Engineering Solutions for Sustainable Future: Addressing the United Nations' (UN) 17 Sustainable Development Goals (SDGs)

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Abstract

This paper addresses the significant challenges facing the global community from the implementation phases of the United Nations' 17 Sustainable Development Goals (SDGs) and the ability to achieve the 2030 deadline. The paper is a comprehensive overview of some engineering solutions aligned with each of the 17 SDGs and how it will help achieve the SDGs. It also demonstrates how engineering solutions can be integrated into policy and decision-making processes to drive progress towards the SDGs deadline. It highlights the role of localized and cultural solutions in achieving the SDGs. The paper calls for collaboration among all stakeholders to harness the power of engineering to achieve the SDGs.

Keywords: Sustainable Development Goals (SDGs), Engineering Solutions, policy and decision-making processes, localized engineering solutions, cultural solutions, sustainable, equitable and prosperous future

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1 Introduction

The Sustainable Development Goals (SDGs) were developed at the United Nations Conference on Sustainable Development held in Rio de Janeiro, Brazil, in 2012. "The objective was to produce a set of universal goals that could meet the then urgent environmental, political and economic challenges facing our world"[1] that eventually developed into 2030 Agenda'. This Agenda encompasses 17 broad and interrelated Sustainable Development Goals (SDGs) shown in Figure 1. In 2024, 12 years after and 6 years away from the target date, what is the level of achievement of these goals by the member countries to solve some of the identified humanity's biggest challenges ever. The deliverable from these goals is to end poverty, protect the environment, reduce economic inequality and ensure peace and justice for all.

The UN Secretary General progress report to the General Assembly Economic and Social Council on in 2024 reveals that "only 17% of SDGs targets are on track to be achieved, nearly half are showing minimal or moderate progress, and progress on over a third has stalled or even regressed"[2]. "The pandemic (*natural disaster*) and other factors led to 23 million more people living in extreme poverty and 123 million more suffering from hunger in 2022 compared to 2019, widening the gap in per capita income growth between the poorest and richest countries. In point 11, it states that: "we must double down on those areas that can unlock transformative progress across the goals"[2]. Point 13 is more direct: "The 2024 progress assessment reveals the world is severely off-track to achieve the 2030 Agenda"[2]. The grim picture painted by this report calls for a concerted effort among Engineers all over the world to support the achievement of the goals. Engineering, is the application of science to the optimum conversion of the resources of nature to the uses of humankind. This definition fits well with the challenges we are facing with the implementation of the UN SDGs. Engineering solutions are needed to assist the body and the world reverse the current state of the goals. In view of these daunting challenges, we can begin to explore the intersection of engineering and sustainable development goals.

The question is: "Has engineering solutions contributed to addressing the implementations of the 17 UN SDGs ?". The solar-powered water purification in rural Africa supports SDG 6; clean water and sanitation. Examples of this are the solar-powered water purification systems by UNICEF (United Nations International Children Emergency Fund) in Kenya, solar-powered water purification system by Rwandan government and solar-powered water treatment plant by world vision in Tanzania. There is also the wind energy integration in Denmark to support SDG 7. Denmark is a global leader in wind energy and wind power generates approximtely 43% of Denmark's electricity. Singapore employed the green infrastructure for urban flood management that supports SDG 9. The smart traffic management in Barcelona (SDG 11) is another success story. It employed the emerging technologies like the Internet of things, Artificial Intelligence, cloud computing, big data analytics, mobile and web applications. This reduced traffic congestion by 20%, enhanced safety by 30% decrease in accidents and improved air quality by 15% through emission reduction. An interesting one is the climate-resilient agriculture in Ethiopia that supports SDG 2 and SDG 3. This takes advantage of various engineering solutions to mitigate the impact of climate change to ensure food security. This action reduced crop failure by about 70%, water usage rate reduction of 50%, increase in crop yield of 30% and reduction in soil erosion of 50%. Engineering solutions will guarantee better and sustainable future for all so that we can create more prosperous and equitable world for all.

Nevertheless, these achievements were not easy as engineers face various challenges in supporting the achievement of SDGs. There are capacity building and skills challenge such as brain drain and talent retention issues, knowledge sharing and dissemination together with diversity and inclusion in engineering workforce. Do we have enough Engineers (Capacity) across the world and are they competent enough and willing to work on the sustainable solutions?" Nigeria registered engineers stands at about 67,000 and with a population of about 230m, Nigeria has approximately one engineer for every 3,433 people. "In Swaziland, there is one engineer to 170,000 and compares this with United kingdom where there is one engineer to 1,100"[3]. The UNESCO seems to be addressing this gap through STEM while WFEO (the lead profession in developing and applying engineering to constructively resolve international and national issues for the benefit of humanity) needs to pull through her pet project, the harmonization of professional competencies of Engineering profession across the world as quickly as possible. The Council for the Registered Engineer in Nigeria (COREN) is already domesticating this approach through the Output Based Education (OBE) to bring about parity between local and foreign trained Engineers and ensure mobility of domestic Engineers across the world.

What of the question of diversity in Engineering approach? The diversity of our thought process, cultural values, traditional norms as well as our backgrounds can affect perspectives that can impact on problem solving ability. This can be seen as demonstrated by diverse techniques to problem resolutions and the application of indigenous technology to resolve challenges faced in each regions of the world. Diverse perspectives can lead to greater innovation, creativity and engender various approaches to problem solving techniques. All these can shape engineering solutions from region to region of the world and have some impact in achieving our desired goal of successful implementations of the 17 UN SDGs across the world. There are also technical challenges like a limited access to technology and resources, institutional and policy changes due to lack of policy framework and regulations. Economic challenges seems to impact more due to high upfront costs and financing, uncertainty and risk in investing in sustainable solutions.

2 Methodology

The paper employs desktop research and relies on existing literature and publications. The review is carried out systematically to synthesize the existing knowledge in order to develop the theoretical framework used. This informed the questions raised above and an attempt to answers them as present in the discussion and conclusive part of the report.

The primary motivation for the research is to make a meaningful impact on achieving the 17 UN SDGs, contribute to knowledge and creating a better world for all through the application of sustainable engineering solutions. It will fulfil the SDG commitments by supporting the nations of the world through collaboration, knowledge sharing of sustainable engineering research, innovation and implementation strategies. This will drive economic growth by fostering economic development, prosperity and job creation through engineering collaborations in addressing global challenges impeding the implementation of the SDGs. The research will contribute to shaping the liveable future that will ensure a sustainable future generations where technology and nature will coexist in harmony.

3 Background and Context

The 2030 Agenda highlights the connections between the environmental, social and economic aspects of sustainable development. Sustainability itself is the ability to maintain or support a process continuously over time. The goals become necessary in order to avoid the world to self destruct. We are also witnessing high rate of mass movement of people (migration) from underdeveloped to developed Nations across the world. This can lead to socio-cultural imbalance, cultural dysfunction, political upheaval and species extinction which will negate the UN 2030 agenda. The role of engineers is vital in addressing the gaps that has been identified by various literatures in achieving the target date for the goals. It is through global research collaborations that Engineers can join forces with other international researchers, industries and government across the nations of the world to tackle shared sustainability challenges. The 17 United Nations Sustainable Development Goals (SDGs) aim to achieve a better and more sustainable future for all by 2030. Achieving the goals will create a more equitable, prosperous, and sustainable world for the human race and the 17 goals are:

1. No Poverty: End poverty in all forms.
2. Zero Hunger: End hunger, achieve food security, and promote sustainable agriculture.
3. Good Health and Well-being: Ensure healthy lives and promote well-being.
4. Quality Education: Ensure inclusive and equitable quality education.
5. Gender Equality: Achieve gender equality and empower all women and girls.
6. Clean Water and Sanitation: Ensure access to clean water and sanitation.
7. Affordable and Clean Energy: Ensure access to affordable, reliable, sustainable energy.
8. Decent Work and Economic Growth: Promote inclusive economic growth and decent work.
9. Industry, Innovation, and Infrastructure: Build resilient infrastructure and promote innovation.
10. Reduced Inequalities: Reduce income and social inequalities.
11. Sustainable Cities and Communities: Build sustainable, inclusive, and resilient cities.
12. Responsible Consumption and Production: Ensure sustainable consumption and production patterns.
13. Climate Action: Take urgent action to combat climate change.
14. Life Below Water: Conserve and sustainably use oceans, seas, and marine resources.
15. Life on Land: Protect, restore, and promote sustainable use of ecosystems.
16. Peace, Justice, and Strong Institutions: Promote peaceful, just, and inclusive societies.
17. Partnerships for the Goals: Strengthen global partnerships to achieve the SDGs.

Figure 1 below shows the 17 SDGs in picture form.

Figure 1: The 17 SDGs in picture

The implementation of the SDGs worldwide started in 2016 and the UN Secretary General issued the global call in 2019 for Decade of Action to deliver the Sustainable Development Goals by 2030. There are two main types of actors that are involved in the implementation of the SDGs: the state and non-state actors [4]. The state actors are Continental/regional groupings, sovereign governments, state governments and local authorities, whereas the non-state actors are multinational corporations and various non-governmental organisations. The Engineers and the professional Engineering organizations across the world falls under the non-state actors.

Nigeria is one of the 44 Nations of the world to have presented its Voluntary National Review (VNR) in 2017 and 2020 on the implementation of the SDGs at the High-Level Political Forum on Sustainable Development (HLPF). In 2020, Nigeria was ranked 160 on the 2020 world's SDG Index and the government affirmed that Nigeria's current development priorities and objectives are focused on achieving the SDGs [6]. Nigerian Engineers must rise up to support the Government in her quest to implement the SDG correctly to ensure we do not lag behind among the comity of Nations.

3.1 Challenges On The Implementation Of The SDGs

The "UN Member States agreed that the SDGs should be addressed in an integrated, indivisible manner, by recognizing their interlinkages"[5]. They also call on all state actors and non-state actors "acting in collaborative partnership, to implement the Agenda"[5]. Nevertheless, there are challenges faced in achieving the goals are multifaceted and complex from region to region as summarised as follows:

i. Funding and Resources: Many countries lack the financial resources and human resource capability to implement necessary programs and infrastructure.

ii. Political Instability: Conflicts and political instability across the world is disrupting progress and diverting resources in some region most especially Africa.

iii. Climate Change: This is impacting human health with extreme heat waves causing rising sea levels which at times resulting to flooding, draughts in some regions and droughts leading to food insecurity.

iv. Inequality: Persistent inequalities in income, gender, and access to services hinder progress.

v. Data collection and Monitoring: Lack of adequate and reliable data, data collection and monitoring mechanisms.

vi. Global Cooperation: Difficulty in achieving international cooperation, agreement and commitment across the regions.

vii. Technological Gaps: Lack of or limited access to technology and innovation across the developing nations as well as leveraging technology and innovation is critical. Integrating and accepting local technological innovations is a big issue rather than exportation of solutions from one region to the other. The integration of multiple engineering disciplines that can create sustainable systems to directly address the whole 17 UN SDGs has being a complex endeavour.

viii. Disaster risk reduction and resilience: Building resilience to natural disasters and crises with the ability to respond easily and manage these efficiently.

ix. Public Awareness: Lack of awareness and engagement among the general public across the nations of the world can impede efforts.

4 Engineering Solutions and The UN 17 SDGs Implementations

One of the Engineering Solutions is to develop an innovative solution to achieve affordable housing which is a cornerstone of SDG 1. This includes the utilization of renewable energy sources, water-saving fixtures, and waste reduction techniques that collectively contribute to the sustainability of the housing sector. The Nigerian Building and Road Research Institute (NBRRI) plays a pivotal role in developing sustainable materials and construction techniques, such as pozzolana cement and interlocking blocks. One promising avenue is the use of alternative building materials such as bamboo, laterite-brick, stonecrete block and prefabricated panels, which are not only cost-effective but also environmentally sustainable. For instance, bamboo is strong, renewable, and has been used traditionally in various parts of Nigeria, offering a culturally relevant and sustainable building option. Similarly, laterite-brick, made from a mixture of clay, sand, straw, cement and water, provides a low-cost and thermally efficient alternative to conventional building materials [8]. The Nigerian Building and Road Research Institute (NBRRI) has been instrumental in developing a range of sustainable materials aimed at improving the construction industry in Nigeria. Figure 1 shows sustainable housing development pattern.

Figure 1: Sustainable Housing Development Pattern

Some of the developing nations depend on agriculture to sustain their economies. “A group of engineering students is helping a community in Nicaragua improve its food supply and fight the effects of drought with a project tagged ‘water for life’. Using a $2,300 grant from EPICs in IEEE, students are working with a non-profit organization to test a prototype water monitoring system and develop bio-intensive garden beds to find local solutions to agricultural problems”[9]. The Engineering solutions proffered are rainwater harvesting, solar-powered water pumps and irrigation systems, water storage tanks and distribution networks, greywater reuse systems, watershed management and conservation strategies. This "Water for Life" project started January 2024 will address water scarcity and agricultural productivity that will contributes to achieving SDGs 1 and 2. It has the potential of promoting a more sustainable and equitable future for rural Nicaraguan communities of about 500+ members. It will also provide hands on experience for engineering students thereby enhancing engineering capacity. Tata Motors developed Nano car in India in 2008 as the world's affordable transportation solution. This is how engineering solutions alleviate poverty as it created job in its manufacturing and sales network.. Local suppliers and vendors will benefit while the service industries will grow through maintenance and repair services. It was a low cost transportation to reduce poverty and it launched with a price tag of approximately $2,500. This contributed to economic empowerment and social mobility for low-income families to improve their living standards.

“SDG2 (Zero Hunger) comprises four main priorities: ending global hunger, achieving food security, improving nutrition and promoting sustainable agriculture”[10]. It is assumed that 1,000 tons of food are wasted every minute due to lack of access to food storage and preservation technologies. Fresh food frequently spoils before consumption in developing nations where electricity is limited and costly. A cost-effective and climate-positive engineering design used to prevent food waste from spoilage was developed by inventor Nigerian Mohammed Bah Abba in the 1990s.

The "pot-in-pot refrigerator (Zeer) is a small pot with a lid inside a larger pot with wet sand between them covered by a wet cloth. As water evaporates, the temperature of the inner pot decreases, creating a refrigeration effect without needing electricity. Abba created an alternative to the original

evaporative cooling system technology, resulting in an all-natural, non-electric, and economical version that extends the life of perishable foods from days to weeks and reduces food waste in rural and poor communities of northern Nigeria"[11, 12]. This demonstrates the potential for simple, low cost innovations that aid zero hunger by making foods available and also reduce poverty.

Poor infrastructure or lack of it often prevents people from receiving food on time as well as connecting farmers to the market. It could also be near impossible to transport food using conventional vehicles through countries with rocky terrain like Bolivia [17]. Drones offer a better alternative due to their speed, compact size and ability to be remotely controlled. It reduced delivery time by 95% in comparing with traditional method, efficiency increase by 50%, reached 80% of inaccessible areas and logistics cost reduction of 30%. Drones can also capture aerial footage and collect data that can assist in discovering new communities fighting hunger, allowing engineers to collaborate with humanitarian aid professionals to get food to more people in the future. GPS-guided drones ensured accurate delivery to designated locations addressing SDGs 2 and 3

Climate change is responsible for killing many crops worldwide and a Bioengineer-Jennifer Brophy [18] is genetically engineering some plants "grow in various conditions, such as retaining more water during a drought by changing the genome of crops and figuring out how to activate specific genes on command". "The Teaching and Research Farm of the Federal University of Technology, Akure (FUTA) has embarked on massive cultivation of the Eva F1 Tomato, a variety five times bigger in size than the commonly available one in the Nigerian market"[13]. It can produce four times paste than the latter and can stay fresh over a period of two weeks. The provision of electricity will help drive irrigation and can be realised through solar irrigation. This is common nowadays but the case of Pimpurna in India is unique and it is a partnership between Lions Club and Sumitomo [14]. Using renewable energy generated by solar panels, water from the nearby Pimpurna Dam is pumped to the fields of 29 farmers in the village. This allows farmers to grow two to three crops a year. Farmers used to grow only one crop, but now they can grow a second and third crop, which naturally increases their income. In addition, migration will be stopped during the dry summer, allowing children to continue their education in the village. This single project addressed SDG 1 - 4 and 7- 9.

SDG 3 can be achieved through efficient medical devices and equipment designed by engineers. Engineers play major role in healthcare infrastructures like medical waste treatment, telemedicine platforms, hospital design and construction. Biomedical engineering is advancing in dental implants, prosthetics and high level diagnostic equipment. A team of researchers at the Federal University of Technology Akure, FUTA developed a portable Positive pressure ventilator during the COVID-19 [15]. The principle of the machine was taken from the bellows used by the local blacksmiths (local technology), and it runs on direct current and solar energy. It increased access to affordable ventilators in Nigeria and Africa, offers improved healthcare outcomes for patients with respiratory issues with reduced reliance on imported medical equipment while enhancing capacity for local medical device innovation.

SDG 4 has seen a radical change since the advent of ICT and virtual learning. There are lots of opportunity like accessibility, flexibility, cost effectiveness, personalization, career advancement and resource availability. Teaching methodologies using multimedia makes it interesting for students to follow the lectures, forge better understanding through animations, off-line and on-line teaching aids and tools. Internet aids better research, teachers are exposed and can develop teaching materials, update existing curricula and make presentation to students easily. Chatbots are available for students to answer questions on various topics in an interactive manner.

Professional engineering institutions are encouraging women participation with the first woman NSE President in Nigeria to ensure SDG 5 is realised. There is the Association of Professional women Engineers of Nigeria, Women in Engineering and STEM that is encouraging women to increase women participation in Engineering. SDG 6 is about clean water and sanitation. Engineers have advance water treatment facilities around the world while waste water treatment plants are developed for the manufacturing sectors. There are precision equipments to detect ground water and made drilling of boreholes seamless. Biodigesters have improved sanitation in the treatment of organic wastes, biogas generated from the biodigester can also be used as cooking gas as is currently being practised in IITA Ibadan in Nigeria.

Engineers have supported SDG 7 by developing low cost renewable energy systems like the solar energy mini and micro grids, geothermal and wind energies. Nigerian brewery pioneered solar hybrid energy system at their plant in Ibadan with 663.6 kWp solar power plant. Itt is expected to supply approximately 800,000 kWh of electricity per year and reduce the site's CO2 emissions by over 10,000 tonnes over its lifespan. The biogas generated from the waste water treatment plant is used to power the boilers offering reduction on fossil fuels. This has the potential to provide up to 10-15% of our brewery's process heat demand and save about 600 tonnes of CO_2 a year [19]. Promasidor Nigeria Ltd is also engaged in hybrid solar energy. The use of Liquefied and Compressed Natural gas for generating electricity addresses both SDGs 7 and 13. Afe Babalola University has been generating electricity with Compressed Natural gas for a long time. "There is the solar Mini Grid at Osi, Aluterin, AraJoshua and Olomu-Oja communities in Osun State by the Federal Government through the Rural Electrification Agency being implemented by the Community Energy Social Enterprises Ltd" [22]. The project is providing affordable clean energy access for the communities, improving healthcare, education and opening-up economic opportunities for them.

SDG 8 deals with decent work and economic growth; Engineering solutions have created opportunities for the diversification of the Nigerian economy with the job creations. New Fintechs have sprang up the world over due to the Artificial Intelligence with various start-up in Nigeria most of these very successful. We have Paystack, Interswitch, SmartCard etc, Flutterwave, Chipper, Opay,

PAGA. When infrastructure is built, it creates jobs and when we think of its maintenance, it opens up a lot more opportunities. Innovation is synonymous with Engineering, and it is the bedrock of economic growth.

"Engineering is now recognized as an enabler of economic growth"[3]. From comfortable and cosy office environments to advancement in telecommunications and transport as seen with the urban rail development in Lagos and Abuja, the provision of essential infrastructures, Engineers are set to help the world achieve SDG 9 faster than 2030. SDG 9 addresses Industry, Innovation and Infrastructure. No modern economy can thrive without Industrialization and Engineering is a catalyst for industrial revolution transforming industries and societies. Modern Engineering continue to drive progress in digital revolution, renewable energy, biotechnology, Nanotechnology and Artificial Intelligence. Engineering continues to drive innovation, economic growth and societal progress thereby shaping the modern world.

SDG 10 is to reduced inequalities and Engineering through SDG 1 to 9 provides a platform for this. Once jobs are created, there are access to essential needs of man such as affordable housing, food, health and opportunity to earn decent wages, we would have achieved global equality for all. There are mobile payment system in Nigeria such as 'OPAY', Moniepoint and Kuda besides the flutterwave, Paypal etc. that have reduced inequalities in the banking sector to near zero. The telecommunications sector with Pay-as-you-go both on voice and data, the prepaid meter facility for electricity is other various platform to achieve this goal.

Engineering play key roles in building sustainable cities and communities. These involve designing and building energy-efficient infrastructures to reduce consumption, developing sustainable transportation system like electric or CNG vehicles, good road network system, creating green buildings and recreational facilities, implementing smart waste management system including running an efficient circular economy and building resilient cities that can withstand natural disaster. Engineering has been in the vanguard of responsible consumption and Production the SDG 12. This has to do with the sustainable management of resources, minimizing waste and promoting eco-friendly practices across the value chain. It helps to reduce environmental impact,conserve natural resources, improves public health and well being. There is a Nigerian company "Free Recycle" that is turning old tyres into bricks, floor tiles and flip flop sandals.

SDG 13 is the Climate action and Engineering was at the forefront of the development of alternative refrigerants that have lower ozone depletion potential in the air-conditioning systems since the Montreal protocol. SDG 13 is directly related to SDG 6, 7, 9, 11 and 12. It is also indirectly related to SDG 1, 2, 3, 4, 5, 8, 10, 14, and 15. In order to address SDG 13, it requires synergies and interconnection with other SDGs.

Life below water is SDG 14. Engineers have been working to protect the rising sea level which is leading to the erosion of our coastline. This has been demonstrated in Lagos, Nigeria by the development of Eko Atlantic City where sea wall about 8.5km long was constructed as a barrier [21]. There are breakwaters strategically placed around the coastline, groynes to trap sand and also heavy sand filling. Engineers protect this great resource, the oceans and seas that not only supply sea foods but also water and source of transportation for sea merchants all over the world.

SDG 15 is the life on land and Engineering solutions help protect biodiversity, preserve our ecosystems and ensure a healthy, thriving environment for all the life on land. We have erosion control in Lagos including the Eko Atlantic City that protects Ahmadu Bello Way in Victoria Island, reforestation efforts in Osun State, Water purification system in Abuja, Landfill management in Ibadan and sustainable agricultural practices in Kano state. An engineering invention, the Global Positioning System helps in transportation (popular in big cities with drivers), precision agriculture, disaster response, environmental monitoring, forestry management to curb poaching and illegal loggings among other usefulness.

Peace, justice and strong institutions is the SDG 16 where engineering solutions such as satellite imaging and remote sensing is used for conflict monitoring. Closed circuit television system is aiding security and safety while social media platforms has made communication effective even in rural areas while drones are very useful humanitarian tool during disaster response activities. In justice delivery, digital forensic tools is aiding investigation, finger prints and biometric identification systems is a protection against identity theft while Artificial Intelligence is powering legal aid systems. Nigeria has the NASRDA for satellite imaging and remote sensing and our telecommunications sector is well developed with advance communication services. There are E-government platform in Nigeria and digital identity system powered by National identity Management Commission (NIMC).

SDG 17: Partnership for the goals; Engineering partnerships for the goals involve synergy within the engineering family either at local level, continental and intercontinental. COREN as the umbrella body in Nigeria is now a provisional signatory to Washington accord and is working her ways into the Sydney and Dublin accords. This made partnership and collaboration with other International Engineers easy. Nigeria Engineers are members of World Federation of Engineering Organisations and a past President of Nigeria Society of Engineers is the incumbent President. There is a collaboration between World Federation of Engineering Organizations, Nigerian Society of Engineers, Council for the Regulation of Engineering in Nigeria and Engineering Council UK. Nigerian Institution of Mechanical Engineers partners with Institution of Mechanical Engineers, UK. There is collaboration between African Engineering Deans Council and Global Engineering Deans Council. UNESCO and Nigerian Commission for UNESCO, Nigerian Society Of Engineers/American Society of Civil Engineers etc. These are aimed to leverage our expertise, resources, knowledge and networks to drive the achievement of goals in Nigeria.

5 Challenges Before Engineers

Engineers face myriads of challenges globally in their efforts to contribute towards implementation of SDGs since

it could be difficult to effectively implement engineering solutions. Some of these are stated below.

i. Financial Challenges: Limited funding and material resources is a key barrier facing the engineers. It limits design options and innovation. It often times delayed engineering project implementation that leads to eventual failure

ii. Technological Barriers:This hinders the adoption and implementation of engineering solutions, particularly in the context of sustainable development. Lack or inadequate infrastructure such as energy, transportation, emerging technologies, communication and connectivity can become an albatross.

iii. Institutional challenges: Lack of policy support and regulation to control implementation is a big challenge for the engineers. It is often very complex to align engineering projects with national and international policies as these differ from country to country.

iv. Social challenges: There are limited public awareness and engagement that leads to resistance from stakeholders. Cultural and social diversity hinders the adoption of these solutions in some cases. Ensuring inclusivity and making engineering solutions beneficial to all segments of the society poses a significant challenge.

v. Environmental Impact: Engineering solutions at times , while beneficial, can sometimes have significant environmental impacts, such as pollution or habitat disruption. The advent of PET bottles contributes greatly to plastic pollution (ocean, land and air).

vi. Capacity Building: There is limited education and training to equip engineers with the skills required to tackle the evolving challenges of sustainable development. This leads to insufficient expertise in this important area. There is brain drain from developing to developed nations causing acute shortage of manpower. Limited knowledge sharing and collaboration across the world is a huge barrier.

vii. Interdisciplinary Collaboration: Lack of effective co-ordination of collaboration across various engineering disciplines across the world. This is due to communication barriers and integration challenges (managing diverse stakeholder expectations).

Despite these challenges, engineers continue to innovate and develop solutions that contribute to the implementation of the SDGs.

6 Discussions and Inference

Partnership and interdisciplinary collaborations between engineering families is important to achieve the SDGs. Such partnerships can come within the Institutional conferences, interdisciplinary research centres and joint academic programs. Professional Associations can hold conferences and seminars together, establish combine mentoring programs, share resources and knowledge. Nevertheless, industrial partnerships where industries can collaboratively fund research and development programs can be formed. The industry/academia collaboration is another area where researches can be incubated and executed. These are essential in order "to build capacity and knowledge transfer mechanisms for inclusive approaches to sustainable development"[16]. The solutions for the implementation of individual SDs revolve around multiple engineering disciplines across the nations of the world.

However, there are factors that can impact or influence the outcomes of the engineering solutions, the partnerships and interdisciplinary collaborations. Globalization and economic shifts such as the rise of new economic super powers like China and India. The increase visibility of international commerce and investment, new regional economic alignment (BRICS, ASEAN, EU, AU) and cryptocurrency. Emerging technologies (IoT, blockchain, AI, cloud computing), cybersecurity threats, data analytics and data protection. We are also faced with the challenges of energy storage and renewable energy, transportation and logistics innovations across the world and advance telecommunications. We have political factors across the globe (policies and regulations, conflicts and geopolitical tensions across the world, international co-operations and agreements). There are environmental factors (natural disasters and climate resilience, biodiversity and ecosystem conservation and integration) and social factors (cultural differences and societal values, social inequality, justice and inclusivity, education, workforce development and 'gen z' phenomenon).

All these factors need serious and deep considerations to help engineers, all stakeholders including policy-makers to develop robust and impactful engineering solutions towards achieving the desired sustainable goals. There are also potential synergies and trade-offs between the SDGs that can impact the worldwide implementations.

The synergies

i. SDG 6 (Clean Water) and SDG 3 (Good Health): When water quality and sanitation is improved, it will reduce water-borne diseases.

ii. SDG 7 (Renewable Energy) and SDG 13 (Climate Action): Renewable energy reduces carbon footprint which is an emission reduction solutions; an actiobn to combat climate cahnge .

iii. SDG 4 (Quality Education) and SDG 8 (Decent Work): Quality education reslts to educated workforce that can drive economic growth and decent employment.

iv. SDG 11 (Sustainable Cities) and SDG 9 (Infrastructure): Sustainable cities can reduce costs of

infrastructure and create thriving, resilient and environmentally friendly urban ecosystems.

v. SDG 2 (Zero Hunger) and SDG 12 (Responsible Consumption): Sustainable agriculture practices can reduce waste and promote responsible consumption.

Trade-offs:

i. SDG 8 (Decent Work) and SDG 12 (Responsible Consumption): Decent work will bring economic prosperity that may lead to overconsumption, waste and resource depletion.

ii. SDG 7 (Renewable Energy) and SDG 9 (Infrastructure): Large-scale renewable energy infrastructure is already generating waste which may disrupt the ecosystems.

iii. SDG 2 (Zero Hunger) and SDG 6 (Clean Water): Intensive agriculture may deplete water resources and create water scarcity.

iv. SDG 11 (Sustainable Cities) and SDG 10 (Reduced Inequalities): Urbanization will create Megacities that may exacerbate social inequalities.

v. SDG 14 (Life Below Water) and SDG 8 (Decent Work): Marine conservation efforts may impact fisheries and livelihoods of fishermen.

Nexus Areas (Interdependence or Convergence points):

i. Water-Energy-Food (SDGs 2, 6, 7)

ii. Infrastructure-Transportation-Urbanization (SDGs 9, 11, 12)

iii. Health-Education-Economic Growth (SDGs 3, 4, 8)

iv. Climate-Disaster-Resilience (SDGs 13, 1, 11)

v. Biodiversity-Ecosystem Services-Conservation (SDGs 14, 15, 12)

7 Conclusion

The paper highlights some localised engineering solutions that are supporting the implementation of the SDGs. This is vital for contextual relevance, increased effectiveness and resource efficiency. This will engender commnal ownership that will enhance its sustainability. Key factors within engineering and the world that can impact or influence the outcomes of the engineering solutions were clearly stated. The need for engineers to collaborate with policymakers, industry leaders, and local communities to develop and implement sustainable solutions were discussed, as an important factor. It points out the need for a multidisciplinary approach with other experts outside engineering field while within engineering community, it highlights the importance of interdisciplinary collaborations. There is need to explore further the indigenous technology, how to encourage it rather than importing already developed technology from abroad to solve local problems. Localized engineering solutions will empower communities, it will drive sustainable development and could accelerate SDG implementation progress.

Cultural solutions is also very important as it leverages traditional knowledge, practices, and values to address Sustainable Development Goals (SDGs) challenges like the pot -in-pot refrigeration systems.

The paper is a major highlights of engineering solutions being a very important factor in the implementation of the United Nations' 17 Sustainable Development Goals (SDGs).

8 Recommendations

Engineering solution being a systematic and scientific approach to solving a problem through the application of engineering principles, theories, and technologies; the following are recommended.

i. An Integrated Approach for solutions: We must combine and integrate both the technological, social and economic solutions together in order to address the complex problems holistically. This will also consider multiple perspectives and stakeholders.

ii. There is also the need to integrate localized engineering solutions, local technologies and cultural solutions into the implementation of the SDGs as pointed out in this study.

iii. There should be a collaborative efforts across the divide that will foster partnerships among stakeholders, governments, policy-makers, industries and academia.

iv. Premium must be placed on contextual understanding that will integrate local knowledge, expertise, cultural value systems, economies and environments. This will ensure that the solutions addresses the real-world needs in conformity with environmental and geographical constraints.

v. Capacity building is very crucial to enhance skills and the knowledge of local professionals and communities so as to improve solution design, implementation and maintenance. It will support technological transfer, adaptation and encourage local ownership for sustainability.

vi. SDG can be integrated into engineering curricula to encourage ownership and accountability.

vii. Support innovation by encouraging research and development within the government, industry and academia for the deployment of new technologies. This will drive economic growth and competitiveness that will enhances adaptation to changing circumstances in our world.

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