# CIVIL ENGINEERING AND SUSTAINABLE DEVELOPMENT GOALS (SDGs): FUTURE CHALLENGES IN BUILDING RESILIENT TOWNS AND CITIES

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Abstract : Civil engineering plays a very crucial role in achieving the United Nation's Sustainable Development Goals (SDGs) by 2030 towards building our towns and cities into self-sustaining and resilient communities. From the critical review of literature and reflections from the author's work experience, this paper attempts to recognize the leadership roles and linkages of civil engineers with SDGs. The findings from the study provide a clearer direction for civil engineering professionals to take – engaging and committing themselves to participate and collaborate in infrastructure developmental projects towards high quality outcomes and standards. With technological advancement and innovative solutions, civil engineers should go beyond minimum compliance, offering exceptional engineering products and services in the construction industry and education sector.

*Key words : civil engineering, resilient communities, sustainable development, sustainable development goals*

## 1 INTRODUCTION

The United Nations Educational, Scientific and Cultural Organization (UNESCO) fully acknowledged the contributions of engineering professionals in addressing the challenges brought by sustainable development (SD). Engineering professionals play a major role not only in the growth and development of a country's economy but also in improving the quality of life. Thus, there is an ever-increasing role of engineering professionals in enabling a country to participate in the global economy and in the protection of the environment. Specifically, more of engineers are required to address the challenges and problems that brought about by rapid urbanization, depletion of natural resources, and environmental degradation. For instance, the development of renewable energy sources, advancements in technology, solutions for sustaining the environment and improving healthcare require engineering applications. To this end, engineers are key players in nation's building particularly as agents of infrastructure development and environmental protection and management (Dutta & Sengupta, 2014; Quadrado et al, 2013; Lucena, Schneider & Leydens, 2010; UNESCO, 2010; WFEOCT, 2002; Qureshi & Nawab, n.d.).

Even in the late 1990s, several international academic and professional organizations and societies such as the World Engineering Partnership for Sustainable Development (WEPSD), American Society of Engineering Education (ASEE), and the American Society of Civil Engineers (ASCE) had acted in the call of SD - taking actions by declaring their positions by revising their codes of ethics and challenging their members to address SD in their workplace, and creating international professional partnerships and collaborations (Lucena, Schneider, and Leydens, 2010). Some of these engineering organizations assisted in the United Nations' MDGs/SDGs setting process; and others like the International Federation of Consulting Engineers, American Society for Civil Engineers, the Institute of Chemical Engineers, the British Institution of Civil Engineers, the Institution of Engineers of Australia, and the Association of Professional Engineers and Geoscientists of British Columbia have policies, principles, indicators and guidelines for putting sustainability into engineering practice have been developed (Boyle & Coates, 2005).

For example, WEPSD's vision indicates that *"engineers will translate the dreams of humanity, traditional knowledge, and the concepts of science into action through the creative application of technology to achieve sustainable development. The ethics, education, and practices of the engineering profession will shape a sustainable future for all generations. To achieve this vision, the leadership of the world engineering community will join together in an integrated partnership to actively engage with all disciplines and decision makers to provide advice, leadership, and facilitation for our shared and sustainable world."* In 1999, the ASEE's Statement on Sustainable Development Education also states that *"engineering students should learn about sustainable development and sustainability in the general education component of the curriculum as they are preparing for the major design experience." Engineering faculty should use systems approaches, including interdisciplinary teams, to teach pollution prevention techniques, life cycle analysis, industrial ecology, and other sustainable engineering concepts."* Even the American Society of Civil Engineers (ASCE) has also declared that *"its engineers shall strive to comply with the principles of sustainable development, which is defined as the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development."* Further, the World Federation of Engineering Organizations (WFEO) issued a resolution that encourages all engineers to become knowledgeable of SD principles and be continuously trained about the current SD technologies applicable to their work (WFEO, 1997 as cited by Boyle & Coates, 2005).

On the other hand, one of the fundamental canons of the Philippine Institute of Civil Engineers (PICE)'s Code of Ethics is that *"civil engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their duties."* In addition, the Philippine Commission on Higher Education (CHED)'s strategic framework (2011-16)'s objectives are anchored to the overall societal goal which is the *"attainment of inclusive growth and sustainable development."* (CHED, n.d.). With the latest issuance of CHED's Policies, Standards and Guidelines (PSGs) for the Bachelor of Science in Civil Engineering Program to be implemented in the academic year 2018-19 highlighted the attributes and competences of a civil engineer in "*conjunction with the Civil Engineering Professional Practice towards a personal commitment to societal, health, safety, legal and cultural issues recognizing obligations to society, subordinates, and the environment*" (CHED, 2017).
Indeed, the role of civil engineers is paramount in the planning and managing our communities to become more resilient to human-induced hazards, climate change and natural disasters. It is also important to note that civil engineering graduates must be prepared by their academic qualifications in the practice of their profession and to take leadership roles in facilitating SD in their respective communities.

## 2 OBJECTIVES

This paper attempts to recognize the linkages between engineering (civil engineering in particular) and sustainable development goals (SDGs), with respect to the social, economic, ethical, cultural, and environmental challenges that civil engineering professionals are facing today in building sustainable and resilient society. Moreover, this paper seeks to highlight the leadership role of civil engineers in realizing SDGs by 2030, specifically in areas where they can provide innovative solutions to: (a) ensure inclusive and equitable quality education (SD Goal 4), (b) ensure available and sustainable management of water and sanitation (SD Goal 6), (c) ensuring access to affordable, reliable, and modern energy for all (SD Goal7), (d) build resilient infrastructure (SD Goal 9), (e) make cities and human settlements inclusive, safe, and resilient (SD Goal 11, (f) take urgent action in combat climate change and its impacts (SD Goal 13), (g) prevent marine pollution of all kinds, particularly from land-based activities (SD Goal 14, and (h) ensure the conservation, and restoration of terrestrial and inland freshwater ecosystems (DG Goal15).

## 3 METHODOLOGY

Reflections from the author's working experience were considered, and critical review of literature and past studies, were carried-out to highlight the major responsibility and accountability of civil engineers in helping our communities grow sustainably through better decision-making to get more cost-effective and efficient infrastructures and services. The significant roles that civil engineering professionals should play are also highlighted in the discussion to have a better appreciation and full understanding of the challenges that civil engineers will be confronted towards the achievement of SDGs specifically in meeting the identified targets by 2030.

## 4 DISCUSSIONS

### 4.1 Promotion of Sustainable Development Goals (SDGs)

SD is defined by the World Commission on Environment and Development (WCED) in its 1987 report, Brundtland Commission Report as a kind of development "*that meets the needs of the present without compromising the ability of the future generations to meet their own needs*." Furthermore, the report states that SD is "*not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs*." (Enger & Smith, 2009; Harding 2002; WCED, 1987). Thus, this development can be "*pursued in harmony with changing productive potential of the ecosystem… and it must rest on political will*." (WCED, 1987). Moreover, the concept of SD has been accepted worldwide to link economic and social development with rigorous environmental management to achieve "sustainability." (Harding, 2002). Harding (2002) points out further that SD is not a "*business as usual*" scenario. The author viewed SD as a framework for development which poses new demands on the roles of engineers and scientists and will affect the decision-making process and outcomes. These new roles from engineering professionals entail different skills – away from the traditional educated professionals and it is expect them to have the following essential qualities: (a) attitude: an environmental ethic and holistic approach; (b) specific skills: the ability to understand and work with complex systems, work as a team with diverse backgrounds, good communication skills and high level of creativity; and (c) broad knowledge: in terms legal, social economic and ecological aspects.
After the Brudtland Report, numerous agreements, conferences and summits on SD followed worldwide, including the adoption of the Eight (8) Millennium Development Goals (MDGs) of the United Nations (UN) taken from the UN Millennium Declaration that took effect in September 2000 with specific indicators and targets to be achieved by the year 2015. The MDGs basically aimed to combat hunger, poverty, illiteracy, disease, environmental degradation, and discrimination against women and children. The UNESCO's Report (2010) clearly recognized the critical roles of engineers towards the achievement of MDGs. In particular, two of these goals relate to the environmental limits that require engineers to be involved in the delivery of infrastructures with pro-poor outcomes in the entire project cycle.
As the prime mover of SD, the UN came up with another set of goals in September 2015 - the Sustainable Development Goals (SDGs), consisted of 17 goals (with 169 targets) as presented below, Table 1. Overall, these goals provide many challenges and opportunities for engineers worldwide (Kelly and Mohsen, 2016).

**Table 1** The 17 Sustainable Development Goals

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|---|---|
| Goal 1 | End poverty in all its forms everywhere |
| Goal 2 | End hunger, achieve food security and improved nutrition and promote sustainable agriculture |
| Goal 3 | Ensure healthy lives and promote wellbeing for all at all ages |
| Goal 4 | Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all |
| Goal 5 | Achieve gender equality and empower all women and girls |
| Goal 6 | Ensure availability and sustainable management of water and sanitation for all |
| Goal 7 | Ensure access to affordable, reliable, sustainable and modern energy for all |
| Goal 8 | Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all |
| Goal 9 | Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation |
| Goal 10 | Reduce inequality within and among countries |
| Goal 11 | Make cities and human settlements inclusive, safe, resilient and sustainable |
| Goal 12 | Ensure sustainable consumption and production patterns |
| Goal 13 | Take urgent action to combat climate change and its impacts |
| Goal 14 | Conserve and sustainably use the oceans, seas and marine resources for sustainable development |
| Goal 15 | Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss |
| Goal 16 | Promote peaceful and inclusive societies for sustainable development, provide access to justice for all |
| Goal 17 | Strengthen the means of implementation and revitalize the global partnership for sustainable development. |

At the local scene, the Philippines formulated its own Agenda 21 (known as the National Agenda for Sustainable Development) in response to the UN Agenda 21 – the global blueprint for sustainable development forged during the UN Conference on Environment and Development (UNCED) in 1992. In 1997, the Philippine Council for Sustainable Development (PCSD) was also created through Executive Order No.15 with the mandate to operationalize SD at the national level with representatives from government, private sector and civil society (Galang, 2002). Galang (2002) further discussed that prior to PA 21, the Philippines has already adopted the Philippine Strategy for Sustainable Development (PSSD) in 1989 which served as a framework for environment and development issues. PSSD is designed to achieve sustained economic growth without additional depletion of natural resources and sacrificing the quality of environment.

One of the notable initiatives during the Aquino administration is the inclusion of strategies in pursuing sustainable and resilient communities in the National Framework for Physical Planning (2001-2030) and the National Urban Development and Housing Framework (2009-2016), (Magno, 2017). In particular, the latter plan document highlighted the use of "market-based incentives and disincentives" approach to encourage sustainable planning and green building, including the integration of climate change adaptation and disaster risk management into community and regional development.

With the present Duterte Administration, its Philippine Development Plan 2017-2022 is geared towards the attainment of Ambisyon Natin 2040 and it also takes into account the country's international commitment to SDGs (NEDA, 2017). For example, it is expected that individuals and communities will be more resilient from various natural and human-induced hazards. The Plan reiterates that building up resilience reduces exposure to hazards, mitigates the impact of the risks, and accelerates or fast recovery if and when the risk materializes. In terms of education, lifelong learning opportunities will be available to all, including investment for infrastructures in basic education are more accessible and with relevant curriculum offering. Thus, improvement in the quality of higher and technical education leads competent and highly skilled individuals and workforce. It is also explicitly focused by the Plan to promote new urban agenda in developing integrated neighborhoods and sustainable communities which involves innovative solutions to housing construction and improved community relations between communities and government towards safe and secured communities. Finally, the Plan states that the foundation for sustainable development is to have a balanced and strategic development of infrastructure, while ensuring ecological integrity and a clean and healthy environment. In terms of environment and natural resources management, the Plan contains strategies to rehabilitate and restore degraded natural resources, and protect fragile ecosystems through "a ridge-to-reef approach" and a sustainable area development framework.

### 4.2 Engineering Education and Profession in Relation to Sustainable Development Goals (SDGs)

In reference to SD Goal 4: *Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*, the applicable targets include the following: (a) by 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others; (b) by 2020, substantially expand globally the number of scholarships available to developing countries; and (c) by 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries.

What are the implications of these SDGs' targets for engineering education and profession specifically for civil specialization?

*Engineering Higher Education Programs/Courses*

According to Kelly et al (2016 and Kelly (2015), engineering graduates will need to have a deeper knowledge and understanding of sustainable development and the overall university education needs to ensure context particularly in the social aspects of sustainable development. Engineering faculty in higher education should also take opportunities to ensure that the engineering aspects of sustainable development are addressed for all students.

Kelly et al (2016) outline some of the opportunities for faculty members to contribute to achieving these SDGs as engineering educators preparing the next generation of civil engineers and as engineering professionals/practitioners. The authors suggest

by deepening and applying the sustainability knowledge base with respect to civil and environmental engineering in the curriculum where SD could be embedded in discussions of leadership, project management, business, policy, and ethics and other professional practice subjects.

On the other hand, it is viewed that graduate and undergraduate education on engineering programs should be in accordance with the principles for sustainable development to provide students a more integrated perspective as well as the skills for achieving sustainable solutions in their future engineering practice. (Quadrado et al., 2013). Further, it is suggested that a "problem-based learning" methodology which promote an active learning environment, student centered, and encourage teamwork in a multidisciplinary environment. In this learning approach, students develop knowledge by solving real problems that can promote active learning and radically change the way that classes are usually taught in most universities. In the long term, this approach will educate future engineers with more problem-solving skills, essential for evaluating and developing solutions within the principles of sustainability that demand adaptable solutions.

In the latest PSGs of CHED in the country, through an "outcome-based" educational (OBE) system in higher education for engineering programs offering, a new graduate should have a level of competency to "*determine relevant and appropriate applied sciences, engineering principles and techniques that can be used to address engineering concerns such as construction engineering and management, geotechnical and geo-environmental engineering, structural engineering, transportation engineering, and water resources engineering."*(CHED, 2017).

According to Vea & Cabig (2015), with this shift towards OBE policies for both institutional and program levels, merges with the outcomes-based accreditation system of the Philippine Technological Council (PTC). Monsada (2015) adds that to align the engineer's qualification at entry practice level requires the delivery of engineering degree programs that is aligned to international standards (i.e. Washington Accord). In order to achieve this, PTC implemented a program, the Washington Accord Initiative (PTC-WAI) in 2009 and the Certification and Accreditation System for Engineering Education (CASEE) in 2011 to pursue accreditation of engineering programs as well as for recognizing the qualification of Filipino engineering graduates in the country.

It is expected that OBE accreditation as well as international program accreditation (i.e. Washington Accord) are mechanisms to achieve increased mobility of professionals across ASEAN border members and full recognition of higher education institutions (HEIs) (Monsada, 2015; Nera & Oallares, 2015).

It is argued, however, that there are still works to be done in terms of upgrading the quality of higher education programs/courses in the country. For instance, Macaranas & Cabig (2015a) identify two equally important themes towards improvement of engineering education programs in the country, namely: "continuous quality improvement" and "technology forecasting" that are very important in providing efficient and effective CQI and OBE processes that will mainly focus on the considerations on what the students will learn, what knowledge and skills they will need to be successful after graduation. It is also observed that out of 1,600 universities and colleges, 600 of them offer engineering programs/courses, many of these HEIs are inadequate in terms of equipment and facilities, hands-on trainings, accreditation, benchmarking and screening (Maglalang & Cabi, 2015).

Maglalang & Cabig (2015) emphasize that, to improve the quality of instruction, it is very important that faculty members should be creative and be inspiring mentors to their students. They should be able to conduct and publish researches as well as active in their professional organizations as part of their continuing professional development (CPD) or professional growth. Moreover, to be more qualified and competitive, faculty members should undertake post graduate studies and short-term training courses in specialized fields through study grants and exchange programs locally and abroad. It is important to note that practicing engineers should also consider sharing their knowledge and expertise by becoming lecturers in HEIs on a part-time basis.

Indeed, the HEIs both private and state universities and colleges (SUCs), and their faculty members need to play their part in ensuring that both tertiary and graduate programs provide all civil engineering graduates with an appropriate working knowledge and understanding of sustainable development.

*Practice of Engineering Profession*

Quadrado et al. (2013) emphasize that practicing engineering professionals have a responsibility to maximize the value of their activity towards building a sustainable world which requires an understanding of what society demands and what is achievable, and a recognition that these change over time. The authors emphasize that engineering professionals should: (a) recognize that though their activity may be local and immediate, the potential impacts of their work may be global and long-lasting; (b) have an understanding of other relevant social and cultural structures outside their own normal community of practice; (c) understand the important potential role for engineers in the sustainable development; and (d) recognize the impacts of engineering, at a local and globally scale, and consider the views of the society.

There has been much dialogue on the topic of sustainability and its application to engineering practice (Boyle & Coates, 2005). It is viewed that "sustainability" should be at the heart of engineering practice. It is observed that most professional engineering associations have incorporated a requirement for engineers to include sustainability in their practice but there has been little work done on how this can be successfully achieved. Boyle & Coates (2005) identify some of the code of ethics, policies, principles, indicators and guidelines for putting sustainability into engineering practice that have been developed by various international engineering organizations such as the International Federation of Consulting Engineers, American Society for Civil Engineers, the Institute of Chemical Engineers, the Institution of Civil Engineers in the U.K., the Institution of Engineers of Australia, and the Association of Professional Engineers and Geoscientists of British Columbia.

It is recognized that sustainability principles had to bridge the gap between existing engineering practice and the long-term focus on sustainability, taking into account the integrated, holistic view of environment, society, and economics, as well as the viability of the natural environment. From this ground, the following key principles for engineers are developed and the basis of sustainability as presented in Appendix.

The World Federation of Engineering Organizations' Committee on Technology (2002) also cited some of the

environmental policies that are similar to code of ethics but deal with more of the principles of professional practice that many of the international and national engineering organizations developed. Some of them are as follows: the WFEO Arusha Declaration on Environment and Development (ArushaDeclaration.doc); the WFEO Model Code of Ethics, (WFEO Ethics.doc) adopted in September 2001; the FIDIC adopted a powerful set of environmental policies in 1990 which include guidelines on the obligations of the consulting engineer with respect to their projects and clients; the Melbourne Communique is a statement of operating principles adopted by 20 national organizations of Chemical Engineers; and the American Association of Engineering Societies' The Public Policy on Sustainable Development and Action Principles in 1992 and six action principles to guide engineers in applying sustainable development. In addition, the Code of Ethics of the American Society of Civil Engineers was a pioneering effort that has far reaching implications that requires consideration of sustainable development principles in civil engineering projects.

### 4.3 Specific Roles of Civil Engineers and Challenges towards Sustainable Development

In general, engineering is a requirement to achieve the 17 SDGs (WFEO, 2015). From the provision of water, safe food, energy and fuel generation, transportation, communication, and design and production of medical equipment have involved engineers of all disciplines. Science and engineering make possible improvement of our quality of life but associated with negative social and environmental impacts. Thus, engineers have a duty to enhance the good associated with technology while minimizing the harm. WFEO (2015) also acknowledges the challenges arise when costs and benefits transcend user groups, thus, sustainability requires the overall benefits always outweigh costs and that society and ecosystems must be able to accommodate the costs. In relation to the three suggested principles (Appendix), the key sustainability factors for engineers to consider: (a) In relation to Principle 1, there is a need to manage changes in the environment as the result of any engineering activities; (b) With Principle 2, it is very important the need to maintain equity and safety of engineering activities for both current and future generation, including the means to improve the quality of life in developing countries. (c) For Principle 3, professional engineers have the skills in solving problems to be done in a holistic way which does not lead to another problem, and following the sustainability principles, engineers need to consider resolving existing problems caused by failures.

Specifically, there are a number of the SDGs that deeply dependent on civil engineering discipline. These goals are as follows: SD Goals 6, 7, 9, and 11. It is argued however, that even these goals are heavily engineering, should make it clear that achieving sustainable development as defined in the Goals will require a truly transdisciplinary approach (UN, 2017; UN 2016a; UN, 2016b; UN, 2016c; UN, 2016d; UN, 2016e; UN, 2016f; UN, 2016g; Kelly et al, 2016; Sandhu et al, 2016; Kelly, 2015). To summarize, Table 2 provides the appropriate targets for each SDGs that have a direct link or significance to the leadership roles of civil engineers.

Further, the matrix also identifies the specific roles and contributions of engineering profession, specifically highlighting the linkages of civil engineering with SDGs.

**Table 2** Specific Roles and Contributions of Engineering

| Goal/Target | Engineering Contribution** | Civil Engineering Leadership Roles |
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| *G1: End poverty in all its forms everywhere*<br>*T1: Access to basic services, ownership and control over land and other forms of property*<br>*T2: Build the resilience of the poor and those in vulnerable situations* | Provision of basic services; applied technology and provision of urban systems that make growth (wealth creation) possible | Design and construction of affordable housing units and low-cost settlements that can stand extreme events and disasters; better community/town planning and development; strict compliance with building codes, CLUP/zoning ordinance and applicable laws |
| *G2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture*<br>*T1: Ensure sustainable production systems and implement resilient agricultural practices*<br>*T2: Increase investment, including through enhanced international cooperation in rural infrastructure, agricultural research and extension services* | Manage the nitrogen cycle; sustainable irrigation; sustainable transportation; adjudicate genetically modified organisms | Design and construction of flood control/abatement and irrigation infrastructures, including water impounding system, soil erosion control system; Design and construction of farm-to-market roads; strong involvement in watershed/river basin and river system management; Provision for infrastructures in the promotion of agri-tourism products and services |
| *3. Ensure healthy lives and promote wellbeing for all at all ages*<br>*T1: Reduce the number of global deaths and injuries from road traffic accidents*<br>*T2: Substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination* | Engineer better medicines; Advance health informatics; Clean air, clean water, safe food; production; Develop bio-engineering & nanotechnology life improvement devices & materials | Design and construction of road networks with high quality standards; Proper traffic management and monitoring system; Design and construction of waste management facilities, including customized water/wastewater treatment, sewage drainage facilities, |

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| | | including air pollution control facilities; strict compliance with applicable environmental laws and regulations (RA 9003; RA 8749 and RA 9275) Refer to Goal 6) |
| *4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*<br>*T1: Equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university* | Advance personalized learning; Quality engineering education in all countries to ensure local workforce | OBE system and accreditation in civil engineering program; Practicing civil engineers as lecturers and pursue post-graduate studies and trainings; conduct researches and extension programs; encourage/mentor women to take civil engineering courses; active participation in professional organization as part of CPD |
| *G5. Achieve gender equality and empower all women and girls*<br>*T1: Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making* | Increase participation of women in all engineering fields | Mentoring women in the field of civil engineering, including full support and acknowledgement of their work; Provide equal opportunities and incentives for women to excel in the workplace and other professional practice |
| *G6. Ensure availability and sustainable management of water and sanitation for all*<br>*T1: Achieve universal and equitable access to safe and affordable drinking water for all*<br>*T2: Improve water quality by reducing pollution, eliminating release of hazardous chemicals and materials*<br>*T3: Implement integrated water resources management at all levels*<br>*T4: support and strengthen the participation of local communities in improving water and sanitation management* | Provide clean water for all | Design and construction of efficient water supply and distribution system; promotion of rainwater harvesting and water re-use/recycling system; Innovative and cost-effective ways in water quality management (freshwater and groundwater); Promotion of 3Rs (reduce, recycle and reuse) approach in water usage; Promotion of integrated water resources management (reservoirs, dams, irrigation); river basin/watershed management (Refer to Goals 2 and 3) |
| *G7. Ensure access to affordable, reliable, sustainable and modern energy for all*<br>*T1: Ensure universal access to affordable, reliable and modern energy services*<br>*T2: Increase substantially the share of renewable energy in the global energy mix* | Make solar energy economical; ensure safe nuclear power safe; provide energy from renewable; increase efficient use of energy | Active agent in the promotion of alternative sources of energy such as wind, solar, hydro, wave and geothermal and biomass; Design and construction of buildings and facilities that promote renewable use of energy and efficient/energy saving; |
| *G8.Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all*<br>*T1: Promote development-oriented policies that support productive activities, etc.*<br>*T2:Protect labor rights and promote safe and secure working environments for all workers*<br>*T3: Devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products* | Restore and improve urban infrastructure; continue to provide the underpinning of wealth generation, e.g urban systems, mobility, communication, data; safe and inclusive work environment for professionals and participants | Conduct of research and extension work, including creation of patents and other innovative products and services in the construction industry; Promotion of occupational health and safety programs; Compliance to relevant laws and regulations; Implementation of infrastructure projects with high quality standards; Promotion in the utilization of alternative construction materials available in the locality; Promotion in the restoration of structures with historical significance or value; Full support to programs On-Job-Trainings (OJT) or apprenticeship; Promotion of ISO EMS and QMS certifications |

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| | | (Refer to Goal 2) |
| *G9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation*<br>*T1: Develop quality, reliable, sustainable and resilient infrastructure, with a focus on affordable and equitable access to all*<br>*T2: Upgrade infrastructure and retrofit industries to make them sustainable* | Sustainable and resilient infrastructure; sustainable manufacturing | Promotion of green engineering; Adoption of comprehensive countryside and regional planning; Promotion of urban regeneration strategies and retrofitting/re-engineering urban planning approach; Implementation of life cycle assessment (LCA) in infrastructure development; Adoption of best practices in infrastructure development (public-private partnership) (Refer to Goals 2, 3, 6, and 8) |
| *G10. Reduce inequality within and among countries*<br>*T1: Facilitate orderly, regular and responsible migration and mobility of people* | Provide global example within profession; highlight the Negative 'consequences of inequality on engineering systems | Be active participants in the ASEAN engineers registry and engineering program accreditation (Refer to Goal 4) |
| *G11. Make cities and human settlements inclusive, safe, resilient and sustainable*<br>*T1: Ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums*<br>*T2: Enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management*<br>*T3: Reduce the adverse per capita environmental impact of cities including attention to air quality and municipal and other waste management* | Restore and improve urban infrastructure; Development of te chnologies and processes globally to ensure safety & security across engineered systems - cyber security for mass transit | Design and construction of housing and settlements using local alternative construction materials; Promotion of integrated land use and transport network plans; Promotion of mixed-use schemes (MUS) development in urban regeneration areas (redevelopment or renewal); Compliance with LGUs'CLUP and zoning ordinances; Full implementation of RA 9003 and RA 8749 (Refer to Goals 1, 6, 7, 8 and 9) |
| *G12. Ensure sustainable consumption and production patterns*<br>*T1: Achieve the sustainable management and efficient use of natural resources*<br>*T2: Achieve the environmentally sound management of chemicals and all waste throughout their life cycle*<br>*T4: Substantially reduce waste generation through prevention, reduction, recycling and reuse*<br>*T3: Promote public procurement practices that are sustainable, in accordance with national policies and priorities*<br>*T4: Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products* | Circular Economy (material flows)- cradle to cradle minimize waste in the manufacture of pr oduct; enhanced resource efficiencies, industrial ecology & demineralization | Strict compliance to relevant environmental laws and regulations particularly ISO EMS and QMS certifications; Strict compliance to RA 9184 and RA 9003 (Refer to Goals 2, 6, 7, 8, and 11) |
| *G13. Take urgent action to combat climate change and its impacts*<br>*T1: Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters*<br>*T2: Integrate climate change measures into national policies, strategies and planning* | Develop carbon sequestration methods; monitor, research & provide professional input on the role of geoengineering; sustainable energy for all; make the built environment adaptable and resilient to uncertain climate & weather extremes; substantially reduce green-house gas emissions from the built environment; ensure safe nuclear power | Design and construction of infrastructures that can stand against natural disasters and extremes weathers; Promotion of alternative renewable sources of energy (Refer to Goals 7 and 11) |
| *G14. Conserve and sustainably use the oceans, seas and* | Improved | Strict compliance with applicable and relevant |

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| *marine resources for sustainable development*<br>*T1: Prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities*<br>*T2: Sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts* | monitoring; better provision of independent data | environmental laws and regulations; Civil Engineering curriculum development with areas of specialization (oceanography, port development, geographic information systems) (Refer to Goals 3, 7 and 11) |
| *G15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification,*<br>*T1: Ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services*<br>*T2: Promote the implementation of sustainable management of all types of forests* | Restore organic matter to degraded soils; better integrate biofuels | Strict compliance of relevant and applicable environmental laws and regulations Refer to Goals 3, 7, 11 and 14) |
| *G16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all*<br>*T1: Substantially reduce corruption and bribery in all their forms* | Prevent nuclear terror; secure cyberspace; Provide credible monitoring and measures of success | Strict compliance of RA 3019, The Anti-Graft and Corrupt Practices Act and the RA 11032, Ease of Doing Business and Efficient Government Service Delivery Act of 2018 |
| *G17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.*<br>*T1: Strengthen domestic resource mobilization, including international support to developing countries*<br>*T2: Encourage and promote effective public public-private and civil society partnership* | Play a more active role in the global partnership as practitioners of sustainable development | Pro-active in lobbying new relevant legislations through professional membership or affiliation; Close collaboration and partnership with foreign investors |

*** Adopted from WFEO (2015)*

## 5 CONCLUSION

The findings from this study provided a clearer direction for civil engineering professionals to take – engaging and committing themselves to participate and collaborate in various infrastructure programs and projects towards high quality standard outcomes. With the technological advancement, innovative solutions and strategies in the construction industry as well as in the academe/education sector, civil engineers should go beyond minimum compliance, offering exceptional engineering products and services.

In conclusion, sustainable development should be at the core of the higher education institutions (HEIs) which will require both local and national commitments. Definitely, it is expected the demand for civil engineering skills and expertise will be higher than in the past years to meeting the challenges of achieving the sustainable development goals. Finally, the roles of civil engineering professionals through their active affiliations with various organizations and civic societies somehow enhance their leadership roles in shaping our towns and cities inclusive, resilient, safe and sustainable.

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**APPENDIX**

Three Sustainability Principles for Engineers

*Principle 1: Maintaining the viability of the planet*

a) Humans need to maintain the integrity of global and local biophysical systems to retain the irreplaceable life support functions upon which human well-being depends.

b) The efficiency of products needs to be improved and the material and energy intensity needs to be reduced by a factor of 10 to 50 to achieve sustainability; thus redesigning engineered products, processes, and services and minimization, recycling, and reuse of resources are needed to achieve this factor.

c) Depletion rates of non-renewable resources shall equal the rate at which renewable substitutes are developed by human invention and investment. Renewable resources must be managed to ensure that they can be produced over the long term without damage to the environment, and harvest rates of renewable resource inputs must not exceed the regenerative capacity of the natural system that generates them.

d) All waste products from the life cycle of engineered products, processes or systems should be eliminated, preferably at the source. Waste discharge should be kept within the assimilative capacity of the local and global environments.

e) The use of hazardous materials must be minimized and, wherever possible, eliminated.

f) The use of materials and chemicals that can accumulate in the environment needs to be reduced to a minimum that

will not exceed natural or hazardous levels, whichever is lower.

g) When selecting an engineering option for product design, processing or providing a service, weight shall be given to choices that, for a given expenditure, minimize the use of resources, particularly non-renewable resources such as fossil fuel-based energy and metals.

h) Options chosen for product design, processing, or providing a service should be based on the precautionary principle and reduce risk as much as practicable or foreseeable.

*Principle 2: Providing for equity within and between generations*

a) All members of society have equal rights to achieve an acceptable quality of life, to be given choices in their life and to work to reduce significant gaps in health, security, social recognition, political influence, etc. between rich and poor people. These rights must be respected.

b) Excessive consumption of resources by the wealthy needs to be reduced to allow those in poverty to fulfil their needs while ensuring resource use is within the environment's carrying capacity.

c) Development and resource use must be considered over a sufficiently long time scale so that future generations are not disadvantaged economically, socially, or environmentally.

d) All those affected by engineering projects need to be given equal opportunity without repercussions to voice their concerns and opinions and to have their views incorporated into the planning and decision making process.

*Principle 3: Solving problems holistically*

a) Problem solutions shall be based primarily on human needs and ecosystem viability rather than the availability of technology.

b) A holistic, systems-based approach shall be used to solve problems rather than focusing on technology alone.

c) Methods that provide optimum outcomes for all stakeholders rather than expedient or single solutions shall be implemented.

d) The use of non-sustainable practices or practices that present a risk to sustainability shall be minimized and reduced to zero over time. Where it is practicable or desirable, past degradation must be reversed.

e) Problem solving shall be based on prudent approaches and not through solving one problem at the expense of another.

*Source: Boyle and Coates (2005)*

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