The Academy of Sciences Islamic Republic of Iran

Shiraz University

Iranian Society of Engineering Education

First International & Fourth National Conference on Engineering Education
Shiraz University, 10-12 November 2015

Engineering Ethics and Sustainable Development

Abdol Reza Chini[1], Seyyed Amin Terouhid[2], and Maryam Mirhadi Fard[3]

Abstract— **Engineering is a bridge over which humankind passes into nature to understand it, control it, and guide it to its own field of interest and service. In the last two centuries and in parallel to industrial revolution, engineers made significant contributions to well-being of society elevating the standards of living and adding to the comforts of life through introducing new technologies. However, they didn't pay a proper attention to the negative side of scientific advancements such as contamination of water, degradation of soil, emissions in the air, and climate change. This paper is about making good decisions by engineers to promote sustainability in use of technology. Sustainability is the balanced pursuit of ecological health, social equity, and economic welfare. It is grounded in an ethical commitment to meet the needs of present without compromising the ability of future generations to meet their own needs. The paper starts with an overview of some of the most pressing challenges humankind faces today, followed by exploring the three pillars of the ethics of sustainability: the social dimensions, the ecological dimension, and the economic dimensions. Application of the ethics of sustainability to decision making for engineers and scientists are discussed and several strategies used to integrate ethics of sustainability in engineering education are explored.**

I. Introduction

Engineers are concerned about design, building, and use of machines and structures in their practices, and they have embraced public safety as a core operating value and priority. Unlike safety, however, sustainability has not properly been incorporated in engineering thinking and training. From a sustainability perspective, human societies face a variety of challenges, and it is engineers' responsibility to play a proactive role in addressing global challenges such as overpopulation, overconsumption, climate change, resource depletion, and poverty. Furthermore, from a professional ethics prospective, engineers are required to ensure they abide by universally accepted principles of social, environmental, and economic ethics.

In the following sections, some of the most pressing challenges of human societies are reviewed; and the requirements of the three pillars of sustainability ethics will be explored. In addition, recommendations for a proper integration of sustainability values into engineering thinking and education will be provided.

II. Contemporary Challenges

A. *Overpopulation and Overconsumption*

As the world population grows, consumption of water, food and energy is expanding at a rate that cannot be maintained without depleting the planet's resources. **Error! Reference source not found.** shows United Nations two projections for world population. The high projection has a fertility rate of just half a child above that in the medium projection. Region fertility rate for Africa is 4.7, Asia 2.2, Latin America 2.2, North America 1.9, Europe 1.6, Oceania 2.4, and World 2.5. The medium projection has 9.73 billion people worldwide in 2050 and 11.21 billion in 2100. Figure 2 shows the same projections for population of Iran.

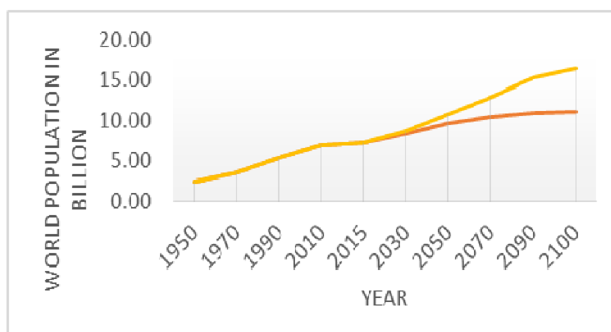

Figure 1. World Population Prospect: United Nations, Department of Economic and Social Affairs, Population Division (2015).

[1] University of Florida, Gainesville, Florida, USA (phone: 352-273-1165, e-mail: chini@ufl.edu).
[2] The Vertex Companies, Long Island City, New York, USA (e-mail: terouhid@ufl.edu).
[3] Hill International, New York, NY, USA (e-mail: mirhadi@ufl.edu).

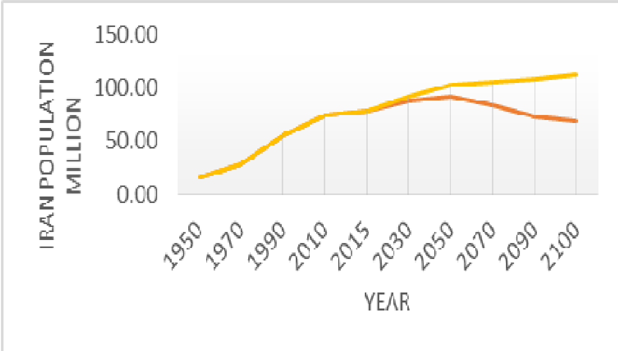

Figure 2. Iran Population Prospect: United Nations, Department of Economic and Social Affairs, Population Division (2015).

Overpopulation causes shortage of all essential resources such as food, water, and energy; war and social conflicts; overcrowding; and the health and survival of other species.

Consumption has also increased over recent decades outstripping population growth rates.

- a fifteen-fold increase in global water withdrawals between 1800 and 1980 when population increased by only a factor of four [1];
- average per capita food consumption increased by 15 per cent between 1969 and 2005 [1]; and
- from 1980 to 2010 the worldwide extraction and consumption of natural resources increased from 35 to 72 billion metric tons (Table 1), an aggregated growth of more than 100 percent when population increased by 54 per cent from 4.44 billion in 1980 to 6.93 billion in 2010. Consequently, per capita material consumption worldwide increased from 7.9 to 11.8 metric tons (Table 1).

Table 1. Total and per capita material consumption in 1980 and 2010 for Iran and neighboring countries [2]

	MMT Consumption		**Metric Ton Per Capita**	
Country	**1980**	**2010**	**1980**	**2010**
Afghanistan	40	55	2.9	1.7
Iran	212	868	5.4	11.7
Iraq	57	120	4.0	3.8
Pakistan	231	621	2.9	3.6
Saudi Arabia	190	560	19.8	20.4
Turkey	333	820	6.0	11.3
World	**35,064**	**72,313**	**7.9**	**11.8**

Furthermore, the distribution of these consumption is totally unequal, with average consumption in developed countries far in excess of the average in developing countries. For example, each new born UK citizen will likely be responsible for 12 and 53 times the amount of greenhouse gas emissions than a baby born in Bangladesh and Ethiopia, respectively [1].

B. *Climate Change*

The key environmental challenge facing humanity today is climate change. The climate change can increase or decrease rainfall, influence agricultural crop yields, affect human health, cause changes to forests and other ecosystems, or even impact the energy supply.

Climate change is primarily caused by the release of carbon dioxide (CO_2) from fossil fuel consumption to the atmosphere. Table 2 shows that carbon emissions – emissions stemming from consumption of solid, liquid, and gas fuels and gas flaring – have increased from 22 billion metric tons of carbon to the atmosphere per year in 1990 to 33.5 billion metric tons in 2010, and its per capita emission from 4.2 to 4.9 metric tons.

Table 2. Carbon dioxide emissions in 1990 and 2010 for Iran and neighboring countries - World Development Indicators 2015, The World Bank

	Carbon Dioxide Emissions			
	Total		**Per Capita**	
	MMT		**Metric Tons**	
Country	**1990**	**2010**	**1990**	**2010**
Afghanistan	2.677	8.471	0.2	0.3
Iran	211	572	3.7	7.7
Iraq	53	111	3.0	3.6
Pakistan	69	163	0.6	0.9
Saudi Arabia	218	533	13.4	19.6
Turkey	146	298	2.7	4.1
World	**22,201**	**33,516**	**4.2**	**4.9**

C. *Resource Depletion*

In addition to the problems caused by emissions from human activities, our planet faces other challenges as well. Resource depletion can be regarded as one of the top challenges and it will continue to increase unless firm steps are taken to develop environmentally friendly solutions to overcome this problem. As mentioned before, increased demand for natural resources and energy is the primary cause of the resource depletion problem.

Given current trends of growth, the extraction of natural resources could increase to 100 billion metric tons by 2030. Non-renewable materials, such as fossil fuels, metal ores and minerals sum up to more than 70 per cent of total material extraction, with a rising trend [2].

D. *Poverty*

Generally, climate change is seen to be a challenge that will ultimately affect human well-being adversely, particularly in lower income populations of impacted countries. These effects are either direct or indirect. Examples of direct are the effects of severe weather on health and loss of life in extreme weather conditions; whereas, examples of indirect effects include diminished water and air quality, agricultural problems, and food availability.

Climate change is expected to affect countries disproportionately; and it is reasonable to accept that the populations of poor countries, in general, and lower income populations in these countries, in particular, will be affected to a greater extent. Therefore, it is expected that climate change poses greater risks to the populations in developing countries. For instance, according to the Royal Society Report [1] by 2025, "a child from the developed world consumes 30-50 times as much water as one from the developing world and 1.8 billion people could be living in areas where water is a scarce commodity." The same is true for food and energy, in 2010 "close to one billion people did not receive enough calories to reach their minimum dietary energy requirements."

E. *Sustainability Challenges in Iran*

Iran is facing serious problems of pollution and devastation of its environment. In recent years, Iran has followed the same approach as that of other developing countries; i.e. it has placed economic development above environmental considerations. In this way, growth of industries, roads, towns, vehicles, etc., has and will continue to result in irrevocable consequences for the country. Some regions such as large cities or forests are being devastated by environmental pollution that is already nearly irreversible in some location. From 1975 to 2005, the area of the forests decreased from 18 million to 5 million hectares. The number of floods has increased 9 times and the severity of disasters has increased 20 times in the former forest areas. More than 40,000 tons of urban refuse are produced in the country daily and are buried without proper management. This is leading to more soil and groundwater pollution [3].

A 2013 study by the World Resources Institute ranked Iran as the world's 24th most water-stressed nation, putting it at extremely high risk of future water scarcity. In less than 50 years, Iranian used all but 30 percent of their groundwater supply, which took a million years to gather, and it's getting worse and worse due to unsustainable development [4].

With respect to Environmental Sustainability, Iran is the 7^{th} highest carbon emission-intensive country in the world. Total CO_2 emissions in 1990 were 211 million metric ton (MMT), which has increased rapidly at an average annual rate of 5.7 percent to 572 MMT by 2010 (Table 2). Per capita carbon emission in 1990 was 3.7 metric ton (MT), 12 per cent less than the global average of 4.2 MT. This figure increased to 7.7 MT by 2010, 57 per cent higher than the global average (Table 2). Iran's high levels of CO2 emissions primarily results from high levels of energy consumption per capita, energy-intensive industries, and inefficient energy use throughout the country.

Unemployment and poverty in Iran are also rising. A recent report titled Measurement and Economic Analysis of Urban Poverty showed that between 44.5 percent and 55 percent of Iran's urban population lives below the poverty line. This report was published at a conference organized by Tehran University and the United Nations Population Fund [5].

III. SUSTAINABILITY ETHICS

A. *Sustainable Development*

The most commonly used definition of sustainable development is "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs." [6]. Following this initial philosophical definition, the definition of sustainability has tended to shift toward a more tangible multi-dimensional characterization that takes into account economic, social, and environmental factors in all decisions [7]. The Earth Summit held in Rio de Janeiro in 1992 [8] further promoted sustainable development as a scientific concept and a philosophical ideal; and published an important document, entitled Agenda 21, that provided a "blueprint for action for global sustainable development in the 21^{st} century". This document emphasized on the objectives of sustainable development and promoted ethical views of sustainability by focusing on an array of goals such as income equity, health, community safety, and social justice [9]. The American National Society of Professional Engineers (NPSE) defines sustainable development as [10] "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."

B. *Ethics*

Ethics is a branch of philosophy which seeks to address questions about morality, concepts like good and bad, right and wrong, justice, virtue, etc. Sustainability ethics is a new discipline that analyzes the issues regarding our morale obligations to future generations with respect to the environment. From ethical perspective, sustainability has social, environmental, and economic dimensions. The following sections will explore different dimensions of sustainability ethics, including social, environmental, and economic ethics.

C. *Social Ethics*

Social ethics demonstrate the characteristics of a good society, including inter-relationships between economic and political institutions, and also between individuals and communities [11]. It is important to note that one cannot recognize social ethics without paying due attention and respect to environmental and economic ethics. Examples of social dimensions of sustainability include justice, equity, human rights, and interdependence.

Since the publication of Agenda 21, more serious questions concerning the distribution of "goods" (such as natural resources, well-being, housing, and food) and "bads" (such as resource depletion, poverty, and pollution) have been asked. As stated by Manion [12], “it would be difficult to expect constructive cooperation towards sustained development if more and more people are denied healthy and secure lives, while a small elite fight to protect its surplus.” Therefore, for a sustainable community, an approach that considers economic and environmental issues as well as ethical and political issues must be adopted.

There are four ethical principles that address the social aspect of sustainability [11]:

The Golden Rule – The right to have our basic needs met should be extended to our local and global neighbors, and to future inhabitants of the earth.

*The Right of Vulnerable (*Also known as *Care Ethics) -* To share responsibility for the welfare of the poor, weak, sick, and excluded people of the world.

The Distributional Principles – Ensuring that both benefits and risks are equitably distributed in society.

Chain of Obligation – The distributional principles apply to future generations.

D. Environmental Ethics

Environmental ethics transforms traditionally established rules of ethics by a focus on the value of nonhuman beings [11]; and studies moral responsibilities of humans with respect to nonhuman nature. Many discussions in the literature of environmental ethics are primarily centered around the argument that whether the value of nonhuman nature is an instrumental value (i.e., value as a means, or extrinsic) or is it an intrinsic value (a value of a being as ends in itself regardless of whether it is also useful as means to other ends).

Engineering practices can be claimed to be in the benefit of the public only if they are performed in environmentally responsible manners. Proper manners are those that recognize not only the established norms and ethical values of human societies but also the value of nonhuman nature.

Two ethical principles are identified that address the environmental aspects of sustainability [11].

The Land Ethic – Decisions must be made based on preserving the ecological integrity of the nature and not human beings.

The Rights of Nonhuman World – Other living species have rights similar in most respects to those of human beings.

E. Economic Ethics

Economic ethics is concerned with ethical attributes and implications of economic activities performed by individuals or institutions. This branch of ethics studies value-based decisions in economic activities ranging from micro to macro levels.

For instance moral responsibilities to other forms of life can be determined in our economic activities. Business ethics and sets of principles that companies should adopt can also be considered as part of economic ethics.

The four ethical principles of economic sustainability are [11]:

The Polluter Pays Principles – The burden of responsibility and the costs of cleanup, mitigation, and abatement of pollution should be justly allocated among those causing the pollution.

Extended Producer Responsibility – Manufacturers of products are responsible for the entire life cycle of their products. They are required to take back and recycle the product and its packaging. This principle advocates design of products with minimum waste, one of the major tenants of sustainability.

The Beneficiary Compensate Principle – Those who are benefiting from the contribution of valuable natural systems should compensate those who are making the contribution.

Full-Cost Accounting – All the social and environmental cost of a product or activity should be identified and built into the price of the product or activity.

IV. Ethics of Sustainability in Engineering education

In this section, the role of engineering codes of ethics as well as pedagogy requirements set forth by engineering schools on achieving the objectives of sustainable development are discussed. As stated by Byrne [13], “{sustainability is} emerging as a key manifestation in codes of ethics … which is in itself a reflection of its increasing role in societal discourse. Recognition that engineers have an ethical duty towards sustainability implies a responsibility towards future generations.”

Engineers have an ethical duty towards sustainability and a responsibility towards future generations. This requires avoiding a practice which may result in future negative consequences by virtue of passive neglect. According to Vesilind [14]: “engineers can destroy or alter environments that support the global ecosystem and in such manner kill future humans on a global scale. Clearly, the moral responsibilities of engineers must include commitments for providing a high quality and sustainable environment for future generations.” This in turn requires that the precautionary principle (if the effects of an action are unknown, then the action should not be taken) be considered as an evaluation criterion for proper course of actions in engineering practice

A. Teaching Ethics

Ethics is all about morality and what is right and honorable. Ethics, which is considered to be the standards that govern the conduct of an individual or community, becomes even more meaningful if it is considered in the context of a profession, such as engineering. The dignity and integrity of the profession is fashioned by the collective conduct of its individual members; and frequent or systematically-occurring unethical behaviors can damage the honor and credibility of professional communities as a whole. Therefore, teaching ethics in engineering schools is of an utmost importance. However, teaching ethics with a focus on ethical implication of sustainability is not usually incorporated into the teaching of ethics in engineering schools [13].

A paradigm for ethics has always been expected from engineers due to the fact that their responsibilities demand satisfying the needs of society. One of the first fundamental commitments indicated in many codes of ethics is to make decisions and take actions based on the best interests of society, public safety, and the environment. This commitment should be an indication to individuals and engineering communities that they must give priority and protect the collective interests of the society. Promoting the principles of sustainability by choosing correct course of actions is one of these protection strategies. Professional engineering codes of ethics are increasingly making professionals accountable for environmental, social, and economic implications of their decisions. However, some authors have suggested that sustainability be included in paramountcy clauses of engineering codes of ethics based on the belief that sustainability is a requirement for health, safety, and welfare of the public [15]. An example of these codes of ethics is the following commitment asked for by the American Society of Civil Engineers (ASCE): "{Canon 1:} 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 professional duties." [16].

As emphasized by Manion [12], proper development of engineering public policy is achieved by a focus on the following three key sources of influence: "1) professional engineering societies through their codes of ethics; 2) engineering organizations, and 3) pedagogy requirements set forth by leading engineering and technology accreditation institutions and their affiliates." The role of codes, standards, and regulations should not also be discounted.

The issues engineers face demands a macroethical (large-scale ethics distinguished from individual ethics or microethics) framework dealing with broader societal issues. A framework that recognizes the fact that a good engineering requires perspectives from non-engineering disciplines including organizational, social, legal, and political subjects.

Engineering courses can effectively incorporate ethics and sustainability by providing a suitable combination of theory and practical applications and adequate teaching methods, including decision-making case problems [17]. They should cover professional engineering ethics, including the engineer's role with respect to society, the environment, sustainability and health and safety. The course learning outcomes should include Expanding the importance of safety, the environment and professional ethics in the process of engineering and in the broader world; and advocating the roles and social responsibilities of engineers within society [13].

B. *Case Studies*

Sustainability ethics can be taught by developing problem-centered case studies that focus on solutions in response to real-world problems and needs of practitioners. Such case studies facilitate decision making in ethically sensitive areas of engineering practice and guide students in choosing a correct course of actions. Examples of topics for case-studies may include:

- Is incineration an ethically acceptable municipal solid waste management practice in cities?
- Is it ethically acceptable to allow for mining activities in environmentally sensitive areas such as national parks?
- To what extent the use of recycled material in the manufacture or construction of new products should be permitted?

Appendix A provides an example of a case study that asks the students to discuss if is ethically acceptable to take water from various sources, including groundwater and desalinated sea water, into a river to overcome future shortage of water at the city of Dublin Ireland [13]. A list of other case studies and links to additional information about each case has been provided in Appendix B.

V. Conclusion

The unintended, unexpected, and unprecedented adverse effects of industrialization have created many challenges for societies; and environmental challenge is one of the most pressing challenges humankind faces today. This challenge has provided the opportunity for societies to identify the limitation of traditional ethical theories; and it guided ethical studies to the extent that new ethical values such as the principles of social, environmental, and economic are now being recognized.

The environmental challenge is going to remain one of the key challenges of the 21st century; however, engineers are in a unique position to lead the sustainable development movement by paying due regard to the principles of sustainability with a sound design, development, and use of products and services. Green design, design for deconstruction and adaptive reuse, and design for environment are examples of areas in which a variety of engineering disciplines have opportunities to contribute towards a new era of engineering based on the principles of sustainable development. The goal is to arrive at a point where engineering practice will "incorporate tenets of sustainability into all phases of …practice, so that 'sustainable engineering' eventually equates with 'good engineering.'"[18]

APPENDIX A

Case Study: Water supply to Dublin for the 21st Century [10]

Problem statement

The population of the Dublin region in terms of water supply is currently 1.5 million. The current average daily water requirement is 550 million liters. This equates to an average of 134 m^3 per person per annum. Water is supplied from water treatment plants operated by Dublin City Council supplied by water from the rivers Liffey. The population is expected to increase to 2.2 million by 2031 however, and assuming per capita consumption remains constant, the predicted rate of growth the city's water demand would surpass capacity of existing supply from around 2016. The principal contributing factors to water demand are 1) Population, 2) per capita usage and 3) leakage and wastage. Supply is also likely to come under pressure into the future. It has been predicted that water levels in the River Liffey could be just half of what they are today by mid-century due to low rainfall. This emerging issue was identified in a government publication on the Greater Dublin Water Supply Strategic Study 1996-2016. Following this, the engineering consultancy group RPS were commissioned to examine the issues and make suitable recommendations. Their reported findings were published in 2008 with an accompanying website (http://www.watersupplyproject-dublinregion.ie/). Possible options identified include increasing capacity by taking water from various points in the River Shannon, from the River Barrow, desalination of sea water and sourcing groundwater.

Task

You are a graduate engineer working with a consultancy company. Your company has been asked by the Irish Government through the Department of the Environment to review the RPS report and recommendations and having done this to recommend a preferred way forward. You and your small team have been asked by your employer to work on this project and prepare a report. The report should contain;

- A critique of the RPS report
- A proposed way forward along with suitable recommendations.
- You will need to provide a suitable rationale for your proposed option/s.
- As a team of engineering professionals, you should also demonstrate how and where, your proposals epitomize the Professional Code of Ethics.

You should research and reference as required and feel free to be innovative!

Presentation *[60 marks]*

Each group will be required to make a 10 minute presentation addressing the above topics. During the presentation session each group will also be assigned another group whose work they will critique.

Critique *[Asking Questions: 20 marks; Answering Questions 20 marks]*

At the close of the presentation session, each group will consult and critique their designated group's presentation over a 15 minute period. A second session will then involve each of the presentation groups being interviewed by their designated examining group. Each member of the examining group should put at least a one point to the presentation group. Points may include general comments, discussion points, questions, follow-up questions, criticisms or praiseworthy comments, seeking points of clarification, etc. Each group will be questioned for a period of about 7-10 minutes and other class members will also have an opportunity to raise points.

APPENDIX B

A list of case studies related to sustainability ethics with links to additional information about each case [19].

- Should the oil and gas industry be exempt from certain environmental protection laws to encourage the discovery of new sources of fuel? - See more at: http://www.scu.edu/ethics/practicing/focusareas/cases.cfm#sthash.R7evFT68.dpuf
- A quality engineer has concerns about a product failing under extreme conditions, but her bosses tell her to push the product through to production. - See more at: http://www.scu.edu/ethics/practicing/focusareas/cases.cfm#sthash.R7evFT68.dpuf
- Is the Bangladeshi government or the factory owner more at fault for a fire that killed 112 people? - See more at: http://www.scu.edu/ethics/practicing/focusareas/cases.cfm#sthash.R7evFT68.dpuf
- Steve and his housemates have thrown a big party. When he gets up the next morning, he finds that his friends have bagged up all the trash without recycling. What should he do? - See more at: http://www.scu.edu/ethics/practicing/focusareas/cases.cfm#sthash.R7evFT68.dpuf
- Whose responsibility is it to keep college common areas clean--the students who use them or the custodial staff? - See more at: http://www.scu.edu/ethics/practicing/focusareas/cases.cfm#sthash.R7evFT68.dpuf
- A company must decide whether to order cheap shirts from China or expensive shirts from a local eco-friendly manufacturer. - See more at: http://www.scu.edu/ethics/practicing/focusareas/cases.cfm#sthash.R7evFT68.dpuf
- A company is planning to expand in a country where bribery is a normal part of doing business. - See more at: http://www.scu.edu/ethics/practicing/focusareas/cases.cfm#sthash.R7evFT68.dpuf
- Ethical dilemmas for engineers charged with clarifying and overseeing product safety. - See more at: http://www.scu.edu/ethics/practicing/focusareas/cases.cfm#sthash.R7evFT68.dpuf
- A new city councilmember must weigh the community's need for affordable housing with the desire to preserve

open space. - See more at: http://www.scu.edu/ethics/practicing/focusareas/cases.cfm#sthash.R7evFT68.dpuf

- A retired city engineer goes back to work for the city as an independent contractor. When he bids for a job, a councilmember raises questions. - See more at: http://www.scu.edu/ethics/practicing/focusareas/cases.cfm#sthash.R7evFT68.dpuf
- Your company can make more money for shareholders by relocating plants to a country with low costs and fewer regulations. - See more at: http://www.scu.edu/ethics/practicing/focusareas/cases.cfm#sthash.R7evFT68.dpuf

REFERENCES

[1] The Royal Society (2012). People and Planet – Summary and Recommendations, https://royalsociety.org/policy/projects/people-planet/ Visited August 21, 2015.

[2] SERI and Dittrich, M. (2012). Global Material Flow Database. 2012 Version. Available at www.materialflows.net Visited August 21, 2015.

[3]Ghazinoory, S., Cleaner production in Iran: necessities and priorities. Journal of Cleaner Production, 2005. 13(8): p. 755-762.

[4] Rezaian, J., “Iran’s water crisis the product of decades of bad planning,” Washington Post, July 2, 2014.

[5] Frazier, P., “Poverty in Iran in the Rise,” Borgen Magazine, July 23, 2014. http://www.borgenmagazine.com/poverty-iran-rise/

[6] Brundtland, G. H., & Khalid, M. (1987). Our common future: The world commission on environment and development. Oxford, GB: Oxford University Press.

[7] Terouhid, SA (2013). A dynamic decision support system for organizational sustainability excellence of construction firms. PhD Dissertation, University of Florida, Gainesville, FL. ProQuest/UMI, 2008. Retrieved from ProQuest Dissertations and Theses.

[8] UNCED (1992). The United Nations Conference on Environment and Development, Rio de Janeiro, June 1992

[9] Mirhadi Fard, M., Kibert C., and Chini, A. (2015). Decision making for sustainable location of a cement plant in the State of Florida, International Journal of Sustainable Engineering, Taylor and Francis, published online July 2015015. DOI 10.1080/19397038.2015.1050971

[10] National Society of Professional Engineers (2007) Code of Ethics for Engineers. NSPE, Virginia http://www.nspe.org/Ethics/CodeofEthics/index.html

[11] Kibert, C. J., Monroe M. C., Peterson A. L., Plate, R. R., Thiele L. P (2011).Working Toward Sustainability: Ethical Decision-Making in a Technological World. John Wiley & Sons, Inc., Hoboken, NJ, USA.

[12] Manion, M (2002). Ethics, engineering, and sustainable development. Technology and Society Magazine, IEEE.

[13] Byrne, Edmond P. (2010). Teaching engineering ethics and sustainability, Engineering Education in Sustainable Development. Gothenburg, Sweden, September 19-22, 2010.

[14] Vesilind PA (2002) Vestal virgins and engineering ethics. Ethics & the environment, 7:1, 92-101

[15] Michelfelder, D., Jones SA (2013). Sustaining engineering codes of ethics for the twenty-first century, Science and engineering ethics, Springer.

[16] ASCE, The American Society of Civil Engineers Code of Ethics, Retrieved on July 28, 2015 from http://www.asce.org/code-of-ethics/.

[17] El-Zein A, Airey D, Bowden P, Clarkeburn H (2008) Sustainability and ethics as decision-making paradigms in engineering curricula. International Journal of Sustainability in Higher Education 9(2):170- 182

[18] Allenby B, Folsom Murphy C, Allen D, Davidson C (2009) Sustainable engineering education in the United States. Sustainability Science 4:7-15

[19] Markkula Center for Applied Ethics, Santa Clara University, Santa Clara, CA http://www.scu.edu/ethics-center/index.cfm