit a snug. The global economic system's up-scaling has strained the natural resource base, and an intervention is paramount. Economic sustainability restrains the use of natural capital and does not seek sustainability at the environment's expense. Therefore, replacing economic growth with economic development has become commonplace, qualitative instead of quantitative growth. Fashioning urban designs such that they offer the public's needs while maintaining their naturalness is not easy. Most definitions and focus of sustainability major on activities that impact the environment. Whereas that is true, the bias towards the atmosphere is insufficient in addressing the subject. Many factors are at play, deals with economic factors. There are four main material aspects to consider [28,29]:

1- Economic performance

2- Market presence

3- Indirect economic impacts

4- Procurement practices

Critical measures for financial performance include economic growth, inflation, and unemployment. Other critical factors include national debt, disposable income, income inequality, investment levels, and exchange rate. Besides, poverty levels and the human development index are also crucial in measuring economic performance [30]. Both the developing and developed nations exert some level of environmental stress. For instance, developing countries experience rapid population growth, inefficient technology, inadequate health systems and governance, and low income per capita. As a result, they emphasize on economic growth, which takes precedence over the environment. On the other hand, developed countries have a high income per capita, sound healthcare systems, and improved living standards. This state of affluence impacts environmental degradation, which arises from industrialization [31].

Economic growth is a primary objective for many nations across the world. A country that achieves economic growth increases the capacity to meet individual needs, eradicate poverty, and improve living standards. Besides, economic growth can protect the environment by creating reserves, parks and formulating applicable policies. According to the Kuznets curve (Figure 1), environmental degradation increases with increased income per capita, but only to a certain point beyond which it decreases. When countries achieve their development plan, they tend to focus on renewable energies [10,32].

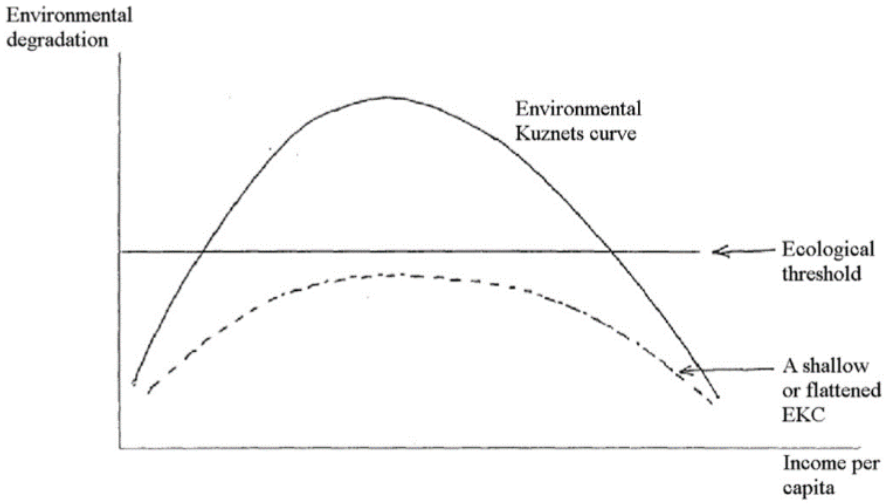

Figure 1. The environmental Kuznets curve [10].

However, rapid economic growth spurs excessive use of natural capital resources and produces more waste products, leading to environmental degradation and exhaustion. If not controllably executed, economic growth can overshadow ecological concerns. On the other hand, some researchers have noted that people value ecological amenities as development occurs. For example, it is not until they achieved their economic objectives that industrialized countries began focusing on their environmental problems [33]. Even if wealthy countries can reduce pollution, the growth will eventually stress the ecosystem. Therefore, economic development impacts the environment, and environmental degradation will hinder economic activities in the long run.

The international community has realized that through sustainable development, the world can foster growth and protect the environment at the same time. Sustainable development encompasses meeting basic needs and improving quality of life, democracy and respect of human rights, and job creation through education, innovation, social cohesion, and environmental protection [34]. Research conducted proved that a high economic growth rate in developing countries degrades the environment [35].

5. Social sustainability

There are few theoretical and empirical studies regarding social sustainability, yet climate change poses a serious social threat. Environmental externalities are distributed geographically and among people leading to risks, vulnerabilities, and social polarization. The basis of the social aspect of dimension is the fact that equality and interdependence of people in the community are essential in well-being. Opportunities, wealth, and resources should be equitably distributed to achieve long-term sustainable development. Security, human rights, food, education, housing, and healthcare should be accessible to all. Moreover, the protection and development of new social values, capital, and solidarity with marginalized groups are essential in developing social competence [36]. Therefore, conceptualizing and operationalizing the social pillar of sustainability is critical, which can be pointed out as follows [36–38]:

- Dimensions of social sustainability: Robert Prescott-Allen [36] provides essential elements of the human well-being index.
- Good health: Citizens enjoy equitable healthcare services and long lives in perfect health.
- Right population: The human population is maintained within the bounds of human and natural resources.
- Household wealth: Individuals, families, and households have sufficient income to guarantee basic needs and decent lives.
- National wealth: Communities in any state have sufficient resources to support enterprises and prosperity.
- Knowledge: Citizens are educated and innovative, hence coping with changes, living sustainably, and attaining their full potential.
- Culture: Freedom to hold spiritual views, creativity, and self-expression.
- Freedom and governance: Respect for human rights and dignity. Individuals are free to make personal decisions, and institutions being open, clean, and useful.
- Peace and order: Peaceful co-existence among communities, little crime, and violence.
- Household equity: Sharing burdens and benefits among household or group members fairly.
- Gender equity: Both females and males have equal opportunities.
- Social sustainability in business: It is a proactive approach in identifying and managing the impact of

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business on the value chain, employees, and local communities. It focuses on the relationships between people, organizations, and societies.

6. Political sustainability

Political intention to get things done is critical in energy and environmental sustainability. A policy integration encompassing the formulation of guidelines, support, and execution machinery will actualize its theoretical concepts. Moreover, the coordination of governmental and non-governmental actors needs a structural organization to increase efficiency. For example, a transport infrastructure that links public health and urban centers and ensures safety to wildlife, pedestrians, and cyclists is essential. Whereas there is a global trend in green strategy and policy formulation, many institutions and groups pursuing sustainability lack a strong political or administrative force behind them. One of the significant barriers to sustainability is the lack of support from political leadership and economic departments or ministries [39].

In 2012, Rio de Janeiro hosted political leaders worldwide for the United Nations Conference on Sustainable Development. In the conference, the leaders committed to using means to perpetuate sustainability within their reach, political or otherwise [40]. However, the actions undertaken by policymakers, civil societies, and businesses have not reversed unsustainable dynamics. Therefore, sustainable development is a global political issue, and the formulation of environmental policies for sustainability is a governance issue. Therefore, an overhaul is essential to recognize sustainability as a political issue and make policies from a cosmopolitan perspective.

Political of green energy structures are at the core of the transformation towards sustainable development. Governments can utilize a set of instruments to initiate structural changes called "green energy policy." Such policies are fundamental for achieving a green economy. Meanwhile, the procedures depend on other systems that harmonize with other policies like trade and public investment mandatory. Moreover, green energy policies need to meet specific standards.

According to [41], few significant action measures advise green energies shaping and planning in a technologically uncertain environment and seek to nurture new technologies to make them commercially viable. And they should spread over a long time to take care of the long-term transformation process. Also, they should provide directionality, narrow technological development corridors, and accelerate innovation.

Governments use regulation, subsidies, and tax incentives to promote the green economy. However, it cannot achieve much single-handedly. The state needs to incorporate non-state actors, groups, and societies. To attract non-state actors relevant to green transformation, the government needs to attract investment by making significant economic sector changes to guarantee profitability. It can catalyze the shift with incentives that redistribute more profit to clean assets. Research conducted in northern Italia provides that territorial policymakers need to formulate policies that focus on indicators that are of little concern to people, the unexploited opportunities [11,42].

7. Institutional sustainability

One of the sustainable development pillars is the institutional framework for sustainable development. A strengthened institutional framework is critical for sustainable development. It responds effectively and coherently to current and future sustainability challenges and bridges gaps implementing the plan. In addition, the institutional framework aims to integrate and align the rest of the sustainability pillars and dimensions and be inclusive, transparent, and viable. The UN sustainable development goals provide what the institutional framework entails with specific requirements [43–46]:

- Integrating the dimensions of sustainable development in a balanced manner.
- Putting into consideration relevant cross-cutting issues and is based on an action- and result-oriented methodology of implementing sustainable development.
- Providing the importance of interlinkages and uses a systematic approach in handling issues and challenges at appropriate levels.
- Enhancing efficiency, transparency, and effectiveness by enhancing coherency, reduce overlap and fragmentation, and promoting cooperation.
- Covering all countries and nations of the world in decision-making.
- Providing for review and stocktaking on the progress of implementation of the sustainable plan.
- Allowing participation of the civil society and stakeholders to enhance public participation, transparency and improve partnerships.
- Involving top political leadership in providing guidance and identifying specific measures that promote sustainability.
- Considering the role of financial institutions in sustainability. The local and international financial institutions play a central role in their policies, decisions, and strategies that promote sustainable development.

According to [43–46], financial institutions should be committed to sustainability. They should integrate ecological limits, economic justice, and social equity in their cooperate philosophy. Sustainability is to be but on equal footing with profitability, stakeholders, and client satisfaction. Also, they should promote financial transactions that promote sustainability. The institutions should be committed not to harm. Their portfolio and transactions should be in a way that prevents detrimental effects on the environment and should be adopted as a matter of policy and principle. Institutions should be committed to accountability. They should influence financial decisions

that impact the environment and lives. Corporates should be committed to responsibility. They should be willing to take responsibility for the social and environmental impact of their dealings. Firms should be committed to governance and sustainable markets. The institutions should support market mechanisms, public policy, and regulations that facilitate sustainability. Besides, they should identify gaps in implementing the sustainable plan and design contracts that bridge the gaps.

8. Conclusion

The economic theory predicts that people would prefer inexpensive input in the production process over others. As a result, the world has majored in energy use over labor and capital, which is detrimental to current and future generations. For instance, since Thomas Edison invented light bulbs, they have been virtually unchanged over a century later, despite being inefficient. They are cheap and subsidized, making them popular, yet they lose 90% of energy as heat [29]. Until recently, computer engineers began to consider power consumption; they focused on speed and capacity while managing extra warmth by air conditioners. Moreover, recently, fuel economy became a selling point for planes, cars, trucks, ships, and Lorries. Therefore, energy subsidies have, for a long time, promoted wasteful energy consumption.

The world risks depletion of energy reserves if the current consumption trends continue. An urgent need for a paradigm shift to renewable energy alternatives is long overdue. Fossil fuels under the earth and resources are fixed, but the population and the demand increase daily. Examples of green or clean energies include biogas, wind, geothermal, hydro, biomass, and solar. Besides, the current and future generations are at risk of having a dirty ecosystem that causes illnesses and cannot supply their needs. The persistent increase of carbon dioxide emissions, the oxides of nitrogen, sulfur, and methane to the atmosphere is detrimental to humanity's health. Moreover, like agriculture, other human activities lead to deforestation and emissions and need urgent mitigation to revert the consequences. An all-inclusive approach that employs the technical, technological, economic, social, institutional, and political dimensions will increase efficiency in creating a green economy.

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