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Handbook of Sustainable Development through Green Engineering and Technology

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Achieving Sustainable Development through Sustainable Entrepreneurship and Green Engineering

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1 Achieving Sustainable Development through Sustainable Entrepreneurship and Green Engineering

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1.1 INTRODUCTION

Since 1987, the term sustainable development has become a significant notion in the language of various policy makers like politicians, practitioners, and planners (Burton, 1987). One of the oldest definitions for the term sustainable development was published in 1987 in the Brundtland Commission report; its main aim was to help world nations toward sustainable development to encourage harmony between humankind and nature. According to the report, the term sustainable development

has been aimed at “satisfying the present need not be at the cost of future.” In simple terms, development should be a continuous process of meeting the current needs and considering the requirements of future generations also (WCED, 1987). The term “needs” in the definition emphasizes the indispensable requirement of the poor. In spite of the existence of many definitions for the term sustainable development, the most repeatedly used definition is the one suggested by the Brundtland Commission (Dernbach, 1998). From its inception until now, the concept of sustainable development has made incessant progress as it has been augmented with new variables, coordinates, hypothetical, procedural, and practical valances (Kardos, 2012). “Conserving resources for future generations” is how the term sustainable-development policy stays distinct from conventional environmental policy. Further, the comprehensive objective of sustainable development (SD) emphasizes long-term survival of the economy by integrating and acknowledging the concerns of macro environmental factors throughout the decision-making process (Emas, 2015).

The role of developing nations is vital in maintaining sustainability as they have better experience in the practical application of responsible innovation to serve individuals and society. One of the critical components of sustainable development is designing scientific and technological solutions that are accustomed with the nature of energy and materials society uses (Mihelcic 2005). In the process of achieving sustainable development to maintain and enhance the quality of life without disturbing the planet, sustainability into products, procedures, processes, and systems must be accomplished in an accessible way. This concept is the main theme of green engineering (Anastas & Zimmerman, 2003). To make the resources available in the long run, sustainable development aims to use resources at an optimum level. The society, the economy, and the environment are the three essential pillars of sustainable development, and all the three are interrelated and interdependent; the actions of one pillar may impact the other directly or indirectly, either in the short run or long run (Hoyer & Naess, 2001).

1.2 ENTREPRENEURSHIP AND SUSTAINABLE DEVELOPMENT

The association between entrepreneurship and sustainable development has been communicated by multiple researchers from various streams of thought, theories, and literature. For instance, ecopreneurship focuses on providing solutions to environmental problems, social entrepreneurship focuses on providing solutions to social issues, sustainable entrepreneurship focuses on providing solutions to economic issues, and social and environmental concerns provide solutions through the understanding of successful business goals (Zahedi & Otterpohl, 2015). Entrepreneurship plays a crucial role in addressing unending socio-economic challenges and also contributes toward the attainment of sustainable development goals, especially related to food, security, hygiene and sanitation, and trustworthy sources of energy, which are the pressing priority of the developing and underdeveloped countries (UNCTAD, 2017). In addition to that, entrepreneurs have been strengthened and encouraged to

execute ideas on green entrepreneurship that stimulates economic and environmental benefits (Hockerts & Wüstenhagen, 2010). Green entrepreneurship is a broad concept that connects environmental entrepreneurship and sustainable development, and obeys to the “triple bottom line” of the environment, society, and the economy (Ye et al., 2020). With numerous tycoons advocating entrepreneurship as a solution for many social-environmental problems, entrepreneurship is highly instrumental in bringing out positive transformation toward sustainable products and processes (Hall, Daneke, & Lenox, 2010). Developing entrepreneurship for sustainable development is a phenomenon that exhibits the linkages of three aspects, namely, environmental, social, and economic dimensions among entrepreneurial procedures, market revolution, and societal developments (Johnson & Schaltegger, 2019). The paradigm shift toward a sustainable business model, along with the implementation of environment-friendly business practices, can, possibly, provide a surplus range of opportunities for entrepreneurs (Jeevan & Priti, 2014). Many research papers that focus on social, environmental, and sustainable entrepreneurship emphasize that entrepreneurs can ascertain, generate, and capitalize on the opportunities for sustainable development by encouraging major reforms through social and technological innovations leading to market transformations (Cohen & Winn, 2007). Sustainable development is a multifaceted phenomenon that addresses five key attributes: financial capital, physical capital, social capital, human capital, and natural capital. A sustainable society is one that is long lasting, resilient, and intelligent enough for the sustenance of its physical or social systems of support (Meadows, Meadows, & Randers, 1992). Long-term productive capacity coupled with long-term wealth and comfort derived from substitute resources are the key elements of sustainable development (Ahmed & McQuaid, 2005). Thus, sustainability is a thought-provoking process for all society, and particularly for business. It should be a commitment and a fundamental driver of the corporate strategy for the majority of businesses (Jeevan & Priti, 2014). Sustainability requires creative thinking across the field of human endeavor, which is not limited to scientists and technologists (Ahmed & McQuaid, 2005). Undeniably, sustainable development has been viewed as one of the important tools to progress toward a more inclusive model by promoting an exemplary relationship among economic, social, and environmental systems for both existing and future generations (Cobbinah, Black, & Thwaites, 2011). The contribution of entrepreneurship and small business holds an important role in addressing the challenges involved in the implementation of sustainable development (Omri, 2018). Though researchers have agreed that entrepreneurship plays a key role in the economic development of the nation, however, the majority of the literature emphasizes that both sustainable development and entrepreneurship are considered as solutions to guarantee the overall development of the entire society (Hall, Daneke, & Lenox, 2010). In addition to that, the green engineering principles also align with sustainable development.

Considering the concepts of entrepreneurship, sustainability, and sustainable development, sustainable entrepreneurship can be stated as a fusion concept stemming from the concept of both business entrepreneurship and sustainable development (Katsikis & Kyrgidou, 2007).

1.3 SUSTAINABLE DEVELOPMENT AND SUSTAINABLE ENTREPRENEURSHIP

To justify the concepts, an intensive review of literature that emphasizes sustainable development, principles of sustainable development, sustainable entrepreneurship, and green engineering has been carried out and is presented below.

(Austin, Stevenson, & Wei-Skillern, 2016) stated that while establishing the venture, the founders of the company should remember sustainable business models. Accordingly, when sustainability is linked with entrepreneurship, “sustainable entrepreneurship” will fall in place and the same will become the driving force for the integration of a sustainable economic-environmental-social system. Thus, sustainability shifts the focus from the development of technology, innovations, and living conditions to ensure endurance with greater responsibility regarding social, environmental, and economic factors. Thus, sustainable entrepreneurship aims at a perfect blend of people, planet, and profit (Nejoua, Fateh, & Charaf, 2017). Identification of a sustainable innovation and its implementation, either through dynamic reorientation of existing companies or a start-up, achieves the desired ecological or social objectives (Hockerts, 2003). It is the way opportunities are identified, created, and exploited for productions of goods and services, for the present and future, by stakeholders knowing the environmental and ecological consequences (Cohen & Winn, 2007). The definition given by (Tilley & Young, 2009) focuses on ethical dimensions and future dimensions. It aims to improve the quality of life of all stakeholders locally and globally, for both the present and future generations, by doing business through ethical and economic development. However, (Brundtland, 1987) is the first to give a formal definition of sustainable development “which meet the needs of the present without affecting the future generations’ ability to meet their own needs.”

Various common elements among the many definitions include equity among public, public health, water management, education system for all, renewable energy management, chemical engineering, waste management, environmental protection, optimum utilization of resources, and protection of natural resources. Different disciplinarians stated their own interpretations of sustainable development and tried their best, from their own point of view, without missing the focus on the themes of sustainable development. Among all the disciplinarians, engineering discipline is the one that has applied this concept most effectively compared to any other disciplines. This might be because they are in mechanical (products and processes) or civil (use of natural resources) or chemical (environment protection), and interesting aspects all fall under the engineering or economics domain. This might be the input for the development of the concept of green engineering. Community development and environment should be given equal importance for sustainable development. Development of one without the other will not solve the purpose of sustainability (Khosla, 1987). Sustainable development should focus on ethical principles and future interest with scientific realities (Repetto, 1986). The present generation’s development should not be at the cost or survival of future human generations. There must be equal consideration for present and future human health. Of course, this goal should be achieved with satisfaction of immediate and

future subsistence needs with a low degree of risk (Norgaard, 1988). Sustainable entrepreneurship should aim for community development, without which the purpose of it will not be achieved (Patzelt & Shepherd, 2011). Sustainable entrepreneurship shall also concentrate on transforming sectors toward sustainability (Schaltegger & Wagner, 2011). Accordingly, the authors have made a comparison between sustainable development and sustainable entrepreneurship based on the available literature.

1.3.1 SIMILARITIES BETWEEN SUSTAINABLE DEVELOPMENT AND SUSTAINABLE ENTREPRENEURSHIP

Authors	Identified Areas in Sustainable Development	Authors	Identified Areas in Sustainable Entrepreneurship
(Norgaard, 1988)	Survival of future human generations and future human health are core concepts. In addition to that, the present and future needs are to be satisfied. All the above should be achieved with minimum risk.	(Nejoua, Fateh, & Charaf, 2017), (Schaltegger & Wagner, 2011)	Innovations, social and environmental dimensions, sustainable technological innovations, transforming sectors toward sustainability
(OECD, 2006)	Developing and sharing the economic benefits to all the stakeholders by converting brownfields into educational and housing projects. Development of innovative industrial processes with ecological balance and environmental protection.	(Hockerts, 2003)	Ecological and social objectives Sustainability of natural resources
(Anastas & Zimmerman, 2003)	Enhancement of quality of life without disturbing ecological balance by proper design of products, systems, processes for today and tomorrow.	(Cohen & Winn, 2007)	Products for present and future with environmental, social, economic consequences
(Repetto, 1986)	Focus on ethical principles and future interest with scientific realities.	(Tilley & Young, 2009)	Ethical dimensions and future dimension along with new opportunities
(Khosla, 1987)	Community development with due consideration of the environment.	(Patzelt & Shepherd, 2011)	Community development

1.4 BUILDING SUSTAINABLE ENTREPRENEURSHIP ECOSYSTEM

The term “entrepreneurship ecosystem” has gained its cynosure in the last decade. It was first defined by Cohen (2005) as “interrelated group of performers in a geographic community who are dedicated to seed sustainable development” by providing assistance and creating novel sustainable ventures. According to (Van De Ven, 1993), entrepreneurial ecosystems progress through an interaction of a myriad of mutually supporting components, which may create new ventures over time. (Figure 1.1).

The fundamental idea of an entrepreneurial ecosystem is to provide a favorable environment that supports innovation and aids in the formation of new ventures. Therefore, sustainable economic growth can bring it within a specific geographic boundary (Garud, Kumaraswamy, & Karnøe, 2010). The application of multiple components of entrepreneurial ecosystem was first examined by (Neck, Meyer, Cohen, & Corbett, 2004). According to (Neck et al., 2004), entrepreneurial ecosystem components, namely informal networks like entrepreneur family members and friends, formal networks like government, professional services, universities, support services, capital services, and access to the talent pool are the predominant variables in fostering a sustainable entrepreneurial ecosystem.

The main objective of sustainable development ventures in the purview of the sustainable entrepreneurial ecosystem arises to create economic, social, and

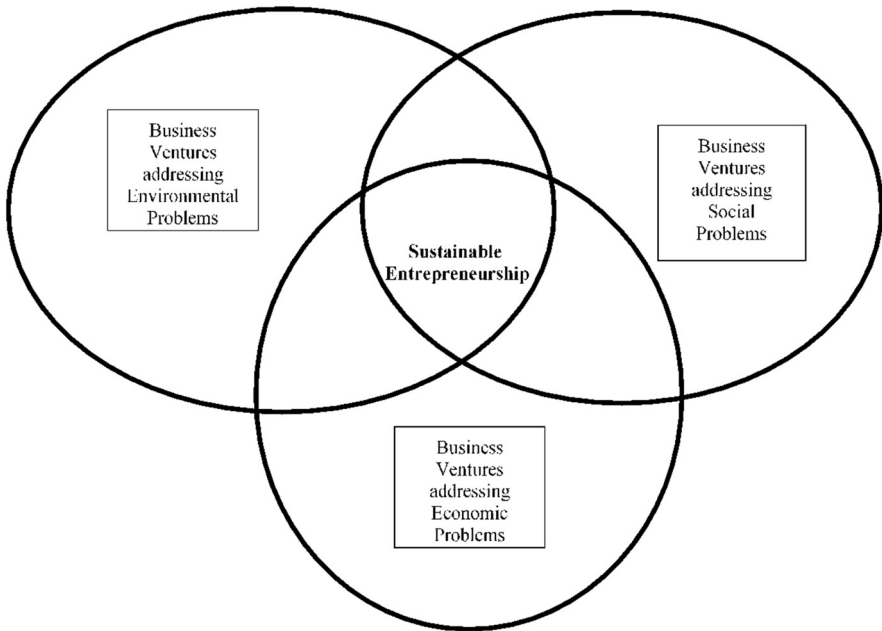


FIGURE 1.1 Conceptual framework of sustainable entrepreneurship and green engineering.

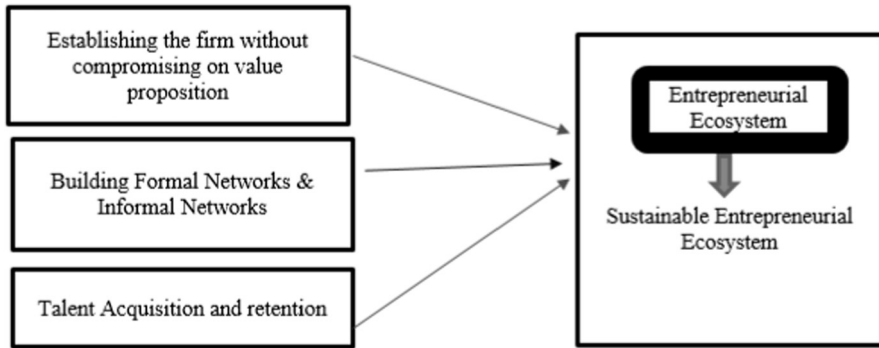


FIGURE 1.2 Components of building sustainable entrepreneurial ecosystem.

environmental value (Pankov, Velamuri, & Schneckenberg, 2019). While establishing the business venture only, it is imperative for the entrepreneurs to have a sustainable business idea, and the actions of sustainable business ventures must be grounded by considering the concerns that are particular to economy, environment, and society.

In addition to that, to build a sustainable ecosystem, an entrepreneur should ensure supportive talents and not compromise on the value of the long-term vision, culture, employees, collaborations, and product planning (Forbes Business Council, 2020). Similarly, entrepreneurs must focus on developing a sustainable business model that stays afloat in the long run by considering environmental impacts. To execute a sustainable business plan, entrepreneurs must understand the key elements of a sustainable business model as a value proposition, long-term vision, and usage of sustainable resources (Hendricks, 2018).

Well-developed entrepreneurship ecosystems are highly instrumental in building a sustainable economy. They look at the micro-level overview. For corporate entrepreneurs, it is very important to focus on the key actions like drafting to support guidelines for an underprivileged segment of people, establishing the ventures that support the local community, and collaborating with other private partners (Endeavor Insight, 2015). For example, the UAE is an oil-driven economy, and to materialize the knowledge driven and entrepreneurial economic model from the oil-driven economy, they have considered three core components, like “getting corporates involved to use the competencies, investors’ participation, and community education” (Jagannathan, 2017) (Figure 1.2).

1.5 SUSTAINABLE DEVELOPMENT AND GREEN ENGINEERING

Innovations play an important role in designing the products, processes, and systems with sustainability as a core theme. It is the right time to think about social innovations that will aim to protect the environment, value generation to all the stakeholders, recycle waste, and use renewable-energy resources in the

process. Many companies are focusing on sustainability missions, considering the above factors, with optimum utilization of resources for today and tomorrow and benefit to all stakeholders in the society. One should not forget that, ultimately, the companies have to compete in a dynamic market. There are many other challenges for the companies to play safe in the competitive world (Jenck, Agterberg, & Droesher, 2004).

Different researchers had given different principles of sustainable development. Of course, all the principles have commonalities. However, Veselaj (2019) has identified the following ten principles to achieve sustainable development.

- a. Optimum utilization of resources: Resources are not abundant but scarce. In such a situation, the resource utilization should be careful and productive in such a way that it will lead to the development of the present and future. It includes protection of natural resources. Some European countries have adopted these principles as an integrated part of their laws so that all will follow automatically.
- b. "Prevention is better than the cure" is a well-known saying. It holds well in environment degradation, too. Optimum utilization of resources should be attained without affecting the pollution level and environmental degradation.
- c. Social, economic, and environmental development is incomplete without the public's participation. Awareness of sustainable development among the public is not sufficient; involvement of the public in decision making is important.
- d. Manufacturers have to pay real costs for the activities involved in the consumption of natural resources, as well as the activities engaged that will harm the environment. Now many governments have National Pollution Boards in place to address this need. Integration of natural resources of the nations and globe is essential to achieve sustainable development. In simple terms, national water policy, forest policy, energy policy, agricultural policy, industrial policy, trade policy, and other related policies should have a common vision.
- e. Equity among the generations is the core principle.
- f. A systems approach is also known as a holistic approach. A system is a group of interrelated and interdependent elements that are working toward a common goal. Similarly, social, ecological, and economic concepts are interrelated and interdependent and working toward the common goal of sustainable development.
- g. Social reasonability of the producers of the goods and services is always an important element of sustainable development. Use of limited resources should be compensated in some way. This principle also highlights the need for waste management and reforestation.
- h. Conservation and sustainable use of nature and local diversity needs to be maintained.

- i. A healthy environment should be made a fundamental right in society.
- j. The factors to be sustained for sustainable development are i) Nature
ii) Sources of life support and iii) Communities.

Current engineering evolution is due to increased concerns regarding the degradation of the environment, global warming, and the decrease in natural resources and increase in population growth. This all leads to new design development, with sustainability as a performance factor. The goal of wealth creation for society is concerned about the current generation as well as the future generation. Optimum utilization of resources is needed for society both today and tomorrow. Utilization of resources largely depends on the design, development, and commercialization of industrial processes that are not only sustainable but also economically feasible with protecting the environment. Through green engineering, the above will be met with little risk to human health and environment. The right decision-making process at the design and development phase of a product or process will impact the cost effectiveness with proper protection of environment and human health (Patel, Kellici, & Saha, 2013).

The 12 green engineering principles (Anastas & Zimmerman, 2003) are collectively guiding principles for engineers. However, one should not forget that engineers are more involved in successful implementation rather than making policy decisions. Entrepreneurs play a vital role in decision making. Both engineers and entrepreneurs should be aware of these principles. These principles are focused much beyond quality and safety, and they should be considered in designing processes, products, and systems. These principles of green engineering are discussed in detail.

- a. Focusing on nonhazardous production in society by proper utilization of entire materials and energy inputs.
- b. Focusing on prevention of waste rather than recycling of waste.
- c. Designing framework with purification and separation operations.
- d. Increase production with systems components, including maximizing mass and energy.
- e. Pulling output rather than pushing inputs through system components.
- f. Planning of the recycling process and reuse of resources should be considered from an investment point of view that will lead to sustainability.
- g. Long-lasting results should be the goal for design.
- h. Using “one size fits all” solutions rather than building unnecessary capacity.
- i. Minimizing material diversity and value retention for multi-component product development.
- j. Integration and interconnectivity of design of process and system with available energy and material flows.
- k. Performance will not be output unless it is designed. The design should also aim for the performance after the commercial life.
- l. Usage of reusable and largely available inputs throughout the life cycle.

1.5.1 SIMILARITIES BETWEEN SUSTAINABLE DEVELOPMENT AND GREEN ENGINEERING

Authors	Identified Areas in Sustainable Development	Authors	Identified Areas in Green Engineering
(Norgaard, 1988)	Survival of future human generations, future human health, satisfaction of immediate and future subsistence needs with low degree of risk	(Patel, Kellici, & Saha, 2013).	Factors in consideration with optimum utilization of resources for today and tomorrow and aim to benefit all the stakeholders in the society.
(OECD, 2006)	Developing and sharing the economic benefits to all stakeholders by converting brownfields into educational and housing projects. Development of innovative industrial process with ecological balance and environmental protection.	(Veselaj, 2019)	Performance will not be output unless it is designed. The design should also aim for the performance after the commercial life. There should be clear cut plants for reuse of the resources throughout its life cycle.
(Anastas & Zimmerman, 2003)	Enhancement of quality of life without disturbing ecological balance by proper design of products, systems, processes for today and tomorrow.	(Anastas & Zimmerman, 2003)	Principles are focus beyond quality and safety, and should be considered in designing process, products, and systems.
(Repetto, 1986)	Focus on ethical principles and future interest with scientific realities.	(Veselaj, 2019)	Planning of recycling process and reuse of resources should be considered from investment point of view that will lead to sustainability
(Khosla, 1987)	Community development with due consideration of the environment.	(Ye et al., 2020).	Environment, society, and economy.

The following conceptual framework has been developed. (Figure 1.3).

From the above picture, it is clear that sustainable development is the common area among social entrepreneurship and green engineering.

After studying the 12 principles of green engineering and ten principles of sustainable development, one can understand that there exist some commonalities among these principles.

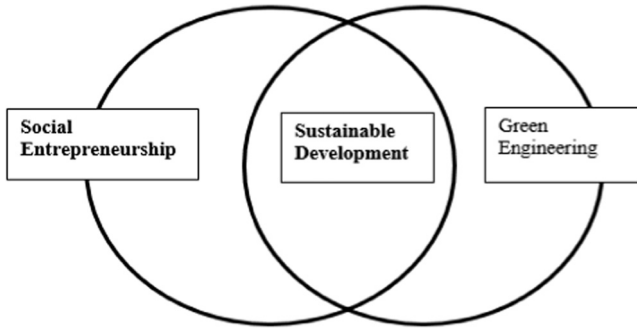


FIGURE 1.3 Inter relationships between social entrepreneurship, sustainable development, and green engineering.

Mere knowledge of these principles is not sufficient. One has to plan for implementation of these principles. After gaining awareness of these principles, the biggest challenge lies with the implementation of these principles. The following table gives commonalities in the implementation of sustainable development and green engineering principles.

1.6 COMMONALITIES IN THE IMPLEMENTATION OF SUSTAINABLE DEVELOPMENT AND GREEN ENGINEERING PRINCIPLES

Sustainable Development Principles	Green Engineering Principles	How to Implement
Optimum utilization of resources: Resources are not abundant but scarce. In such a situation, the resource utilization should be careful and productive, leading to the development of the present and future. It includes protection of natural resources. Some European countries have made these principles as part of their laws so that all will follow automatically.	Focusing on non-hazardous production in society by proper utilization of entire material and energy inputs.	Both the principles are aiming for the same but with different approaches. Optimum utilization of all the resources is the main theme of sustainable development and not to produce non-hazardous production in the society is added input from the green engineering. The scope of engineering is wide and different disciplines of engineering started practicing it. Green construction is one among them. All the countries, irrespective of developing or under-developing, who are planning to construct houses for the needy should plan only for green houses. Similarly, all the major project <i>(Continued)</i>

Sustainable Development Principles	Green Engineering Principles	How to Implement
<p>Prevention is better than cure is a well-known proverb. It holds well in environment degradation also. Optimum utilization of resources should be attained without affecting the pollution level and environmental degradation.</p>	<p>Focusing on prevention of waste rather than recycling of waste.</p>	<p>approvals should be based on green engineering principles. When the governments take the initiative of implementation of these principles, private organizations also will come forward to practice the same. Of course, the financial resources might be a consideration in the short run, but in the long run, it is definitely economically viable and beneficial to the society. Similarly, green chemistry is one of the emerging areas, if the government's plan to give licenses to those industrial houses which plan for green production. Its implementation becomes easy. Governments should plan to give financial incentives for those projects, industries, startups which are going to plan these principles. Use of renewable energy resources will avoid production of waste itself. Depending upon the country's geographical conditions it has to plan whether to use wind energy, solar energy, hydro power generation. The electric power lost in transportation is around 20% in many countries. If they reduce these distribution losses, it will be great savings for them. If sufficient numbers of dams are built, water scarcity can be avoided in many countries. By building proper storage facilities across the nation, the wastage of grains and other items can be minimized. The main principle is prevention of waste is a suitable strategy rather than recycling the waste after its production.</p>
<p>Manufacturers have to pay real costs for the activities involved in consumption of natural resources as well as</p>	<p>Increased production with systems components, including maximizing mass and energy.</p>	<p>The competition in the markets forced them to change from mass production to mass customization. The price of the product is no more</p>

Sustainable Development Principles	Green Engineering Principles	How to Implement
<p>the activities engaged that will harm the environment.</p>	<p>Minimizing material diversity and value retention for multi-component product development.</p>	<p>cost plus product, but it is the value for money or the price affordable by the customer. Both the concepts focus on the value for money. The resources utilized directly and indirectly to be considered. At the same time, the functions offered by the product directly and indirectly to be considered. The cost of inputs includes usage of all environmental resources to be borne by the producers. To do this, many governments had national boards to take care of this. Integration of natural resources of the nations and globe is essential to achieve sustainable development. In simple terms, national water policy, national forest policy, national energy policy, national agricultural policy, national industrial policy, national trade policy, and other related policies should have a common vision of sustainability</p>
<p>Systems approach is also known as holistic approach to be practiced. Similarly, social, ecological, and economic concepts are interrelated and interdependent, working toward the common goal of sustainable development.</p>	<p>Integration and interconnectivity of design of process and system with available energy and material flows. Pulling output rather than pushing inputs through system components.</p>	<p>A system is a group of elements that are interrelated and interdependent and working toward a common goal. The use of natural resources productively leads to economic development and if it. The integrated approach toward the use of resources shall be considered in production systems.</p>
<p>Conservation and sustainable use of nature and local diversity to be maintained.</p>	<p>Long lasting should be the goal for design.</p>	<p>We produce what we design. Sustainability should be considered while designing the products and use of resources. Government should encourage those companies that are going to produce long-lasting products and the companies that plan to manufacture with sustainable goals.</p>
<p>Social reasonability of the producers of the goods and services is an important</p>	<p>Usage of reusable and largely available inputs throughout the life cycle.</p>	<p>One-time use of resources should be discouraged. Instead manufacturers should be encouraged to use</p>

(Continued)

Sustainable Development Principles	Green Engineering Principles	How to Implement
<p>element of sustainable development. Use of limited resources should be compensated in some way. This principle also highlights need for waste management and reforestation.</p>	<p>Performance will not be output unless it is designed. The design should also aim for the performance after the commercial life.</p>	<p>renewable resources throughout the life cycle of the products.</p>

1.7 CONCLUSION

From the above reviews, it can be inferred that the following are the key dimensions of sustainable entrepreneurship, sustainable development, and green engineering:

- Preservation of natural resources
- Development of goods and services for present and future
- Economic gains along with social gains
- Balancing both environmental and social concerns
- Long term integrated approach for people, planet and profit
- Transforming sectors towards sustainability
- Sustainable venture performance and cultural consideration

Apart from exhibiting similarities between sustainable development and sustainable entrepreneurship, the summary clearly provides the simple difference between conventional and sustainable entrepreneurs where the former one focuses on creating customer value for profit maximization (Ludeke-Freund, 2019) and the latter one focuses on solving environmental and social problems through their business. The term “sustainability” could be viewed expansively as three goals of economic development, ecological balance, and societal equity. In addition to that, the development of sustainable entrepreneurship in the world depends on the action of passionate people who have that internal drive to create a business model that has environmental, social, and economic impact. As this concept is in the development stage, all the stakeholders of the world should be involved in the development of sustainable entrepreneurship.

1.8 LIMITATIONS OF THE STUDY

Sustainable development requires huge amounts of investment by governments and enterprises. Whether they are ready for it is a big challenge. Some rich countries can afford this type of investment. However, the underdeveloped nations and developing countries will have constraints. Underdeveloped nations are more interested in the present community development rather than focusing on both present and

future. At the same time, it is a big challenge for all the companies in both developed nations and developing nations to pay the price for the natural resources they have used. If they start paying the price for all the resources they have used, it will be tough for them to compete in the market. In the completion, “price of the product or service” plays an important role. Already, there are huge disparities among the developed nations and underdeveloped nations; forcing any compulsions may further increase the disparities among them. For example, the true spirit of the World Trade Organization was difficult to implement successfully due to various conflicts among the member countries. There are so many benefits to society through green engineering, sustainable development, and sustainable entrepreneurship. Making all stakeholders aware of benefits and involving them all in the decision making will minimize some of the limitations. The discussions on concepts and principles of sustainable development, sustainable entrepreneurship, and green engineering are not new. They have occurred since the 1980s onward; however, there is not much progress in the implementation of these principles. There are some exceptions to this idea. For example, Bhutan had some of the principles of these concepts in its constitution itself. The Oman government had made sustainability in its vision document with strict compliance. The push should come from big countries rather than smaller ones. Some universities are offering degrees and certificate courses on green engineering and sustainable development. Universities offering entrepreneurship courses should have made green engineering, sustainable development, and sustainable entrepreneurship as part of the course. There are journals in the name of green engineering and sustainable development. However, this study is restricted to the discussion of the conceptual framework and relationship among them.

1.9 FUTURE SCOPE OF THE STUDY

There are 12 principles for green engineering and ten principles of sustainable development, which were discussed in the above paragraphs. There is scope of further research in each of these principles in detail. The following list of the principles is rewritten from the point of view of identifying further research.

- a. Focusing on nonhazardous production in society by proper utilization of entire material and energy inputs.
- b. Focusing on prevention of waste rather than recycling of waste.
- c. Designing a framework with purification and separation operations.
- d. Increasing production with systems components, including maximizing mass and energy.
- e. Pulling output rather than pushing inputs through system components.
- f. Planning of recycling process and reuse of resources should be considered from an investment point of view that will lead to sustainability.
- g. Long lasting should be the goal for design.
- h. Using “one size fits all” solutions rather than building unnecessary capacity.
- i. Minimizing material diversity and value retention for multi-component product development.

- j. Integration and interconnectivity of design of process and system with available energy and material flows.
- k. Performance will not be output unless it is designed. The design should also aim for the performance after the commercial life.
- l. Usage of reusable and largely available inputs throughout the life cycle.

For example, renewable energy itself is a wide area. Waste management and recycling, green chemistry, and green construction are some of the emerging areas that have green engineering and sustainability in their roots. Involvement of community in sustainable development is vital. Without the support of all stakeholders, no program can be successfully implemented. Government should plan for bringing awareness about the use of natural resources for sustainability. For example, integration of former lands with optimum utilization of water resources will be beneficial. Researchers can focus on their local areas' natural resources and plan how to involve local stakeholders for the benefit of all. Researchers can also study how to make sustainability a social movement rather than any other government schemes. Some countries make sustainability principles as part of their constitutions so the programs will be implemented irrespective of the parties who run the government. Researchers can focus more on developing nations and underdeveloped nations since these countries are going to make huge investments in infrastructure in the near future. With additional investments, these countries can plan to implement sustainable principles easily. Researchers can also plan how sustainable development can be made part of the syllabus in the university curriculum. The authors are suggesting that these sustainability principles can be part of primary and secondary education. Researchers can focus on how to utilize the water, soil, and labour optimally. They can also focus on how artificial intelligence, block-chain technology, design thinking, and other latest developments will be integrated with the sustainability principles. Usage of latest technologies will be helpful, particularly for those countries with huge natural resources but below the poverty line. Researchers can focus on the outcomes of corporate social responsibility activities and can suggest sustainability can be made part of CSR. Some countries are not aware of how much natural resources are wasted. In developing nations, electricity transmission losses would be around 30% to 40%. Wastage of food grains due to lack of storage facilities would be around 20% to 30%. Soil erosion is the problem in some of these countries. Use of unnecessary fertilizers has badly impacted the fertility of the soil throughout the world. Again, the traditional farming is back within the name organic farming. However, this concept is not prevalent in many countries, but proper implementation of organic farming will lead to some of the components of sustainability. Research discusses the reasons behind this and how to overcome the problems. Many studies restrict their studies in finding the reasons for the problems rather than suggesting strategies to overcome the problems. Involvement of the researchers in finding the solutions will be great support to the society in suggesting suitable strategies. Engineering should encourage and design only sustainable products for the future. They have to plan for sustainable processes and products with limited resources. There is huge scope for the researchers also to study in detail each principle in theory as well as its implementation in various domains.

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