Chapter 2
Engineers and Development:
From empires to sustainable development

In this chapter, we outline how engineers got involved in development. This is a historical trajectory from their involvement in imperial, national and international development to the present where many engineers are beginning to get involved in SD. We focus here on the historical context that gave rise to ESD, which might also help explain why "community" (C) has been largely absent or ignored in most ESD efforts. The questions we consider in this chapter are:

1. How did we arrive at this point in history? How did engineers come to be involved with development, sustainability and community?

2. What have engineers and engineering inherited from this history and what lessons can be gleaned from this inheritance?

To envision future possibilities for individual and professional involvement, from indirect participation to professional activism in SCD, engineers could benefit from understanding their historical trajectory with respect to development, sustainability and community.

1. Engineers and the development of empires (18th and 19th centuries)

The emergence of engineers, engineering practice, and engineering education has a close connection to the development of countries (Downey and Lucena 2004; Lucena 2009; Lucena 2009). When countries developed as empires and colonies during the 18th and 19th centuries, engineers worked both for the internal organization and expansion of the empires and in the colonies as agents of imperial development (Mrazek 2002).

Key Terms

Empires: Countries like Britain, France, Portugal, Spain and the US that from the 18th to 20th centuries expanded their influence around the word by conquering and colonizing other countries or territories

Colonies: Countries like Brazil, Egypt, India, Mexico and the US that were governed and in most cases exploited by empires

For example, Spanish engineers, with significant influence from French military engineers, built military and civil infrastructures in Spanish colonies in the Americas (Galvez 1996). French engineers worked in Egypt in the construction of the Suez canal

(Regnier and Abdelnour 1989; Moore 1994). Later, British engineers worked in Egypt (Mitchell 1988) and India (Cuddy and Mansell 1994) to improve transportation and irrigation infrastructures that would facilitate imperial control and the extraction of natural resources (Headrick 1981; Headrick 1988). German and British engineers worked for their imperial companies in mining extraction in Brazil (Eakin 2002). Although working under different economic and political relationships between empire and colonies, these engineers shared a primary concern: permanent transformation, i.e., the attempt to transform nature into a predictable and lasting machine (infrastructure) that could be controlled and would last to ensure their imperial patrons a return on investment and display superiority over indigenous people.

Opening of the Suez Canal in 1869. This major engineering project, authorized by the Ottoman governor Sa'id of Egypt, built by a French company and later used by British empire, clearly represents engineering for the development of Empires.
(source: ….)

How were communities perceived and affected during the development of empires? In some cases communities and their environments became sources of forced labor and natural resources necessary for the construction of imperial projects. Quite often villagers were viewed as potential imperial subjects to be organized in ways that would render effective their taxation and conversion to Christianity (or the dominant religion of the empire). By design or by default, engineers working for empires were involved in the political re-organization of indigenous populations and their communities, by surveying and drafting maps of the colonies, building roads and bridges connecting country (where most communities were located), towns or villages (where representatives of the imperial government resided), and ports in ways that would facilitate the extraction of wealth from colony to empire. (Lucena 2009; Lucena 2009)

2. Engineers and national development (19th to 20th centuries)

As independent republics began to emerge in the world scene, as happened first in the American continent in the late 18th and early 19th centuries, engineers from these new nations became preoccupied with mapping the territory and natural resources of newly sovereign countries and building national infrastructures. These infrastructures—mainly roads, bridges, railroads, canals, and ports—connected widely dispersed and diverse populations into a national whole and integrated their productive capacity for national and international markets. Engineering schools followed these developments. For example, in 1820 the U.S. government began training military engineers at West Point to provide the new republic with the necessary infrastructure that would protect it from future European invasions (Walker 1981; Grayson 1993). Right after independence in 1821, engineers from Mexico's Colegio Nacional de Mineria began mapping their territory and building a civil infrastructure that would serve the newly independent country (Lucena 2009). In 1847 and with similar purposes in mind, engineers from Colombia's newly created Colegio Militar developed the first national system of roads and built the national capitol building (Safford 1976), chap 7). Immediately after the creation of the Brazilian Republic (1889), military engineers from the Escola Politecnica de Rio connected the hinterlands of the Brazilian Amazon with the rest of the country through an extensive telegraph network (Diacon 2004).

During his expeditions to build an extensive telegraph network across the Brazilian territory, military engineer Candido Rondon da Silva tried to persuade indigenous groups in the Amazon to embrace the Brazilian nation
(source: Diacon's book. Check access)

Quite often, foreign engineers were invited to work alongside national engineers when independent countries did not have the financial capital, in-house experience, engineering education institutions or machinery to build infrastructure projects. For example, French engineers were invited by the US government to develop engineering curricula in West Point Military Academy and build and supervise road construction (Walker 1981). Francisco Cisneros, a Cuban American engineer educated in Rensselaer Polytechnic Institute (founded in 1824), was invited to Colombia to build the railroad and fluvial transportation systems (Horna 1992). U.S and Canadian engineers were invited to Sao Paulo, Brazil, to develop the automobile industry and construct urban electric rail transportation (da Silva Telles 1993).Whether carried out by domestic or foreign engineers, these projects were not conceived with environmental sustainability or community development in mind. Nature and community were places to be controlled and exploited for other purposes, mainly nation building.

Key Terms

Positivism: “a philosophy that holds that the only authentic knowledge is that based on actual sense experience…[also] referred to as a scientistic ideology, and is often shared by technocrats who believe in the necessity of progress through scientific progress.” (http://en.wikipedia.org/wiki/Positivism)

Spencerism: A view of evolution of society, first developed by English philosopher Herbert Spencer (1820-1903) in which society is considered as an 'organism' that evolves from simpler states to more complex ones according to the universal law of evolution.

During the late 19th and early 20th centuries, engineers in many parts of the former European colonies were heavily influenced by the ideologies of positivism and Spencerism (Nachman 1977). According to these ideologies, the purpose of the State, and those who comprised the state including engineers, was to establish *order* among a country’s population to achieve *progress*. Engineers in Mexico during the government of Porfirio Diaz (1876-1911) were no exception. As economic historian of Mexico Stephen Haber claims

> Diaz surrounded himself with a brain trust of Positivists and Social Darwinists who furnished his government with the ideology and intellectual justification it needed to believe in itself and in its program. Influenced by the ideas of Herbert Spencer and Auguste Comte, the Cientificos, as this group of intellectuals, bureaucrats, and professionals was called, emphasized that government policy should be carried out according to the rules of “science.” That is, they believed that society should be governed along scientific laws, and that there were social as well as natural sciences that governed the order of the world (Haber 1989), p. 23).

Mexican positivists argued that, like an organism, the State has many parts that should perform specific functions. According to them, for a country like late 19th century Mexico to achieve order, the State had to instruct educational institutions to “educate” all people—regardless of ethnic and linguistic differences found among millions of indigenous peoples organized in hundreds of communities—into national citizens who would think and act alike. Meanwhile, some adult citizens would be transformed into professionals by professional and technical educational institutions, which had the responsibility to differentiate specific skills for different needs of the State and industry (Bazant 1984; Bazant 2002). Engineering, like the other professions, had to serve a function and be in harmony with the other professions, all of which served as parts of the same organism (Bazant 2002), p. 223) Only through this level of *order* would a society (organism) ensure its survival and progress.

Under the ideologies of Spencerism and positivism, engineers and communities came together in problematic ways. Engineers were frequently in a position to subdue communities for the purposes of social order and national progress. Historian Todd

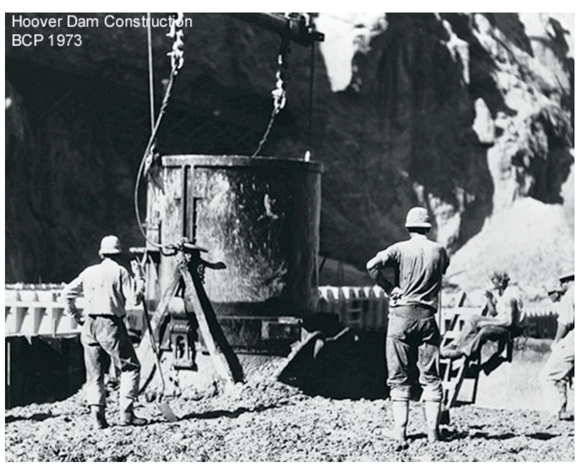
Diacon has written about this in his reflections on the work of Candido Rondon Da Silva, one of Brazil's most influential positivist engineers. During the construction of the telegraph on the eve of the Brailian Republic, Rondon

> quickly moved beyond a purely strategic rationale for telegraph construction. For him, the key was to develop the region, to populate it with small farmers, and to build thriving towns where none currently existed. He noted of telegraph construction that 'more than the military defense of the Nation that every government seeks to secure…we have come to promote the principal necessities of populating and civilizing our Brazil' (Diacon 2004), p.132).

Primarily motivated by positivism, engineers like Rondon wanted economic and political reorganization of their new countries, significantly altering the landscape and integrating indigenous and rural communities into national wholes without much (if any) concern for preserving ecosystems or local cultures. In short, engineers were nation builders, not sustainable designers or community builders.

3. Engineers and international development

During the first half of the 20th century many engineers participated, directly or indirectly, in the building and expansion of their nation-states. In the US, for example, engineers predominantly worked in what would become the big corporations of American capitalism, such as Ford, General Motors, General Electric, DuPont, and federal and state government agencies such as the US Corp of Engineers or the Tennesse Valley Authority (TVA) (Hughes 1989; Reynolds 1991). In the USSR, engineers worked in the constructions of mega-projects, like Magnitosgork and the White River Dam, which came to symbolize the strength of Soviet socialism (Graham 1993). In those countries that were still colonies (most of Africa and many South-East Asian countries), engineers still worked on building and maintaining infrastructures for the benefit of empires(Adas 2006). In either case, national and imperial development took precedence over local communities and the environment.



Pouring of concrete during the construction of Hoover Dam
http://www.savelakemead.com/jpgs/hib/hib003fsConcretePour.jpg

Exercise: Check main employers of engineers. How many of these corporations began in the US in the early 20th century? When were the newer ones created? What does this relationship of employment tell you about engineers?

After WWII a new area for engineering involvement emerged in the world stage: international development. With a new wave of independent countries emerging in Africa and Asia, engineers engaged enthusiastically in both national and *inter*national development. Despite their political differences, engineers from the US and USSR were motivated by ideologies of modernization.

After 1945, many American and Soviet engineers came to believe that it was possible to develop and modernize the world through science and technology, i.e., to move "traditional" societies from their current stage of backwardness and launch them through a stage of "take-off" by implementing large development projects (hydroelectric dams, steel mills, urbanization). Their hope was that these countries could join the superpowers in a "modern" stage of consumer capitalism (US) or industrialized socialism (USSR) (Adas 2006). Quickly, this vision was institutionalized in a number of ways such as:

- **Specific postwar plans:** e.g., the Marshall Plan in Europe and the Alliance for Progress in Latin America
- **Technical assistance agencies**: e.g., US Agency for International Development (USAID)
- **"Independent" regional or international development organizations**: e.g., the World Bank, the Inter-American Development Bank and other development banks
- **Mega development projects**: e.g., the Aswan Dam in Egypt, the Green Revolution in South East Asia, and the Itaipu Dam in Brazil.

This vision was also carefully conceptualized and disseminated by economists who heavily influenced engineers' thinking (such as W.W. Rostow at MIT) and adopted by technocrats in the US, USSR, and China alike (Ibid., chap. 5).

Key Terms

Modernization: "According to theories of modernization, each society would evolve inexorably from barbarism to ever greater levels of development and civilization. The more modern states would be wealthier and more powerful, and their citizens freer and having a higher standard of living." (http://en.wikipedia.org/wiki/Modernization)

Technocracy: "is a form of government in which engineers, scientists, and other technical experts are in control of decision making…Technocrats are individuals with technical training and occupations who perceive many important societal problems as being solvable, often while proposing technology-focused solutions." (http://en.wikipedia.org/wiki/Technocracy_(bureaucratic))

Exercise: Google "USAID" and "engineers" for images. What kind of images do you get? What do you see in them? What kind of cartoons? What do these images tell you about engineers involvement in international development?

The ideology of modernization views human societies as having an evolutionary pattern, which progresses from barbarian to modern. Societies would be able to achieve higher stages of development by changing their economic and political systems of production and participation. According to the ideology of modernization, the freer societies are, both economically and politically, the more modern they become. Traditional ways, often found in communal life, only get in the way of "efficient" economic production and broader participation. Local communities had to be convinced or coerced to join the modernization bandwagon with the rest of the nation or risk irrelevance.

Also, nature became a "national resource" to be incorporated in the modernization bandwagon. Nature was to be organized, planned, and often re-distributed efficiently to help countries move from lower to higher stages of modernization. Once again, under this ideology engineers, communities, and nature came together in problematic ways. Whether as technocrats working on planning departments or as builders of infrastructure, engineers, directly or indirectly, tried to change communities' traditional ways and controlled nature for the benefit of national development.

During the 1960s, labeled by the United Nations as the "first development decade," engineers served in international development projects as major components of the Cold War. For example, in Egypt, while US engineers built a fertilizer plant in Suez (Mitchell 1988), USSR engineers worked in the construction of the Aswan High Dam (Moore 1994; Lotfy El-Sayed, Lucena et al. 2006).

Built by Egyptian and Soviet engineers during the Nasser Era (1952-70), the Aswan High Dam is a clear example of engineering for development during the Cold War.
(source: http://www.pbs.org/wgbh/buildingbig/wonder/structure/aswam2_dam.html)

While US engineers worked on the expansion of the Green Revolution in South East Asia (Adas 2006), USSR engineers participated in the "sovietization" of industrial development in the new East Germany (Stokes 2000). In the case of US-financed projects, engineers' main concerns were to forge a path of development towards modernization and to contain the expansion of communism, or in the case of USSR- or Chinese-financed projects, to modernize and contain the expansion of capitalism. These concerns dictated the location, size, and reach of projects and neglected any consideration for environmental sustainability or autonomy of local communities (Adas 2006). In spite of powerful calls to protect nature and control human population that emerged in the 1960s (e.g., Carson's *Silent Spring*, 1962; Erlhich's *Population Bomb*, 1968) international development projects moved forward.

Key Terms

Green Revolution: Beginning in 1945 in Mexico and then expanding to other highly populated countries like India, this revolution refers to the transformation of agriculture by means of high-yield crops brought by artificial fertilizers, pesticides, and intensive irrigation. "The term was first used in 1968 by former USAID director William Gaud, who noted the spread of the new technologies and said, "These and other developments in the field of agriculture contain the makings of a new revolution. It is not a violent Red Revolution like that of the Soviets, nor is it a White Revolution like that of the Shah of Iran. I call it the Green Revolution."" (http://en.wikipedia.org/wiki/Green_revolution)

Humanitarianism: "In its most general form, it is an ethic of kindness, benevolence and sympathy extended universally and impartially to all human beings...No distinction is to be made in the face of human suffering or abuse on grounds of tribal, caste, religious or national divisions." (http://en.wikipedia.org/wiki/Humanitarianism)

Ironically, by the late 1960s and early 1970s, engineers working within the Cold War's military-industrial complex first expressed concerns for how technologies fit in local contexts. In the U.S., for example, a small group of engineers working at the General Electric plant in Schenectady, New York, and teaching at Rensselaer Polytechnic Institute created a group called Volunteers in Technical Assistance (VITA). They focused on the development of technologies that were simple and inexpensive to build, operate, and maintain so they could be deployed in poor villages around the world (Williamson 2007). Instead of delivering large aid packages or building monumental infrastructural projects, VITA engineers believed that the key to technology transfer was in the diffusion of technical information to help villagers develop technical expertise (Darrow 1986; Pursell 2003).

Volunteers for Prosperity

The connection between volunteerism and the use of appropriate technologies is alive and well today, institutionalized, for example, in the program Volunteers for Prosperity, supported by USAID (source: http://www.volunteersforprosperity.gov/)

Similar approaches to capacity building were implemented in humanitarian crises by a few engineers, such as Fred Cuny, who were concerned with the welfare of people in poor regions of the world who, because of their poverty, became the most vulnerable to disasters (Cuny 1983; Cuny and Hill 1999). A civil engineer from Texas A&M turned disaster relief specialist, Cuny proposed a new approach in dealing with communities, as he viewed them not as passive victims of international aid but as integral partners in reconstructions efforts:

> The term victim has many negative connotations. It provokes images of helplessness, of people who must be taken care of. For this reason, many [development] agencies have used substitutes such as beneficiaries or recipients…Rather than create a new word, [I] have chosen to go with *victims*. Victims, however, are not helpless. Thay are capable of making intelligent choices and when special allowances are made so that victims can cope with personal losses, they can participate effectively in all post-disaster activities…the term *victim* should be coterminous with *participant*. (italics in original) (Cuny 1983), p. 7)

In spite of this exceptional invitation to rethink victims of disasters as participant, the relationship between engineers and communities during these efforts is still one of expert-nonexpert or expert-apprentice where knowledge flows mainly in one direction, from the experts. The capacity and motivation that communities have in recovering from disaster often goes untapped. Also during humanitarian crisis where time is critical in saving human lives, not much attention is paid to long-term sustainability of systems or infrastructure. Ecological concerns play second fiddle to saving human lives. Community values and short and long-term desires are often secondary to expediency and the urgency of the moment in disaster relief crises.

Frederick Cuny in Somalia, 1992

world.std.com/~jlr/doom/cuny.htm

In the US, engineering education largely ignored these marginal developments in appropriate technology transfer or humanitarian engineering. Most engineering education initiatives, including accreditation criteria for engineering programs in place since the 1960s, were aimed at making engineering more scientific and less practical. Since the rise of the Cold War and the launching of Sputnik (1957), the dominant concern in the competencies of engineers has been mastery of the engineering sciences (Seely 1999). According a 1968 statement by the American Society of Engineering Education (ASEE), "all courses that displace engineering science should be scrutinized. The most important engineering background of the student lies in the basic sciences and engineering sciences" (American Society of Engineering Education 1968). ABET accreditation criteria quickly and decisively came to reflect this emphasis on science. Math, basic science, and engineering science and analysis were prescribed to take about 80 % of the engineering curriculum with design and humanities/social sciences taking a distant second place. Thus the decade of the 1960s in the US ended with a scientific engineering education void of any significant impetus for reaching out to "Third World" villages through technology transfer.

Post Sputnik engineering curriculum was organized as follows:

Math and basic sciences:
- Calculus, Differential Equations, Chemistry, Physics

Engineering Sciences:
- mechanics of solids
- fluid mechanics
- thermodynamics
- transfer and rate mechanisms
- electrical theory

- properties of materials

Analysis and Design

Humanities and Social Sciences

Electives

Exercise: Calculate the number of credits required in your engineering major in each of the main categories of the engineering curriculum: math and basic sciences, engineering sciences, design, humanities/social sciences, electives. Calculate the percentage of the total number of credits that each category represents in your curriculum. What category is the most dominant? Which one is the least dominant? How much emphasis is there in your curriculum on courses related to community development? In which category are these courses located?

4. Engineers and the questioning of technology

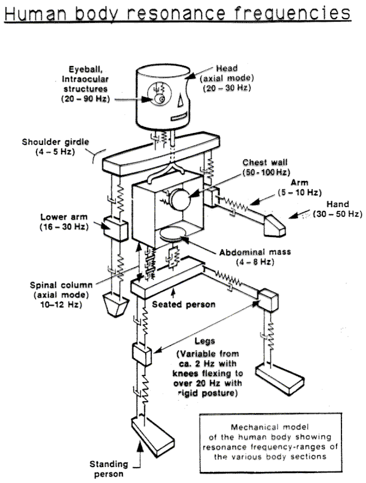
In 1969, the U.S. demonstrated its technical superiority to the USSR with the Apollo moon landing. Before that event, the few alternative technology practices institutionalized in US engineering included the exemplary efforts of VITA volunteers. After 1969, however—and for a variety of historical reasons—there emerged a sharp rise in the questioning of the military-industrial complex, the impact of industrial technologies on the environment, and the use of military technology in the Vietnam War. In both popular and scientific media, science and engineering were questioned for their lack of relevance to solve domestic problems (Cass 1970; Heilbroner 1970). Efforts at making science and engineering relevant to society pressured companies and government agencies to find ways to apply military technologies, such as the systems approach (Dyer 2000), and academic research and development (R&D) to societal problems like poverty eradication and urban renewal (Gershinowitz 1972).

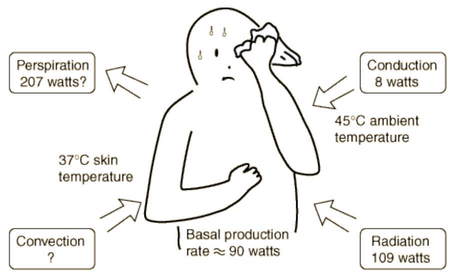
Engineers working in the launch control center preparing for the launch of Apollo XI
[source http://upload.wikimedia.org/wikipedia/commons]

On the international stage, the United Nations and other international organizations shifted their approach to development toward fulfilling basic needs and eradicating poverty. First proposed by World Bank's president Robert McNamara in 1972, the basic needs approach was an attempt "to reconcile the 'growth imperative' with social justice by sketching a dramatic picture of the conditions of people in the South, who were unable to take their destiny into their own hands because they could not satisfy their 'most essential needs'." (Rist 2004), p. 162) After almost two decades of institutionalized international development, proponents of the "basic needs" approach wanted reassurance that development assistance was actually reaching the poorest of the poor without much interference from international bureaucracies or local governments.

Yet, as historian of development Gilbert Rist points out "even if the fundamental case for development is a moral one [as in the case of basic needs], *the ultimate goal was to raise the productivity of the poorest so that they could be brought into the economic system.* " (his italics, Ibid, p. 163) Under a "basic needs" approach, local communities, with their differences in culture, geography, demography, etc., are reduced to basic needs in shelter, food, water with the goal of making them productive and incorporate them into the economy. By focusing on basic needs, development technocrats, including engineers, viewed communities strictly in terms of their deficits (water, food, shelter), instead of valuing their assets, capacities, and diversity. A "basic needs" approach encourages engineers to view communities in terms of deficiencies and to use universal parameters (e.g., minimum body temperature; maximum number of days without water or food, etc) as boundary conditions for their designs[1] and, after these basic needs have been met, in terms of productivity (e.g., output per unit of human labor). Actually, the current vision of EWB-USA calls for "a world in which all communities have the capacity to meet their basic human needs." (http://www.ewb-usa.org/AboutUs/VisionMission/tabid/62/Default.aspx)

[1] Interestingly, although development historians claim that the basic needs approach ended with the decade of the 1970s, the approach was still advocated in the late 1990s. See An Assault on Poverty: Basic Human Needs, Science and Technology By IDRC, United Nations. Commission on Science and Technology for Development. Panel on Technology for Basic Needs, International Development Research Centre (Canada), United Nations Conference on Trade and Development Published by IDRC, 1997. The basic needs approach is still alive among present-day humanitarian engineers who use the approach to energize students to join in their quest to alleviate poverty.





Through simplifications like these ones, engineers often depict the human body as a mechanism made of multiple components and fixed parameters such as resonance frequencies, heat transfer from different parts of the body, etc.
(sources: http://www.powerstandards.com/FunStuff/HumanResonance/HumanResonance.htm; http://hyperphysics.phy-astr.gsu.edu/HBASE/thermo/imgheat/bodycool3.gif)

The questionable outcomes of the Green Revolution, and particularly the negative impact of fertilizers and monocultures on ecosystems and local economies, brought widespread attention, probably for the first time, to the long-term sustainability of large-scale development projects (Pearse 1980). The "social and environmental impact" and appropriateness of technology to local settings and communities also gained widespread attention thanks to books like economist E.F. Schumacher's *Small is Beautiful* (Schumacher 1973).

A few engineering societies and schools organized conferences linking appropriate technology and development (Cook 1973; American Society of Civil Engineers 1978), while some US universities created programs in appropriate technology, as was the case at the University of California at Davis (Pursell 1979), and science, technology and society (STS) programs. Many of these programs were developed in conjunction with engineering faculty and attracted some engineering students who were concerned with the social and environmental impacts of technology (e.g., Stanford, Cornell, SUNY Stony Brook, Penn State, Lehigh, MIT, Virginia Tech, and Rensselaer) (Cutcliffe 1990). Yet for the most part, the questioning of technology and its appropriateness to different local settings remained outside of mainstream engineering education.

In short, in the 1970s, appropriateness and social and environmental impact emerged as concerns for at least a few engineering professionals, educators, and students. Communities and nature became more visible here, yet communities were redefined by development technocrats in terms of basic needs. The oil embargoes and energy crises of the 1970s opened a small opportunity for engineers, some of whom had been advocating for solar energy since the 1960s, to get involved in the development of renewable energy and hence in an early form of sustainability. Unfortunately, this opportunity was shortlived. In the 1970s U.S., most engineers worked in companies that depended heavily on the production and/or consumption of fossil fuels and other petroleum-based products (e.g., auto-manufacturers, GE, Boeing, DuPont, etc.). The election of Ronald Reagan to the U.S. presidency closed any possibility of federal funding for renewable energy or appropriate technology transfer to the "Third World." (Laird 2001; Friedman 2008) p. 14). In the US, as we will see, the institutional and political contexts of the 1980s worked against any significant development in the relationship among engineering, communities, and what would later be called sustainability.

5. Engineers and the "lost decade of development"

In the 1980s, the rise of neoliberal economics and the decline of the Cold War altered the course of international development. Neoliberal policymakers placed their faith in free markets and the individual decisions of producers and consumers, arguing for a reduction of government regulations in the marketplace and the privatization of many public services. They argued that the market, not the state, ought to decide what is best for education, health, technological innovation, and international development. In the U.S., the election of President Reagan sparked the elimination of governmental programs for appropriate technology, such as Appropriate Technology International (ATI), part of USAID, and science and engineering programs for societal needs (Lucena 1989). The AT movement suffered the consequences of this political shift (Winner 1986), chap 6).

The rise of neoliberal economics in many parts of the world brought a transformation of international development by eliminating the basic-need strategy and forcing countries into policies of "structural adjustment" where most social programs in health, education and employment would be significantly reduced or even eliminated. International development programs focused on poor governance (e.g., corruption), reducing government intervention, shifting control of public services from the state to the private sector, and hence increasing privatization. Local communities became disempowered as they faced the challenges of free-markets under unequal competition and the diminishing of state functions, mainly health and education. Environmental regulations came under attack as examples of government intervention on what should otherwise be a place for the free market to decide what is best: the use of natural resources (Rist 2004), chap. 10)

Consequently, the UN has labeled the 1980s as the "lost decade for development" after "employment and basic needs strategies…incorporated in the Third Development Decade Strategy [the 1970s] were swept off the global and national agendas" (United Nations Intellectual History Project 2005).

Key Terms

Neoliberal economics: An economic ideology that 1) endorses the free-market as the ultimate authority of who wins and who loses in the economy, 2) calls for the privatization of public services so these become part of the free market, and 3) advocates against any regulation by the government on the economy.

Structural adjustment: The development policy of neoliberal economics where development banks and lending institutions (e.g., World Bank and IMF) make privatization, deregulation and reduction of trade barriers as conditions for "developing countries" getting new loans or reduced rates on existing loans.

Exercise: Visit the projects website for the World Bank. Under 'Advanced Search,' type "structural adjustment" as keywords or phrase. Likely, you will get more than 1000+ projects. Browse through the list. What do you see? What are the projects about? Where are they located? Read in detail five projects of your interest. Take note of the goals of the project and how even infrastructure projects might be trying to dictate local economies, governance, private vs. public sector balance.

Website at
http://web.worldbank.org/WBSITE/EXTERNAL/PROJECTS/0,,menuPK:115635~pagePK:64020917~piPK:64021009~theSitePK:40941,00.html

In this new political and ideological environment, engineering and engineers rose to center stage. As U.S. government and businesses began defining new national challenges in terms of economic competitiveness against rising technological threats such as Japan and Korea, engineers emerged as the new warriors that would help the U.S. beat the Asian "dragons" and "tigers" in the technological marketplace. Although important discussions were taking place on the tension between economic growth and the environment, most importantly those that lead to the Brudlandt Report (produced by the UN-appointed World Commission on Environment and Development in 1987), U.S. engineering education and practice remained detached from that debate. Instead, engineering education focused on manufacturing, CAD/CAM, and the recruitment of more and more engineers to beat emerging Asian economies in the global economy (MIT Commission on Industrial Productivity 1989; Downey 1998). With the disintegration of the USSR and the end of the Cold War, other countries joined the bandwagon of economic competitiveness, including the former communist countries of Eastern Europe, which focused on reconstruction of their Soviet-age infrastructures and economies to "catch up" with the West (Hart 1992; Pudlowski 1997). As engineering societies and educators became preoccupied with enhancing the economic competitiveness of their nations, the brief impetus for appropriateness and socio-environmental impact of technology achieved during the 1970s was lost to the geopolitical and ideological realities of the 1980s.

Ironically, these concerns over economic competitiveness brought the rise of engineering design education in the early 1990s (see Chapter 3). Design courses were first legitimized as countering overly theoretical engineering curricula that produced inflexible engineers incapable of competing in a global marketplace (Lucena 2003). The first concerted push to incorporate flexibility in engineering education and to graduate flexible engineers came in 1990 from an NSF/NAE-sponsored workshop entitled "Engineering, Engineers, and Engineering Education in the 21st century." Engineer Roland Schmitt, at the time President of Rensselaer, chairman of the National Science Board, and the workshop's chairman, questioned the emphasis on engineering sciences in place since the 1960s: "the unanticipated consequences of emphasis on engineering science were to ignore manufacturing, to focus on sophistication of design and features, and less on cost and quality. Some of the engineering education decisions made in the past had detrimental effects on competitiveness…We need to develop a more flexible definition of 'engineers' and 'engineering'." (Schmitt 1990)

To become flexible, US engineering students needed more experience in design (Downey and Lucena 2003). For almost two decades now, engineering design faculty committed to reforming the curriculum have battled for more space for design courses. The origins of and reasons for this design movement in engineering education set in place a number of preconditions:

1. strong connections to private industry (not local communities)

2. assumptions about relationships between engineers as experts and those in "need" of a product or service as clients (not as equal partners in a collaboration)

3. budgetary and legal constraints as priorities in design considerations (instead of ecological sustainability and community empowerment)

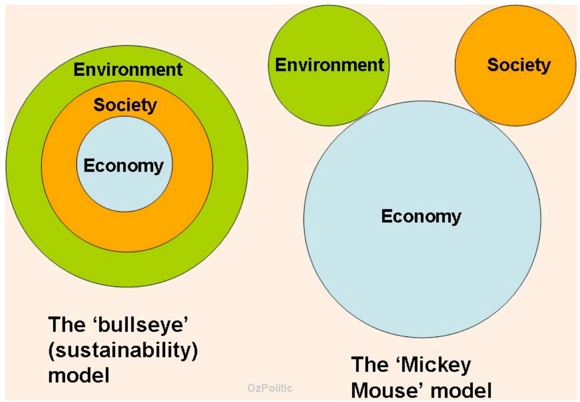
4. through design education, students could become "flexible" in a competitive marketplace and more ready for jobs in industry (not listeners and facilitators in community development).

5. team-work as division of labor among students of different engineering disciplines (not as partnership with people who hold different perspectives than your own)

As we analyze in detail in Chapter 3, most ETH initiatives that have come to rely on existing engineering design courses have inherited these preconditions. We will expand on this problematic relationship throughout the book, particularly as it affects engineers in ESCD projects.

6. Engineers and sustainable development

Sustainable development (SD) was a trend that developed largely out of the failures of the "development decades" of the 1970s and 1980s. One of the key events in this history was the 1992 United Nations Conference on Environment and Development in Rio de Janeiro (also known as the Earth Summit), out of which came the Rio Declaration. There are two dominant theories of SD—the weak and the strong (Neumayer 1999). Weak sustainability, also called "constrained growth," emphasizes economic models that do not differentiate between types of capital (between natural resources, for example, and human-made capital). This approach suggests that scientific and technological advancement will address natural resource depletion and emphasizes the importance of economic and social gains in the face of environmental degradation. Due to its reliance on the "technological fix" and quantification of different types of capital, most engineers support this approach. By contrast, strong sustainability acknowledges that because of natural constraints such as irreversibility, natural capital cannot always be treated like human-made capital. This approach, also called “resource maintenance,” argues for the protection of natural resources even at the cost of “development opportunities.”



Strong sustainability can be depicted with the economy as dependent on social activity which in turn is dependent of the natural environment. Activities that are harmful to the environment damage both society and the economy (the ‘bullseye’ model). Weak sustainability can be represented with the economy as the main focus of human activity and both society and the environment as relevant but tangential considerations. Protecting the environment might be desirable but not essential to society or the economy (The ‘Mickey Mouse’ model) (Source: http://www.ozpolitic.com/articles/environment-society-economy.html)

Key Terms

Weak sustainability: **“**All forms of capital are more or less substitutes for one another; no regard has to be given to the composition of the stock of capital. Weak sustainability allows for the depletion or degradation of natural resources, so long as such depletion is offset by increases in the stocks of other forms of capital (for example, by investing royalties from depleting mineral reserves in factories).” (http://stats.oecd.org/glossary/)

Strong sustainability:
“All forms of capital must be maintained intact independent of one another. The implicit assumption is that different forms of capital are mainly complementary; that is, all forms are generally necessary for any form to be of value. Produced capital used in harvesting and processing timber, for example, is of no value in the absence of stocks of timber to harvest. Only by maintaining both natural and produced capital stocks intact can non-declining income be assured.” (http://stats.oecd.org/glossary/)

Lacking the nationalistic luster of economic competitiveness, which challenged nations and their engineers to compete for market shares around the world, sustainable development (SD) emerged as a marginal preoccupation for engineers. Among a myriad of reports linking technological development to economic competitiveness, one on

Technology and Environment, by the U.S. National Academy of Engineering (NAE), called for the "creators of new technological developments and policymakers…to develop guidelines and policies for SD that reflect for the long-term, global implications of large-scale technologies and that support the innovation of less intrusive, more adaptable technologies at all levels" (Ausubel and Sladovich 1989). While economic competitiveness clearly challenged engineers to develop technologies for ever growing markets, SD did not provide the market demand that would justify investments on new sustainable technologies. These markets had to be created through policy decisions at the national level such as those highlighted by President Clinton's Council on Sustainable Development (1993-96) (Zwally 1996). Unfortunately, the Bush administration did not provide the incentives to create these markets. It remains to be seen how the commitment of the Obama administration towards renewable energy materializes in markets, products and jobs that would attract future generations of engineers.

The challenge of SD came to engineering education through the concerns of a small community of activist engineering educators that annually puts together the International Symposium on Technology and Society (ISTAS) of the Institute of Electrical and Electronics Engineers (IEEE). This community, which also includes engineering faculty making incursions into ethics and humanities faculty teaching in engineering programs, responded with the 1991 ISTAS symposium titled "Preparing for a Sustainable Society." SD became a theme around which engineering educators proposed new curricula in engineering ethics, economics and the academic field known as science, technology, and society (STS) (IEEE 1991). Unfortunately, at that time, these curricular areas became secondary in engineering programs at a time when economic competitiveness was shaping curricular development.

Engineering organizations in the early 21st century heeded the call to SD and have begun taking actions, ranging from hosting regional and world conferences to declaring their position with respect to SD, to revising their codes of ethics and challenging members to address SD principles in their work, and creating international professional partnerships such as the World Engineering Partnership for Sustainable Development (WEPSD). The WEPSD vision statement 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 (World Federation of Engineering Organisations 1997), p. 7).

In 1999, the American Society of Engineering Education (ASEE) released a "Statement on Sustainable Development Education" which 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. For example, studies of economics and ethics are necessary to understand the need to use sustainable engineering techniques, including improved clean technologies. In teaching sustainable design, faculty should ask their students to consider the impacts of design upon U.S. society, and upon other nations and cultures. Engineering faculty should use systems approaches, including interdisciplinary teams, to teach pollution prevention techniques, life cycle analysis, industrial ecology, and other sustainable engineering concepts…ASEE believes that engineering graduates must be prepared by their education to use sustainable engineering techniques in the practice of their profession and to take leadership roles in facilitating sustainable development in their communities." (ASEE Board of Directors 1999)

In addition, as a part of its code of ethics, the American Society of Civil Engineers (ASCE) has declared that its engineers shall "strive to comply with the principles of SD," 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." Other professional societies and organizations have followed suit. But as engineering ethicist Joseph Herkert points out "[engineering societies'] rationale for action regarding climate change [and sustainable development] has heretofore been articulated largely in economic and political terms, with little if any discussions of the ethical implications of climate change [and sustainable development]." (Herkert 2009), p. 439)

Although SD did not challenge engineers to compete in the international arena in the same way that the Cold War did in the 1960s or economic competitiveness has done since the 1990s, it became an interesting problem for some engineers to solve through a systems approach. Engineers appropriated "sustainable development" as an effort to be achieved through the use of technologies to clean up the mess that previous industrial practices had created and positioned themselves as "central players" in the success or failure of this effort (Prendergast 1993). Interestingly, the systems approach that emerged in the 1950s out of military technological development (Hughes and Hughes 2000) was favored again as a key engineering tool to solve the challenges of SD. Interestingly, the systems approach to sustainability has become institutionalized in a small number of engineering education programs such as University of Michigan's Engineering Sustainable Systems dual-degree.
(see http://www.snre.umich.edu/degree_programs/engineering)

As the end of the 20th century approached, engineering educators incorporated SD in the desired set of knowledge and skills for the engineer of the 21st century (Velazquez, Munguia et al. 1999). The emergence of new ABET accreditation criteria for engineering programs in the US in 2000 facilitated this adoption, especially the criterion that calls for engineering graduates to have "an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability." Furthermore, the influential *Engineer of 2020* report challenges engineers in the 21st century to adopt the tools for sustainable designs to the local conditions of developing countries in order to ensure equity in the benefits from using these tools across the world (National Academy of Engineering 2004), p. 21).

The Engineer of 2020
http://www.needs.org/needs/?path=/public/thematic/archive/0205_AfricanAmerican/index.jhtml&

Despite these commitments to SD and exceptional education programs, there is little evidence showing that most engineering students are learning about SD. Although engineering students nowadays seem to show more awareness of environmental issues, they lack knowledge of definitions of and approaches to SD, key SD principles and concepts such as the precautionary principle and inter- and intra-generational equity (and social justice in general), and how to deal with stakeholder participation in SD (Azapagic, Perdan et al. 1999). In a recent workshop on engineering design and sustainability, education researchers Stobel et al confirmed that students see the application of tools for sustainability, such as Life-Cycle Assessment (LCA), and doing engineering as contradictory:

> They [students] expressed that the particular focus on LCA would mean that "functionality is made secondary" or that they would have to "only think of the environment", which students expressed as a puzzle or contradiction to their understanding of engineering. The LCA is perceived as a borderline engineering related task. The researchers did not see much evidence that environmental issues are perceived as a required component of what makes a product 'functional'. A different version of the same argument surfaces, when students express LCAs are

> more valuable for end-users and less valuable for engineers (Strobel, Hua et al. 2009), p. 11)

This book cannot answer all questions nor address all these knowledge gaps but hopes to provide plausible answers to some and perhaps more importantly explain why these gaps exist. We will analyze possible curricular sources of these knowledge gaps in more detail in Chapter 3.

7. The explosion of "Engineering to Help" (ETH) activities

Since the early 1990s, engineering activities dealing with humanitarian and community development activities have proliferated significantly. Stimulated by the involvement of other professions in humanitarian relief, such as Doctors Without Borders (1971), Reporters Without Borders (1985), and Lawyers Without Borders (2000), engineers took up the challenge and independently organized a number of groups under some form of the name "Engineers without Borders": France's Ingénieurs Sans Frontieres (late 1980s), Spain's Ingeniería Sin Fronteras (1991), Canada's Engineers Without Borders (2000), Belgium's Ingénieurs Assistance Internationale (2002), and others. In 2003 these groups organized "Engineers Without Borders—International" as a network to promote "humanitarian engineering ... for a better world," now constituted by more than 41 national member organizations (http://www.ewb-international.org/members.htm).

Simultaneously, many other engineering activities trying to address the challenges of SD have emerged. There are now many student organizations and academic initiatives, such as those listed in the Introduction, NGO-driven organizations such as Engineers for a Sustainable World (ESW) and journals, such as *Environment, Development and Sustainability* (2002-present), *Engineering Sustainability* (2003-present), and *Journal of Engineering for Sustainable Development* (2006-present). This surge of activities is taking place at the historical convergence of three key events: the globalization of US engineering education (Lucena, Downey et al. 2008), the transformation of long-term corporate loyalty to engineering employees (Barley and Kunda 2004) and the unparalleled media coverage of humanitarian crises, violent conflict, poverty, and environmental degradation occurring worldwide (Hoijer 2004). Let us briefly analyze this historical convergence.

As we have seen, the end of the Cold War and the new challenge of global economic competitiveness brought significant changes to US engineering education, including a redefinition of engineering competencies embodied in the ABET EC 2000 criteria (Lucena 2003). The new engineering competencies, intended in part to create global engineers out of US-educated engineers, "has also provided opportunities to other programs and organizations not explicitly aimed at producing competencies for industry" such as EWB, ESW, etc. (Lucena, Downey et al. 2008), p. 5). In short, ETH initiatives have conveniently emerged at a time when engineering programs still struggle to address challenges of ABET accreditation such as developing the abilities "to design a system to meet desired needs…to function in multidisciplinary teams… to understand professional and ethical responsibility…[and] to understand the impact of engineering solutions in a global context" (ABET 2002).

Also since the 1980s, engineers have been experiencing significant dislocations in corporate employment. Practices aimed at increasing work productivity (i.e., more output per unit of human labor) put in place since the 1980s have resulted in continuous cycles of layoffs, workplace restructuring and geographic job reallocations from the US to countries like China and India (Aronowitz and DiFazio 1994; Rifkin 1995; Friedman 2006). No longer committed to their corporate employers, increasing numbers of engineers have become "itinerant experts in a knowledge economy" outside of mainstream employment (Barley and Kunda 2004). These dislocations of engineering employment of the last two decades have opened opportunities for many engineers to serve the public beyond the constraints set in place by many years of corporate employment by volunteering and/or even seeking employment as "relief engineers" (Davis and Lambert 1995) in humanitarian, community development or sustainable development organizations (For an extensive analysis of this emergence, see (Schneider, Lucena et al. 2009).

Key Terms

North-South Divide (or **Rich-Poor Divide**) "is the socio-economic and political division that exists between the wealthy developed countries, known collectively as "the North", and the poorer developing countries (least developed countries), or "the South."[1] Although most nations comprising the "North" are in fact located in the Northern Hemisphere, the divide is not primarily defined by geography. The North is home to four out of five permanent members of the United Nations Security Council and all members of the G8." (http://en.wikipedia.org/wiki/North-South_divide)

Also in last few decades, we have witnessed an unprecedented increase in media portrayals and coverage of humanitarian crises around the world. Beginning with the first televised famine in Biafra (1967), those around the world with access to TV have seen the graphic images of human suffering during the conflicts in Vietnam, Kosovo, Rwanda, Kurdistan, Palestine, Chechnya, and Darfur and after disasters like the tsunami in Indonesia and hurricane Katrina, to name a few. This media exposure, coupled with enduring ideas of progress and superiority of the North over the South, have produced what Barbara Heron calls "a planetary consciousness" and "a sense of entitlement and obligation to intervene globally." She argues that this sense of entitlement and obligation explains "why middle class Americans respond to media portrayals of global problems by feeling, as [Edward] Said argues, that it is up to them to set right the wrongs of the world…" (Heron 2007), p. 37) Engineers have not remained distant from this exposure and appropriation of images of the poor and dispossessed. Often during speeches or ETH program brochures, humanitarian engineers justify their sense of entitlement and obligation to help others by summarizing the statistics of suffering (e.g., # of people without water; # of people earning 1 dollar a day…etc) and showing pictures of the poor in the South.

The banner of the humanitarian engineering program's website at CSM shows an image that perhaps needs no explanation since in the US we have been socialized by the media to immediately assign meaning to a picture like this. What does this image tell you about the person standing against the wall?

8. The emergence of *community* in SD and ETH initiatives

At the same time, after many years of development failures, some engineers and development workers have begun to recognize the need to engage communities in more inclusive and participatory ways. As we have seen, since the relationship between engineering and development began to take shape in the 19th century, engineering work in local communities has been problematic at best. Engineers have been guided primarily by commitments to top-down planning, design, development, and implementation of projects done without consultation with communities. This attitude toward local and indigenous communities has been perpetuated and reinforced first by colonialism, then by the ideologies of positivism and modernization, and most recently by the desire to help (Escobar 1995; Heron 2007). Recognizing this problem, social scientists and development practitioners have been advocating participatory practices since the 1980s to include and engage communities in meaningful participation and equal partnership instead of passive receptivity of development (Salmen 1987). This call for participation has evolved into a full fledged approach and institutionalized in development agencies under the names of Participatory Action Research (PAR) and Participatory Learning and Action (PLA), sometimes adopted by individual engineers (e.g., (Salmen 1987; Salmen and Kane 2006). We will explore some of these approaches to community participation in Chapter 4 of this book.

Yet these participatory approaches to community development remain elusive to most engineering projects for a number of reasons. Historically, we have seen how engineering practices for development have emerged in alliance with specific foreign policies, located within national and international agencies and organizations, and inspired by the ideologies of positivism, modernization and neoliberalism. This history continues to shape many of the practices of engineers in development projects and the approach that even students take toward communities. One professor involved in the development of the EWB handbook told us that the language in the first edition was condescending toward communities, communicating the idea that "we will go and we will teach them [the villagers] how to be sustainable." One recent article on community service planning for engineering students outlined the steps that students need to take to identify project objectives, select projects, and solicit projects. Student satisfaction and the application of engineering knowledge are paramount criteria while community participation is marginal at best (Evans and Evans 2001). As we will see in Chapter 3, the project that received the student humanitarian top prize from a major engineering society in 2009 finally included community input at the pilot stage—after students in the classroom had framed the problem, decided on the design, and built a prototype.

The relatively few US engineering educators who are involved in educational opportunities in humanitarianism and/or SD have been primarily motivated by the needs of students and curricula. For example, many of these educators who want to provide students with an international experience in a "real life" situation have to comply with ABET accreditation criteria for their engineering programs, particularly those that are difficult to incorporate in engineering courses (e.g., "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context"). Such educators want to make their engineering programs relevant to society to increase recruitment and retention. In the United States, in other words, SD is slowly becoming part of engineering curricula as a result of many factors: changes in accreditation criteria, shifts in faculty interests, changes in industrial and political practices context, and an increasing focus on engineering ethics (Manion 2002).

These are worthy and noble causes, but they potentially place the participatory role of communities as secondary. As one committed engineering professor with many years of experience in student-led community projects recently confided to us,

> What I found is people in the villages are smart, they know what's happening, they know what they need. They may not have funds to do certain things that they want to do, but you know this whole thing of going and doing—all this is actually benefiting our students more [than the villagers] because it's opening [the students'] eyes. So let's be honest and say 'Yeah it's a good international exposure for our students but do you want to risk these communities?' I don't know. I don't know. I seriously don't know….I still wonder if [we] left [the villagers] alone, if they would be fine.

SD and ETH programs that do not shine a critical, self-reflective light on their work may risk replicating the dangers of traditional development projects which disempowered the communities that they were meant to serve. We hope that this book will provide strategic guidance on how to be critical and self-reflective when trying to bring engineering knowledge and skills to the service of community. Via the case studies, we also hope the book shows how engineers can be exemplars in listening to and engaging communities.

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