# Safety Engineering and the SDGs: Bridging Occupational Health, Environmental Protection, and Poverty Reduction

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## ABSTRACT

Safety engineering is increasingly recognized as a strategic enabler of sustainable development and poverty alleviation, yet its role remains underexplored in global sustainable development discourse. This paper critically examined the intersection of safety engineering and the United Nations Sustainable Development Goals (SDGs), focusing on SDG 1 (No Poverty), SDG 3 (Good Health and Well-being), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action). Drawing on an integrative literature review of peer-reviewed studies and international organizational reports, the article demonstrated how safety engineering enhances occupational health, safeguards the environment, and strengthens resilience against poverty-inducing shocks from workplace incidents and environmental hazards. The study employed theoretical perspectives from occupational health, environmental justice, and human capital development to position safety engineering as a cross-cutting tool that links individual well-being, environmental protection, and economic productivity. Case analyses from both developed and developing contexts revealed how weak regulation, resource constraints, and cultural attitudes towards risk limit safety engineering contribution to sustainability. At the same time, the study identified opportunities that exist through innovations such as digital safety technologies, safety-by-design in infrastructure, international cooperation, and safety education. The findings highlighted that safety engineering is not merely a technical add-on but a foundational element of sustainable societies. The paper calls for interdisciplinary approaches that embed safety principles into global development strategies, regulatory frameworks, and poverty-reduction programmes. Future research should prioritize comparative analyses of regulatory effectiveness, culturally adapted innovations, and participatory training approaches to bridge existing gaps. By reframing safety engineering as both a technical and socio-economic enabler, this article underscores its transformative potential in advancing the 2030 global sustainable development agenda.

**Keywords:** Sustainable development goals, safety engineering, poverty reduction, occupational health and safety, environmental protection, Occupational Health Theory, Environmental Justice Theory, Environmental Justice Theory.

## INTRODUCTION

Hunger has a devastating effect on the global population. As [1] noted, many people do not have access to enough food to survive while about one in nine people in the world are hungry. Pathetically, the situation has startling consequences and seems to worsen every passing day. While [2] noted that one child dies of hunger every ten seconds, [1] noted that one person in the world dies of hunger every four seconds [1] with [3] adding that an African child dies every 45 seconds from malarial attack. Imagine a situation where every seven seconds a child under the age of 10 dies directly or indirectly of hunger somewhere in the world [4].

The poverty level in the world is also of a major concern. For instance, there is an acute hunger crisis for an unprecedented 345 million people [5]. In Nigeria, for instance, as at 2022, 53.4% of the youths were unemployed, 63% of the citizens were multi-dimensionally poor, 72% of those in the rural community were poor while 42% of those in the urban areas were poor [6][7].

Safety is an essential but often overlooked as a tool in the fight against poverty. While policies and interventions targeting economic growth, education, and healthcare are central to poverty alleviation strategies, safety-related factors such as environmental hazards and health risks often do not receive as much attention as they deserve. However, the importance of safety as a fundamental determinant of well-being has been increasingly recognized in global discussions, particularly in relation to its impact on social stability, economic productivity, and personal security [8]-[10]. Many researchers have pointed out that the lack of safety undermines efforts in eliminating poverty, limiting access to resources, disrupting livelihoods, and increasing vulnerability to exploitation [11][12]. Addressing safety risks is not only a moral imperative but also an economic necessity, as insecurity stifles investment, hinders education, and exacerbates inequality [8][13]. Thus, there is the need to incorporate safety as a critical tool in poverty reduction strategies, examine how its absence perpetuates cycles of poverty and undermines broader development goals.

Achieving the above requires approaching development from a sustainable perspective. This involves adopting developmental strides that maintain, enhance, or improve environmental, social, cultural, and economic resources; support current and future population in pursuing healthy, productive and happy lives; utilize a tripartite approach to balance pursuit of economic development with drive to meet human and societal needs while ensuring environmental protection; ensure that the solutions to today’s needs do not compromise tomorrow’s environment or the quality of life for future generations. The United Nations Sustainable development goals (SDGs) laid a 2030 agenda for global sustainable development [14]. It was adopted in 2015 by all United Nations members and succeeded the 8 millennial development goals (MDGs) as a more comprehensive, global-focused (rather than developing countries-focused) strategy with the aim of "Peace and prosperity for people and the planet" and the mission of “A shared blueprint for peace and prosperity for people and the planet, now and into the future” [14].

Viewed broadly as the systematic application of engineering principles, risk assessment, and control strategies to prevent accidents, ill health, and environmental harm, safety engineering is a central, yet sometimes over-looked, enabler of the United Nations’ 2030 Sustainable Development Goals (SDGs). Particularly, safety engineering plays key roles in meeting the expectation of at least ten out of the 17 SDGs: no poverty (SDG 1), good health and well-being (SDG 3), clean water and sanitation (SDG 6), affordable and clean energy (SDG 7), decent work and economic growth (SDG 8), industry, innovation and infrastructure (SDG 9), sustainable cities and communities (SDG 11), responsible consumption and production (SDG 12), climate action (SDG 13), life below water (SDG 14), and life on land (SDG 15).

Central to safety engineering is the reduction in exposure to hazards, protection of worker and community health, and improvement in the resilience and reliability of built systems. All these functions link directly to the core pillars of the SDGs: health, decent work, resilient infrastructure, sustainable cities, climate action, live below water and on land, and poverty reduction [15][16].

In relation to SDG 3, safety engineers advocate population health outcomes by preventing workplace injuries and work-related diseases through hazard identification, risk assessments, exposure control, and systemic redesign [17]. The safety engineers’ pursuit of safer work environments that enhance productivity and prevent loss from occupational harm, connects directly with SDG 8.

Furthermore, resilient safety engineering practices such as redundancy, fail-safe design, and predictive maintenance, which safeguard industrial processes and critical infrastructure against failure while fostering innovation key directly into the expectations of SDG 9 [18]. Similarly, the integration of safety engineering into building codes, transport systems, and disaster risk reduction strategies as a means of reducing mortality and morbidity from urban hazards connects directly into the focus of SDG 11 in achieving sustainable cities and communities.

The connection between safety engineering and SDG 13 increasingly drives actions to protect the climate. While climate change introduces new hazards such as extreme weather, heat stress, and novel risks from emerging energy technologies, safety engineering provides tools to assess and mitigate these risks, ensuring that climate adaptation and mitigation measures protect both workers and infrastructure [17][20]. Finally, though not often obvious, safety engineering contributes to the attainment of SDG 1 of no poverty through prevention of economic shocks and emotional trauma that arise from workplace injury, illness, and disability - factors that frequently contribute to poverty in many households [16] [20].

The implication is that safety engineering is a cross-cutting enabler of sustainable development. Therefore, embedding safety principles in industrial policy, urban planning, climate protection strategies, and social protection frameworks creates co-benefits across health, work, infrastructure, cities, climate, and poverty alleviation [15][16]. However, safety engineering is often under-explored as a poverty alleviation and sustainability tool.

### Aim of study

The aim of this review is to critically examine the role of safety engineering as a cross-cutting enabler of the United Nations Sustainable Development Goals (SDGs), with a focus on SDG 3 (Good Health and Well-being), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), and SDG 1 (No Poverty). Specifically, the article aims to show how safety engineering practices do not only enhance occupational health and safety but also contribute to environmental protection and the reduction of poverty by preventing economic shocks from work-related injuries, incidents and illnesses. By integrating evidence from research and policy, the article aims to position safety engineering as a strategic tool for advancing sustainable development and to propose pathways for embedding safety considerations into national and global development agendas.

## METHODOLOGY

This study adopted integrative literature review. The literature reviewed were from peer-reviewed journals, international organizational reports (International Labour Organization, World Health Organization, United Nations, World Bank). The literature reviewed were identified through search of different reputable research databases such as Scopus, institutional repositories, Web of Science, Google Scholar, and general searches of different internet sites. Boolean operators such AND & OR were used to mesh key terms and their synonyms to find appropriate literature for the critical review. The key terms and their respective synonyms used for the literature search included safety engineering, sustainable development goals (SDGs), climate change, occupational health and safety, environmental sustainability, poverty alleviation, and innovative technologies. The inclusion criteria were studies linking safety, sustainability, SDGs, and/or socioeconomic outcomes.

### Safety Engineering in the Context of Sustainable Development.

As [15] noted, safety engineering refers to the systematic application of engineering principles, scientific knowledge, and risk management practices to design, operate, and maintain systems that prevent accidents, protect human health, and minimize environmental harm. When placed in the context of sustainable development, safety engineering, beyond the traditional occupational health and safety, also encompasses environmental stewardship, social protection, and economic resilience (see figure 1), and so aligns with the multidimensional goals of sustainability [16].

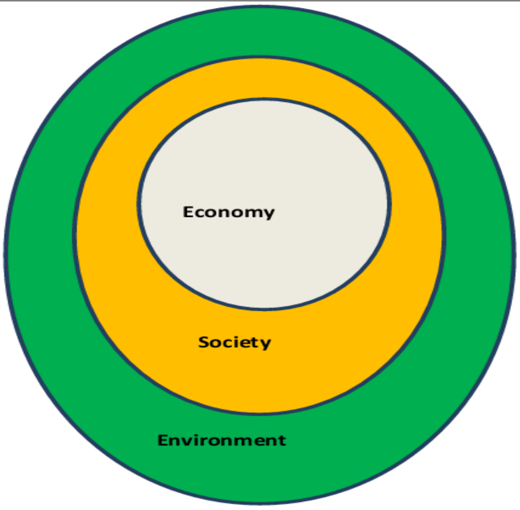


Figure 1: Interaction between environmental, social, and economic variable

Before the advent of safety engineering, most technological achievements were developed without deep and long-term consideration for social, economic, and environmental impacts on natural systems. There was less attention paid to minimizing risk and scale of unplanned or undesirable impacts on natural systems associated with engineering systems. However, lately, there is a rise in local and global impact of human actions on natural systems and thus, there is the need for balance between satisfying the needs of the increasing population and preserving integrity of ecosystems, and maintaining biological and cultural diversity. The increasing population creates unprecedented demands for energy, food, land, water, transportation, materials, waste disposal, health care, infrastructure, among others. The implication is the need for engineers to lead the drive to find the solutions and to integrate hazard prevention, system reliability, and resilience into development planning and industrial innovation. Safety engineers, therefore, ensure that technological progress and economic growth are not deployed at the expense of worker well-being, economic variables, ecological balance, or social equity [17] - see figure 2.

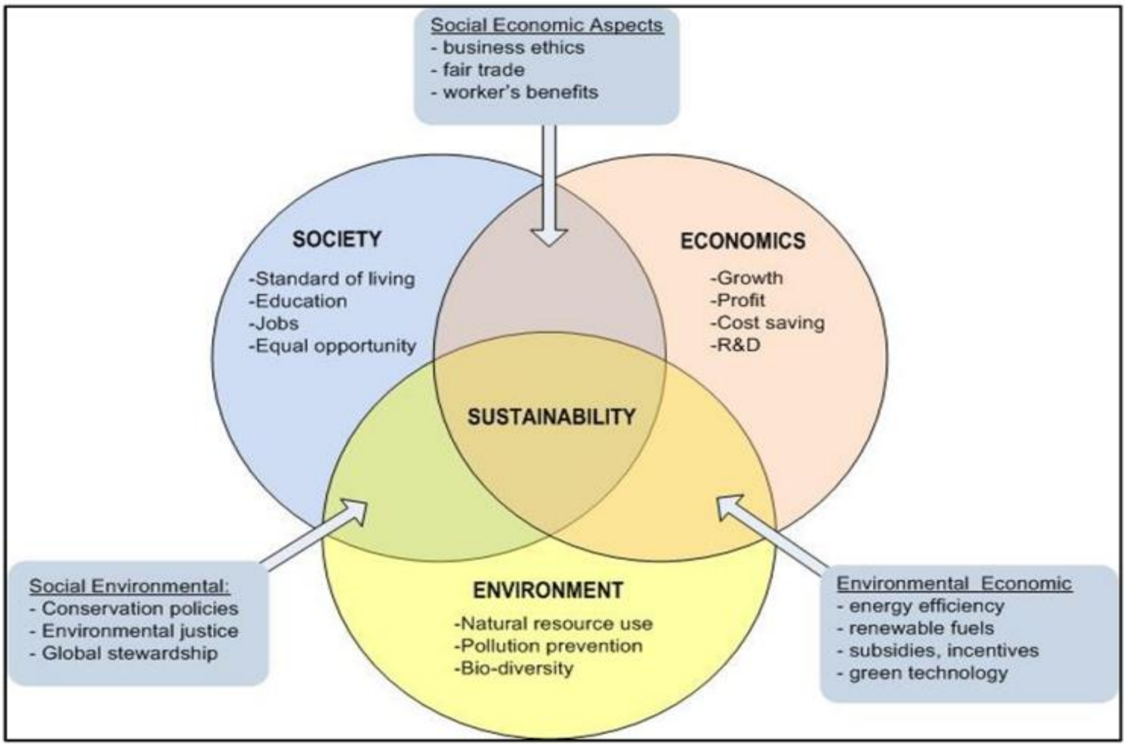


Figure 2: Pillars for achieving sustainability [21]

Therefore, safety engineering serves as a cross-cutting instrument for achieving the Sustainable Development Goals (SDGs) by integrating occupational health, environmental protection, and poverty reduction [19].

**Theories Of Occupational Health, Environmental Justice, And Human Capital Development.**

Several theories have been proposed to explain the concepts of occupational health, environmental justice and human capital development. Here is a review of some of the theories in the context of safety engineering and the sustainable development goals.

Occupational Health Theory: This theory focuses on the prevention of workplace injuries, incidents and illnesses and elimination of hazards as the cornerstone of sustainable economic and social development. Rooted in the public health model of prevention through primary, secondary, and tertiary interventions, occupational health theorist posits that occupational safety and health (OSH) are both a human right and an economic necessity [15]. Viewed from the lens of safety engineering, occupational health theorists justify engineering interventions such as hazard identification, exposure controls, and safe system design not merely as technical safeguards but as direct contributors to good health and well-being (SDG 3) and decent work and economic growth (SDG 8). By viewing occupational health as a key determinant of social equity and productivity, proponents of occupational health theory reinforce the notion that safe working environments are essential in achieving sustainable development [17].

Environmental Justice Theory: The proponents of the environmental justice theory declare that environmental risks, including occupational exposures and industrial hazards, are often unequally distributed, disproportionately affecting vulnerable populations and marginalized workers [9][22][24]-[26]. Aligning with this theory, safety engineering is not merely a technical discipline but also a mechanism for ensuring equity in health management and environmental protection [22]. By embedding environmental risk assessments, safe design, and pollution control into development projects, safety engineering helps operationalize environmental justice enhancing sustainable cities and communities (SDG 11), climate action (SDG 13), and poverty elimination (SDG 1). By driving environmental justice in ensuring that no group disproportionately bears the risks of unsafe workplaces or hazardous industries, safety engineers champion the SDGs' broader mandate of inclusivity and fairness [19].

Human Capital Development Theory: Proponents of human capital development theory view investments in health, education, and worker safety as essential drivers of productivity, innovation, and economic growth [23]. Within this framework, safety engineering provides the instrument to protect workers from preventable injuries, incidents and illnesses that erode human capital. As [27][28] observed, safe workplaces enhance workers well-being, reduce absenteeism, and sustain long-term organizational productivity. This has direct bearing with advancing decent work and economic growth (SDG 8) and indirectly reducing poverty (SDG 1). Furthermore, by safeguarding the health of the workforce and reducing injuries and long-term disability, safety engineering ensures that investments in human capital are preserved and amplified [16]. This theoretical lens reinforces the strategic role of safety engineering in enhancing inclusive and sustainable economic development.

## CONCEPTUAL FRAMEWORK

The conceptual model for this study is the integrative perspective encompassing the occupational health theory, environmental justice theory and human capital development theory as instruments for improved health and environment, productivity gains and poverty alleviation. Taken together, these theories showcase the pivotal role of safety engineering as both a technical and socio-economic enabler of the SDGs. While occupational health theory highlights the preventive function of safety engineering, environmental justice theory emphasizes the need for fairness and inclusivity in distributing risks and making risk-related decision, while the human capital development theory underscores the economic rationale for investing in safety. Collectively, these theories demonstrate that safety engineering bridges the gap between individual well-being, environmental sustainability, and poverty reduction, and hence plays a central role in the attainment of multiple sustainable development goals.

### Occupational Health and Safety (OHS) as a Foundation for Sustainable Development

Occupational Health and Safety (OHS) encompasses the policies, practices, engineering controls, and organizational systems to prevent work-related injury, illness, and death [29]. Beyond legal compliance and immediate harm prevention, robust occupational health management systems drive sustainable development through preservation of human capital, reduction in healthcare and social protection burdens, and enablement of resilient economic activity [15][17][30][31]. When combined with safety engineering, environmental management, and social policy, OHS becomes an effective and strategic instrument for advancing multiple sustainable development goals (SDGs) such as good health (SDG 3), decent work (SDG 8), no poverty (SDG 1), industry, innovation and infrastructure (SDG 9), sustainable cities (SDG 11), and climate action (SDG 13)[16][20][30][31].

Human capital theorists frame health and safety as investments that preserve workforce productivity and long-term economic potential [22]. Interventions from occupational health management system such as engineering controls, process redesign, personal protective equipment (PPE), training, and safety management systems help in reduction of absenteeism, prevention of disability, and loss of productivity as a result of workplace incidents [17]. Preventing occupational injury and illness yields direct economic returns through avoided medical, investigation, legal and insurance costs, preserved business earnings, and indirect returns through maintained skill-sets and workers experience [15][17]. The implication is that workplace safety safeguards the reservoir of skills and competencies that organizations need to innovate and grow.

Apart from individual-level benefits, effective occupational health management system is a means to reduce systemic safety and health-related vulnerabilities. Fewer workplace injuries mean reduced disruption in the flow of household incomes, less emotional traumas and stronger social protection systems for families thereby contributing to poverty reduction and social resilience, promoting SDG 1 [16]. OHS also has impacts on public health. Since workplaces can be sites of disease transmission or prevention, safety practices often have population-level health benefits [17].

The impacts of occupational health management system vary among developed and developing countries. As [17] noted, high-income nations have generally experienced long-term declines in recorded occupational incidents, injuries and fatalities due to a combination of strong regulatory enforcement, technological advances in safety engineering, and mature OHS institutions. Typical examples include the institutionalization of risk-based regulation, mandatory safety management systems in high-risk sectors, and widespread adoption of automation and engineered systems of controls that limit reliability on humans and also remove workers from hazardous tasks. Such advances do not only reduce immediate harm but also enable more stable employment and sustained productivity, thereby reinforcing SDG 8 and SDG 3 outcomes [15][19].

In low- and middle-income countries, there are markedly higher occupational risks driven by large informal sectors, weaker legal frameworks and regulatory capacity, limited access to engineered controls, and resource constraints for enforcement and workers training [16]. In many of the countries, informal and small-scale enterprises account for a substantial share of employment though they lack structured occupational health management systems. The implications, as [20] noted, is more frequent injuries with high health expenditures and impoverishment. There is, therefore, a strong need for technical interventions, strengthened institutions and social protection to translate safety gains into poverty reduction [16][17][32].

Bridging the gap between developed and developing countries may not merely require technological transfer. As [19] recommended, the bridging will require adapting engineering controls to local conditions, combined with participatory training, incentives for compliance, and enactment of policies that formalize safe systems of work. Integrated OHS strategies that include affordable engineering solutions, community engagement, and social protection can reduce the equity gap in occupational risk and strengthen multiple SDGs outcomes simultaneously. As [31] recommended, adopting a common framework for sustainability and occupational safety can be a source of significant benefits at local and global levels.

Effective occupational health management system has direct impacts on several sustainable development goals [30][31]. For instance, with reference to the pursuit of good health and well-being (SDG 3), OHS directly reduces fatality and morbidity from workplace hazards and contributes to broader population health through disease prevention and reduced exposures [16][30][31]. Safe workplaces increase labour productivity, reduce lost work hours and support sustained, inclusive economic participation thereby contributing to decent work and economic growth (SDG 8) [15][23][31]. Over the years, safety engineering has been an instrument of support to build resilient industrial processes and infrastructure reliability thereby reducing failure risk and enabling innovation that is safe by design, contributing to industry, innovation and infrastructure (SDG 9) [18][31]. Different urban safety interventions such as building codes, safe transport engineering, and emergency preparedness help protect urban populations and critical services thereby enhancing sustainable cities and communities (SDG 11) [19][30]. With climate change that amplifies occupational hazards such as heat stress and extreme weather impacts, OHS is evolving to manage climate-related risks to workers and systems thereby contributing to climate action (SDG 13) [16][20]. The linkages between OHS and SDGs show OHS not as an isolated technical domain but as a systemic enabler of sustainable development outcomes [31][32].

### Safety Engineering and Environmental Protection

Safety engineering serves as a preventive tool against environmental hazards through inclusion of hazard identification, risk assessment, and system design in industrial processes. Through designs that encompass redundancy, fail-safe mechanisms, and predictive maintenance, safety engineers reduce the likelihood of catastrophic failures that may result in industrial accidents, chemical spills, and emissions that threaten workers lives, surrounding communities, and the environment [16]. Preventive measures included as part of system designs do not only protect human health but also ensure the continuity and resilience of industrial operations, thereby directly contributing to SDG 9 (Industry, Innovation and Infrastructure). Innovation in safer technologies and industrial practices reinforces infrastructure reliability and fosters sustainable industrial growth without adversely impacting the environment [18].

Safety engineering practices extend into transport systems, energy infrastructure, and industrial zoning to minimize the risks of environmental hazards particularly in urban areas. A typical example is the integration of chemical storage safety standards, fire and explosion prevention systems, and emergency response protocols into urban planning to help reduce the impact of accidental releases or emissions on nearby populations [19]. Such practices enhance SDG 11 (Sustainable Cities and Communities) through urban resilience and protects the public spaces from industrial hazards while ensuring that cities remain safe, inclusive, and sustainable despite expansive industrial activities.

Safety engineering also plays a pivotal role in addressing the climate-related dimension of environmental hazards. While industrial revolution is necessary for enhanced quality of life, it is also a source of emissions that adversely impact the environment and cause environmental degradation and climate change. Safety engineers, therefore, play key roles in ensuring safety-oriented innovations in cleaner production processes, emission controls, and energy efficiency to reduce greenhouse gas outputs and pollution [16] thereby supporting SDG 13 (Climate Action).

### Challenges and Barriers

Despite the critical role of safety engineering in sustainable development, it faces significant challenges that undermine its contribution to the SDGs. In many developing nations, weak regulatory enforcement limits the effectiveness of occupational safety and environmental protection standards. Although legislation may exist on paper, limited inspection capacity, corruption, and lack of political will often mean that industries operate without consistent compliance oversight [16]. The implication is limited progress towards SDG 3 (Good Health and Well-being) and SDG 8 (Decent Work and Economic Growth), as unsafe working conditions continue to generate preventable injuries, illnesses, and deaths.

Another challenge is incorporating sustainable development principles into organizational policies and practices [31]. This is particularly obvious in the identification and assessment of occupational risks [31].

The resource constraints experienced by small- and medium-scale enterprises (SMEs) is another challenge impacting safety engineering. Though SMEs form the backbone of many economies, they often lack the financial and technical capacity to adopt advanced safety engineering measures [15]. Thus, SMEs may resort to prioritizing short-term survival over long-term investments in safety systems. This may lead to minimal hazard controls, outdated infrastructure, and insufficient worker training which hinder the contributions to SDG 9 (Industry, Innovation and Infrastructure) and SDG 11 (Sustainable Cities and Communities) [17].

Issues related to cultural and behavioural attitudes towards risk are other challenges faced by safety engineers. In certain contexts, both workers and employers of labour may normalize hazardous conditions as inevitable, undervaluing preventive and mitigative measures and formal safe systems of work [19]. Furthermore, poverty-reduction strategies often fail to integrate safety engineering, leaving vulnerable populations - especially those in informal or hazardous work - without adequate protection [20]. This oversight perpetuates cycles of poverty linked to incidents, injuries, illnesses, and financial losses, adversely affecting progress on SDG 1 (No Poverty) and SDG 13 (Climate Action).

Sustaining the positive impacts of safety engineering on SDGs requires addressing the various barriers through stronger regulatory frameworks, targeted support for SMEs, cultural change around risk, and the integration of safety into poverty-alleviation and climate-adaptation strategies.

**Opportunities and Innovations**

The rapid advancement of digital technologies creates significant opportunities to advance the contributions of safety engineering to the SDGs. Tools such as the Internet of Things (IoT), artificial intelligence (AI), and predictive analytics enable real-time monitoring of workplaces and environmental hazards, early detection of hazards, early detection of equipment failures, predictive modeling of risks before they escalate into accidents and proactive risk management in industries and urban settings [33][34]. By reducing workplace incidents and industrial accidents, digital safety tools directly contribute to SDG 3 (Good Health and Well-being) and SDG 9 (Industry, Innovation and Infrastructure). Moreover, the adoption of such technologies supports efficiency and resilience, ensuring that industrial growths are sustainable while maintaining safe environments.

Another major innovation is the adoption of safety-by-design principles in sustainable infrastructure projects. This approach embeds safety considerations into the conceptual and planning phases of projects ensuring that risks are systematically eliminated or minimized through engineering choices such as material selection, system redundancies, and environmentally safe designs [35]. Safety-by-design does not only reduce construction and operational hazards but also aligns with SDG 11 (Sustainable Cities and Communities) by promoting safer, resilient urban systems. It further strengthens climate adaptation strategies by ensuring that infrastructure is robust against hazards exacerbated by climate change, reinforcing links to SDG 13 (Climate Action). Also, by integrating hazard identification and risk control into the design phase of projects, safety engineering ensures that new energy systems, transportation networks, and urban developments are built with resilience and sustainability in mind [36]. This proactive approach helps to reduce long-term costs, minimizes environmental hazards, and aligns with SDG 13 by reducing emissions and strengthening climate adaptation capacity, such as designing flood-resilient industrial facilities or renewable energy projects with built-in safety systems to safeguard communities while advancing green transitions.

There are also opportunities for international cooperation and knowledge transfer to accelerate safety engineers' contribution to the SDGs. Collaborative platforms allow developing nations to access global best practices, advanced technologies, and regulatory frameworks that may not be within their reach due to financial or institutional limitations [37]. Deployment of international safety standards, cross-border research collaborations, and capacity-building programmes are options that can help harmonize safety practices globally to ensure inclusivity in progress towards the SDGs and create a level playing field where workers everywhere benefit from safe and sustainable practices.

Finally, improved safety training and education serve as another empowerment tool to extend the reach of safety engineering beyond technical measures. Through training programmes, workers, organizational leaders, and communities can be equipped with safety knowledge to foster a culture of prevention, accountability, and resilience [16]. The awareness from the training would empower workers in both formal and informal sectors to identify hazards, evaluate the associated risks, advocate for safer conditions, and protect their health, thus advancing SDG 1 (No Poverty) and SDG 4 (Quality Education) alongside occupational health goals. In this way, education in safety practices do not only safeguards human capital development but also enhances long-term productivity, profitability and sustainable development.

# CONCLUSION

Engineers played pivotal role in translation and application of science to solve human problems. However, some of the solutions to existing problems have themselves created new problems. The role of engineers is key in mitigating or solving these new problems and driving continuous improvements to achieve the sustainable development goals.

The safety engineers play key roles in balancing social, economic and environmental needs for sustainable development, improved quality of life and poverty reduction. There is, therefore, the need for a shift in the traditional engineering approach to revised strategies that consider potential longevity of vital human ecological support systems, decision making that considers the interconnections and impacts of economic, social and environmental factors on today and future generations' quality of life, and reconciling effort to address human needs with the capacity of the planet to cope with the consequences of human activities.

The implication, therefore, is that safety engineering should not be viewed as a mere technical add-on to industrial processes but rather as a strategic enabler of sustainable development and a great instrument for poverty alleviation. Through the safeguard of human health, protection of the environment, and ensuring resilient infrastructure, safety engineering directly advances several Sustainable Development Goals, such as health, decent work, sustainable cities, climate action, and poverty reduction. Its preventive role in mitigating workplace hazards, environmental risks, and industrial disasters underscores its importance as a foundational element of sustainable societal developments.

Future research should explore how innovations such as digital safety technologies, safety-by-design in infrastructure, and participatory training models can be adapted across diverse cultural and economic contexts. Comparative studies between developed and developing nations are particularly needed to understand how regulatory frameworks, resource constraints, and local cultures influence the effectiveness of safety engineering in advancing the SDGs. By bridging these knowledge gaps, scholars and practitioners can position safety engineering as a transformative driver of global sustainability and equitable development.

# RECOMMENDATIONS

Moving forward, there is a clear need for interdisciplinary approaches that integrate safety engineering with fields such as public health, environmental science, economics, and social policy to help transit safety into the broader agenda of global development and ensure that risk prevention and human well-being are embedded into the core of sustainability planning. Such collaboration is essential for developing inclusive solutions that address both technical challenges and socio-economic inequalities. Safety engineers should, therefore, opt for a holistic and balanced view of development that aligns with the pillars for sustainability as depicted in figure 2.

To realize OHS as a foundation for sustainable development, policymakers need to integrate safety engineering and OHS metrics into national SDGs monitoring frameworks, prioritize social protection for workers, support technology diffusion that is contextually adapted and accompanied by training, and strengthen multi-sectoral governance structure that links labour, health, environmental protection, and infrastructure planning to ensure that OHS investments yield lasting benefits for human capital, economic resilience, and social equity.

To align the focus on sustainable development across different nations, there is the need to strengthen regulatory frameworks and enforcement particularly in developing countries. This would require investing in inspection capacity of regulatory bodies, reducing corruption, and aligning local regulations with international safety standards to ensure progress towards SDG 3 (Good Health) and SDG 8 (Decent Work).

To enable small- and medium-scale enterprises (SMEs) to mitigate barriers hampering alignment of their practices with the demands of the SDGs, there should be tailored financial and technical support to SMEs to overcome resource barriers in implementing safety measures. This may be in the form of subsidies, tax incentives, or shared safety services that enable smaller firms to adopt innovations such as digital monitoring tools thereby contributing to SDG 9 (Industry, Innovation, and Infrastructure).

Policymakers and industry leaders should promote safety-by-design in infrastructure and urban planning by embedding safety in the conceptual and planning phases of projects to create safer and more resilient cities, thereby supporting SDG 11 (Sustainable Cities) and SDG 13 (Climate Action).

Industry professionals, safety engineers and other stakeholders should explore avenues to foster international cooperation and knowledge transfer. This may entail multilateral institutions and professional associations collaborative platforms for global knowledge sharing on safety engineering innovations and best practices to accelerate capacity-building in developing countries and harmonize safety standards across national borders.

Considerations should be given to embedding safety in poverty-reduction strategies, This should include integrating workplace and environmental safety considerations to protect vulnerable populations from hazardous working conditions. Such integration will ensure that progress on SDG 1 (No Poverty) does not come at the expense of health or safety.

Governments, donor agencies, civil society organizations, industries, and academic institutions should expand access to safety training and education at all levels. They should empower workers, managers, and communities with safety knowledge to foster a culture of prevention and resilience while strengthening human capital to meet sustainable development goals.

Safety engineers should not merely aim to achieve the minimum standards. They should comply with existing legislation, codes and regulatory framework but be proactive and anticipate future legislation which may be stronger. Where there are no laws, they should explore avenues to apply best practices and standards. They should drive improvements in existing laws and institution of new laws and codes, where required. They should alert the relevant authorities if there are deficiencies in existing legislation and potential impacts on sustainable development and harness the power of professional bodies to align professional practices with sustainable development goals. They should champion minimizing any adverse impacts on resource sustainability at engineering design stage and advocate for efficient use of natural resources. In project designs, they should design to promote re-use, recycling, decommissioning and disposal of components and materials and collaborate with stakeholders and other professionals to enhance sustainable developments. In all they do, they should not merely focus on achieving today’s desire but aim for a safer and a more environmentally-friendly tomorrow.

There is the need to advance research and innovation to continuously drive the deployment of technology as instruments of sustainable development. Thus, future research should focus on digital technologies such as use of internet of things, artificial intelligence and predictive analytics for safety monitoring, comparative studies of regulatory effectiveness across contexts, and participatory approaches that integrate cultural attitudes towards risk. This will enhance the expansion of the evidence base to link safety engineering with the SDGs.

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