CHAPTER 2

Engineers and Development: From Empires to Sustainable Development[1]

How did engineers get involved in development? How have engineers been engaged in imperial, national, international, and sustainable development? How have historical ideological, and institutional factors influenced the way engineers engage with the groups of peoples (tribes, communities, villages, etc.) that they are supposed to serve? To what extent might this history constrain engineers' ability to effectively define problems and implement solutions for sustainable development? The answers to these questions will help you envision future possibilities and hidden limitations for individual and professional involvement in sustainable community development (SCD) and humanitarian engineering in more realistic, critical, and humane ways.

This chapter traces episodes of the history of engineers' involvement in development, from 18th century colonial development to 21st century sustainable community development. As you travel through the chapter, take the time to pause and answer the critical questions and exercises posed along the way. These are intended to elicit reflection on how much the history of engineers' involvement with development might continue to shape the ways in which you engage community development or humanitarian engineering today.

2.1 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, J., 2009a,b). 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, R., 2002).

[1] Some parts of this chapter originally appeared in Lucena and Schneider, "Engineers, development, and engineering education: From national to sustainable community development," European Journal of Engineering Education, 33:3 (June), pp. 247–257.

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, often for the extraction of natural resources and human labor and/or the creation of markets.

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, A., 1996). French engineers worked in Egypt in the construction of the Suez canal (See Figure 2.1) (Regnier and Abdelnour, 1989; Moore, C., 1994). Later, British engineers worked in Egypt (Mitchell, T., 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, D., 1981, 1988). German and British engineers worked for their imperial companies in mining extraction in Brazil (Eakin, M., 2002). Although working in different parts of the world and under different 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 that could be controlled and would last to ensure their imperial patrons a return on investment and display superiority over indigenous people.

How did engineers, and the imperial governments that hired them, perceive and affect communities during these developments? Answers to this question yield insight into how engineers in some colonial contexts conceptualized and interfaced with communities. In most cases, communities became sources of forced labor to extract natural resources necessary for the construction of imperial projects. Quite often, natives were viewed as potential imperial subjects to be organized in ways that made it possible to tax them, convert them to Christianity (or the dominant religion of the empire) and often force them into labor. 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 city and country, and ports to facilitate the extraction of wealth from colony to empire (Lucena, J., 2009a,b). In short, the political and economic interests of empires over colonies, and the socio-economic and ethnic backgrounds of the engineers (most of whom were paid imperial employees born and educated in Europe, who generally considered themselves superior to colonial natives) dictated this kind of exploitative relationship between engineers and communities.

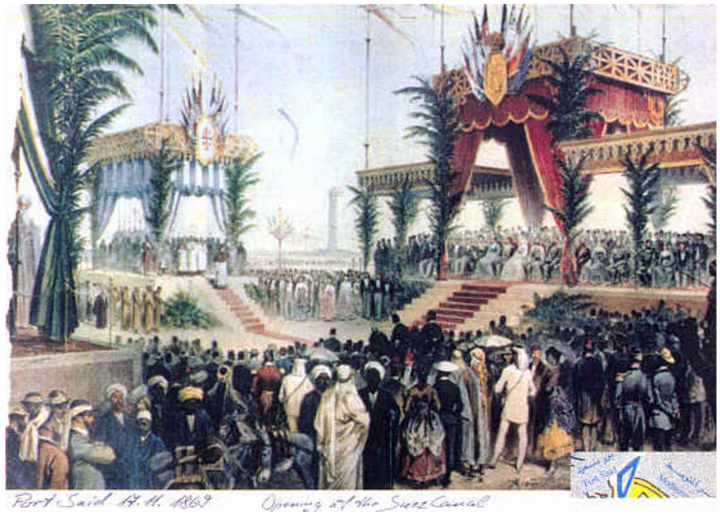

Figure 2.1: Opening of the Suez Canal in 1869. This major engineering project, authorized by the Ottoman governor Sa'id of Egypt, built by a French company and later used by the British empire, clearly represents engineering for the development of Empires.
(Source: `http://www.canalmuseum.com/documents/panamacanalhistory023.htm` Credit: canalmuseum.com).

Critical Questions

When envisioning your participation in a community development or humanitarian engineering project or initiative, how do you see yourself in relationship to the community with which you are working (technologically, culturally, spiritually, in terms of your respective humanity, etc.)? As superior? Equal? Inferior? Be as honest as you can. What might be the justification for your sense of superiority, equality, or inferiority?

2.2 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 beginning 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. Now born, and in some cases educated, in the former colonies, engineers adopted national identities and became preoccupied with developing their new countries. Through new infrastructures—mainly roads, bridges, railroads, canals, and ports—engineers helped connect widely dispersed and diverse populations into a national whole and integrate their productive capacity for national and international markets. New engineering schools emerged with these developments. For example, in 1820 the US 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, P., 1981; Grayson, L., 1993; Smith, M., 2008). In the 1840s, the US Corps of Engineers used slaves to construct coastal defenses in the Florida Keys (Smith, M., 2008). 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, J., 2009a). 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, F., 1976, Ch. 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 (See Figure 2.2) (Diacon, T., 2004).

Figure 2.2: During his expeditions to build an extensive telegraph network across the Brazilian territory to unite Brazil, military engineer Candido Rondon da Silva tried to persuade indigenous groups in the Amazon to embrace the Brazilian nation.
(Source: `http://www.vidaslusofonas.pt/candido_rondon2.htm` Credit: Museu do Indio, Rio de Janeiro. Permission Pending).

Quite often, foreign engineers were invited to work alongside engineers from the newly independent countries when these 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, P., 1981). Francisco Cisneros, a Cuban American engineer educated at Rensselaer Polytechnic Institute (founded in 1824), was invited to Colombia to build the railroad and fluvial transportation systems (Horna, H., 1992). US and Canadian engineers were invited to Sao Paulo, Brazil, to develop the automobile industry and construct urban electric rail transportation (Telles, P., 1993). Yet neither local nor foreign engineers conceived these projects with environmental sustainability or community development, as we understand those terms today, in mind. Rather, consonant with the values of the day, nature and community were to be controlled and exploited for nation building.

Key Terms

Positivism: The belief that we can know and understand the world only through empirical, scientific observations and testing. For positivists, scientific reasoning is a superior, universal, and objective way to understand the world, while other forms of seeing and being in the world are considered inferior, superstitious, local, and ultimately unprovable.

Spencerism: A view of the evolution of society, first developed by English philosopher Herbert Spencer (1820-1903), in which society is considered an "organism" that evolves from simpler states to more complex ones according to the universal law of evolution. For the organism to survive and evolve, every part of society serves a function under an established hierarchy controlled by the State. Under this view, professions such as engineering play key roles in organizing important activities for the functioning, survival and evolution of the organism (e.g., infrastructure, industry) while marginal groups (poor, illiterate, orphans, etc.) and native communities are considered detrimental to the organism.

Social Darwinism: A view of human society rooted in Darwin's notion of survival of the fittest used to justify the superiority and authority of one group of people (usually whites, rich, educated) over other groups of people (usually non-whites, poor, and uneducated). Note that Darwin did not intend his notion of survival of the fittest to be applied to human societies.

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, defined briefly above (Nachman, R., 1977). According to these ideologies, the purpose of the State was to establish *order* among a country's population to achieve *progress*. Spencerism was used to justify the actions of the State (and, by implication, the actions of engineers). An example from Mexico illustrates how engineers were involved in this "ordering" of society. According to one historian, Mexican engineers hired by President Porfirio Diaz (1876-1911) were part of a "brain trust of Positivists and Social Darwinists." This group of men believed that "government policy should be carried out according to the rules of 'science'" (Haber, S., 1989, p. 23).

In other words, Mexican positivists argued that, like an organism, society has many parts that should perform specific functions. In a certain sense, society could be viewed as a system that needed to be engineered for maximum efficiency. According to these thinkers, 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 (Bazant, M., 1984, 2002). Once educated on how to execute superior functions (e.g., build transportation infrastructure, industry), engineers, like other professionals, could contribute to the survival and evolution of society. Only through this level of *order* would a society (organism) ensure its survival and *progress*. Although not all countries adopted Spencerism as an ideology to organize society and justify the role of engineers, other examples can be found in Brazil during the first government of President Getulio Vargas (1930-1945) (Williams, D., 2001) and in Colombia during the last two decades of the 19th century (Henderson, J., 2001).

As you might imagine, under the ideologies of Spencerism and positivism, engineers and communities often clashed. Engineers were frequently in a position to *socially engineer* communities for the purposes of order and national progress, for example, by relocating them or connecting them in different ways to other parts of the country. For instance, Candido Rondon Da Silva was one of Brazil's most influential positivist engineers. During the construction of the telegraph on the eve of the Brazilian 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, T., 2004, p. 132).

Primarily motivated by positivism, engineers like Rondon tried to achieve economic and political development of their new countries by significantly reorganizing and integrating indigenous and rural communities into national wholes without much (if any) concern for preserving ecosystems or local cultures. These were not concerns of the times, yet they help us understand the emphasis of engineers in constructing their national societies.

Critical Questions

As you envision your participation in a community development or humanitarian engineering project or initiative, check your assumptions about the partnering community. Do you think that they need to be better organized or connected through infrastructure (a road, a water distribution or sewage system, a computer network) to a larger whole (a village, a county, a country, a market)? If so, what might the people that you are trying to help be winning and losing through these connections?

2.3 ENGINEERS AND INTERNATIONAL DEVELOPMENT (20TH CENTURY)

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 Corps of Engineers or the Tennessee Valley Authority (TVA) (See Figure 2.3) (Hughes, T., 1989; Reynolds, T., 1991). In the USSR, engineers worked in the construction of mega-projects, like the "steel city" of Magnitosgork and the White River Dam, which came to symbolize the strength of Soviet socialism (Graham, L., 1993). In those countries that were still colonies (most of Africa and South-eastern Asia), engineers still worked on building and maintaining infrastructures for the benefit of empires (Adas, M., 2006). In either case, national and imperial development took precedence over local communities and the environment.

Exercise 1 *Find out who the main employers of engineers are at your school. How many of those corporations (like GM) or organizations (like the US military) were around in the US in the early 20th century? When were the newer corporations created? What does this relationship between corporations and engineering employment tell you about engineers?*

After WWII, a new area for engineering involvement emerged on 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 both motivated by the *ideology of modernization*. That is, 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). As discussed in the Introduction, many engineers have held to this belief to this day. Political elites and technocrats in many of these "developing" countries hoped that their countries could join the superpowers in a "modern" stage of consumer capitalism (US) or industrialized socialism (USSR) (Adas, M., 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., the US Agency for International Development (USAID).

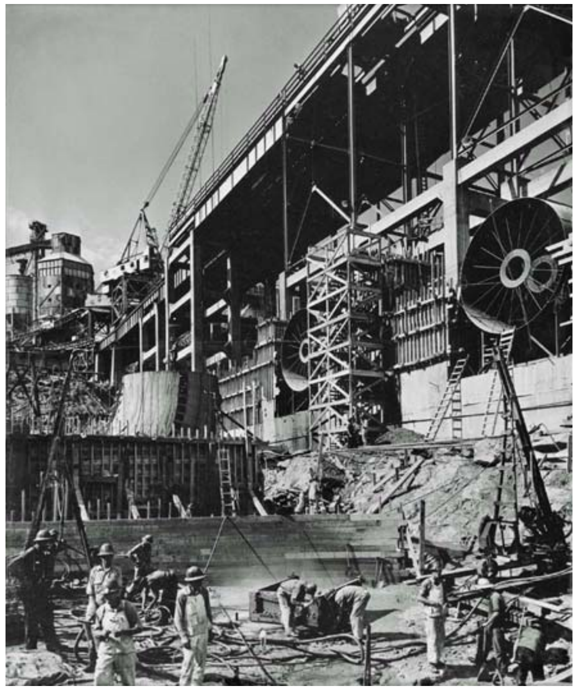

Figure 2.3: TVA under construction. "Everyone who lived near the [Tennessee] river was affected by this. Tens of thousands of jobs were created. Some of the "workers' villages" that were built during dam construction still remain – Norris, Tennessee, being the best example. Thousands of homes, hundreds of farms, and many towns were permanently flooded and had to be moved to higher ground.
(Source: http://www.tnhistoryforkids.org/students/h_7. Credit: TVA).

- **"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 Southeastern 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 (Adas, M., 2006, ch. 5).

Key Terms

Modernization: Modernization can mean many things, depending on the context. When we think about modernization in the development context, however, we are usually talking about the belief that communities, societies, or countries can be moved, step by step, from various states of "backwardness" or "lack" to stages of increasing wealth, "civilization," and access to technology and information. The concept is open to critique because it implies, sometimes wrongly, that certain ways of living are inferior (typically the South countries) to other ways (typically Northern countries), which are seen as superior. Modernization has also been the justification for many development programs, which in some cases have left "backward" societies worse off than before they encountered "civilization."

Technocracy: Technocracy is frequently defined as a form of government that is planned, organized and run by a group of highly educated experts. Technocrats, who are often scientists, engineers and economists, approach social problems the way they approach scientific problems, by breaking them down into constituent parts and integrating technology as means of management and/or control of those parts. Technocracies are frequently criticized as anti-democratic because technocrats centralize, rather than share, the processes and knowledge needed to rule. In effect, they can make it very difficult for the average citizen to be involved in governance because the systems they devise are so complex. The 2008 collapse of the global financial system is often attributed to technocrats.

Exercise 2 *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?*

As depicted in Figure 2.4, the ideology of modernization views human societies as having an evolutionary pattern, which progresses from traditional 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, as societies produce and consume more, the more modern they become. Traditional ways, often found in communal life, only get in the way of "efficient" economic production and mass consumption. Local communities have to be convinced, transformed, or coerced to join the modernization path for "take-off" by abandoning their subsistence economies and increasing their extraction of natural resources and manufacturing capacity to eventually reach a stage of high-mass consumption.

At the same time, technocrats, including many engineers, viewed nature as a "national resource" to be exploited in the name of modernization. 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 to control nature so their countries could progress on the path to modernization and development.

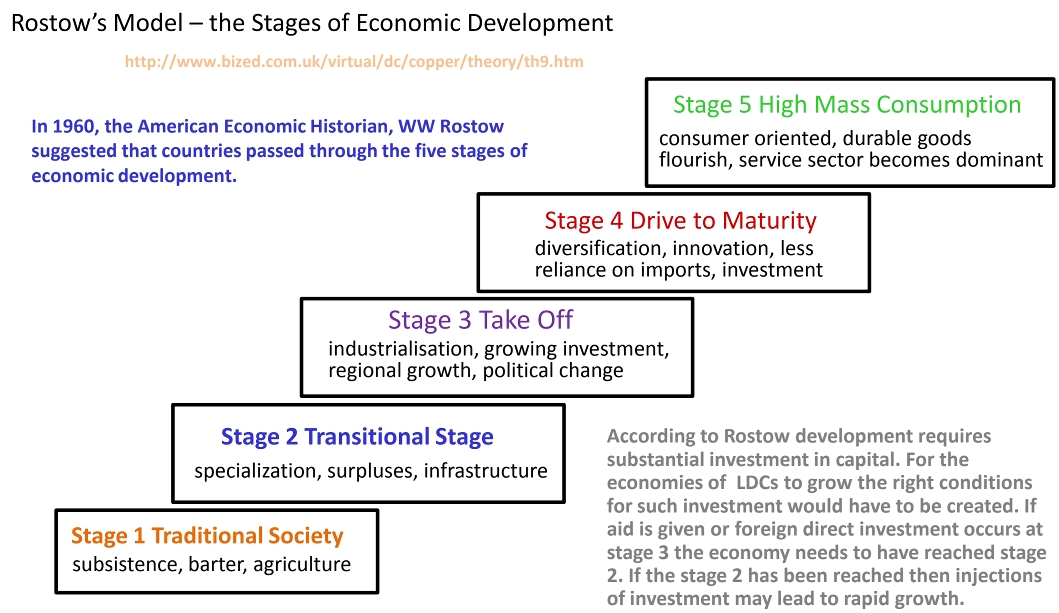

Figure 2.4: Rostow's model of economic growth. (Source: `http://welkerswikinomics.com/blog/wp-content/uploads/2008/02/growthmodels_3.jpeg` Credit: Jason Welker).

For example, 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, as the US and USSR battled for influence in Egypt, US engineers built a fertilizer plant in Suez (Mitchell, T., 1988) while USSR engineers worked in the construction of the Aswan High Dam (See Figure 2.5) (Moore, C., 1994; Lotfy, et al., 2006). In Brazil, US, Italian and Brazilian engineers joined forces to build the Itaipu hydroelectric dam in 1971, one of the flagship projects of a military regime committed to contain the spread communism in Latin America. These modernization projects irreversibly changed local ecosystems and communities and enhanced the local governments' capacity to impose an ideological position on either side of the Cold War.

In spite of the 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. For example, while US engineers worked on the expansion of the Green Revolution in South East Asia (Adas, M., 2006), USSR engineers participated in the "sovietization" of industrial development in the new East Germany (Stokes, R., 2000). In the case of US-financed projects, engineers' main concern was 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

Figure 2.5: 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 Credit: UPI/Corbis/Bettman. Permission Pending).

location, size, and reach of projects and neglected any consideration for environmental sustainability or autonomy of local communities (Adas, M., 2006).

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 outcomes of this "revolution" have been highly contested, with some arguing that the technologies developed during this time have drastically improved food quality and supplies to parts of the word that need them, and others arguing that some of those approaches and technologies (e.g., use of chemicals, genetic modification, centralization of food cultivation) have been damaging to local communities, ways of life, and ecologies.

Humanitarianism: Humanitarianism is a broad term encompassing many meanings. In the context of international development, we can think of it as "systematized help," in which individuals or groups, financed by donor nations and assisted by NGOs, attempt to alleviate human suffering in the face of natural and human-caused disasters or armed conflict. Humanitarians, whether individuals or organizations, can be driven by any number of concerns—religious, ethical, social, economic, opportunistic—but typically see their mission as one of compassion and altruism while the nations that finance their efforts see their mission as part of foreign policy.

Ironically, by the late 1960s and early 1970s, engineers working within the Cold War's military-industrial complex began to express concerns for how technologies fit in local contexts. In the US, 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, B., 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, et al., 1986; Pursell, C., 2003). As shown in Figure 2.6, 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.

Similar approaches to enhance the technical capacity of communities were implemented in humanitarian crises by engineers like Fred Cuny, who were concerned with the welfare of people in poor regions of the world (See Figure 2.7). These people, often because of their poverty, became the most vulnerable to armed conflict, natural disasters or human-induced environmental catastrophes, famines or other grave threats to human security (Cuny, F., 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 reconstruction 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. They 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, F., 1983, p. 7).

Figure 2.6: Volunteers for Prosperity Website, supported by USAID.
(Source: `http://www.volunteersforprosperity.gov/` Credits: Volunteers for Prosperity).

Despite this exceptional invitation to rethink of victims of disasters as *participants*, the relationship between engineers and communities during these efforts is still one of superior to inferior (expert to non-expert or expert to apprentice) where knowledge flows mainly in one direction, from the experts. The capacities and motivations that communities have in recovering from disaster often go untapped. Also, during humanitarian crises, 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 also often secondary to expediency and the urgency of the moment in disaster relief crises.

In short, although humanitarian or disaster-relief engineering of this sort seems a welcome and far cry from the sorts of engineering we saw under national and international development, it still represents a sometimes problematic engineering mindset of how individuals and communities organize themselves and "work." Our point here is not to be critical of such mindsets in an anachronistic way—engineers emerged from their own social contexts and often act from within the constraints and mindsets of those contexts. Rather, our point is that it's important to be self-reflective and aware of those mindsets, so that we might also acknowledge and address their deficiencies or blind spots.

As efforts like Cuny's unfolded 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. Since the rise of the Cold War and the

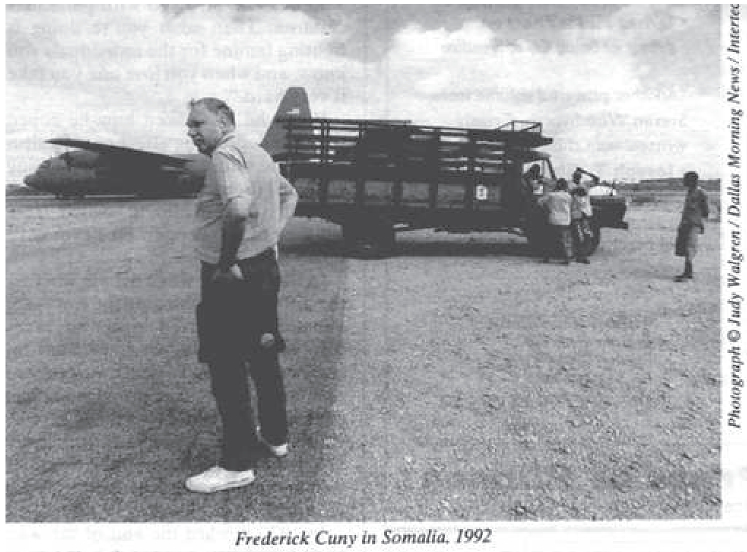

Figure 2.7: Fred Cuny in Somalia.
(Source: `www.world.std.com/~jlr/doom/cuny.htm` Credit: Judy DeHass).

launching of Sputnik (1957) by the USSR, the dominant concern in the competencies of engineers has been mastery of the engineering sciences (Seely, B., 1999). According to 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 set to take up 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

Post Sputnik engineering curriculum was organized around the following main categories (in bold):
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 3 *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 or humanitarian engineering?*
- *In which category are these courses located?*
- *Might these courses be located in categories considered by engineering faculty and students as "soft" or "easier"?*
- *What does this exercise tell you about the relevance of engineering knowledge for community development?*

2.4 ENGINEERS AND THE QUESTIONING OF TECHNOLOGY (THE 1970s)

The 1970s began in the US with a paradox about technology. On one hand, the US demonstrated its technical superiority to the USSR with the Apollo moon landing in 1969 (See Figure 2.8). At the same time 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 both exalted for their achievements *and* questioned for their lack of relevance to solve domestic problems (Cass, J., 1970; Heilbroner, R., 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, D., 2000), and academic research and development (R&D) to societal problems like poverty eradication and urban renewal (Gershinowitz, H., 1972).

Figure 2.8: 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, G., 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). Equally troubling in this approach is how it reinforces the notion that poor people are "unable to take their destiny into their own hands."

What Rist means is that, under a "basic needs" approach, local communities—with their differences in culture, geography, demography, etc.—are also 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 (See Figure 2.9). Although development historians such as Rist claim that the basic needs approach ended with the decade of the 1970s, the approach was still advocated in the late 1990s[2] and is still alive among present-day humanitarian engineers who use the approach to energize students to join in their quest to alleviate poverty. 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`).

Exercise 4 *Find out how your faculty and student peers involved in community development or humanitarian engineering might be thinking about the human body. In their designs, do they envision it as a machine constrained by certain physiological parameters that can be quantitatively measured? Or as a body of mass that exchanges energy with its surrounding environment? As absent altogether from designs? Or perhaps as something else? Where do the numerical values of the parameters under consideration come from? Are these ergonomic and/or physiological values obtained by averaging those of controlled groups such as US Army soldiers or participants in medical experiments in rich countries? If so, how appropriate are these assumptions and values when designing for diverse groups of people in different parts of the world? More broadly, in community development or humanitarian engineering, what are the advantages and disadvantages of a focus on human (mostly physiological) needs?*

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, A., 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, E., 1973).

A few engineering societies and schools organized conferences linking appropriate technology and development (Cook, J., 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, C., 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, S., 1990). Yet for the most part, the questioning of technology and its appropriateness to different local settings remained outside of mainstream engineering education.

[2]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.

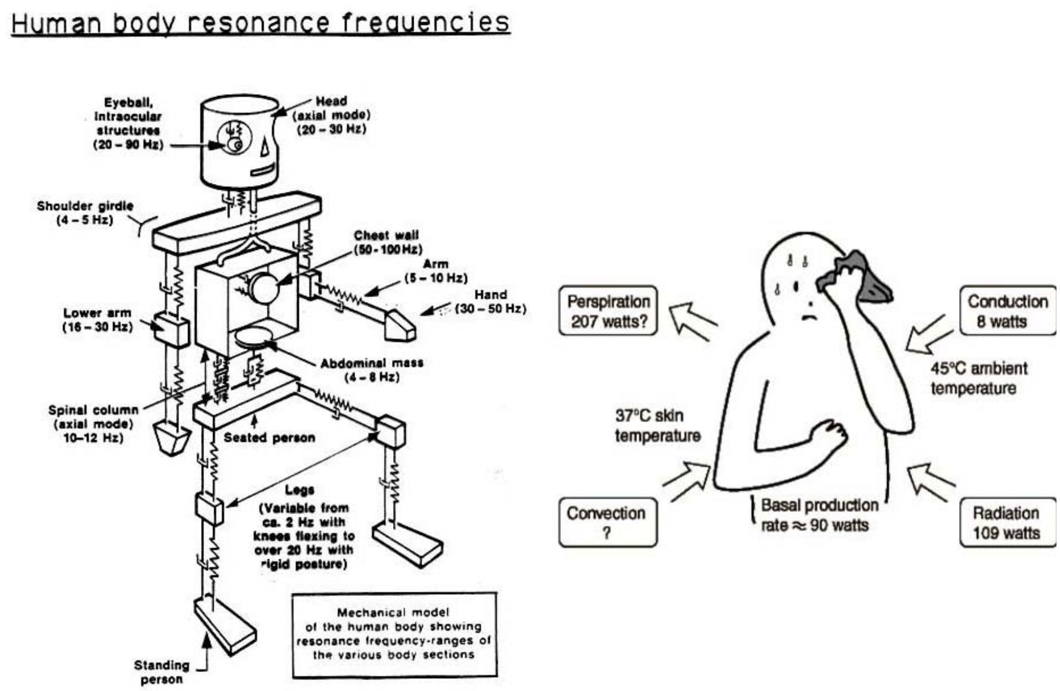

Figure 2.9: Through simplifications like these ones, engineers often depict the human body as a mechanism made of multiple components and fixed parameters such as resonance frequencies, heat transfer from different parts of the body, etc.
(Source: http://www.powerstandards.com/FunStuff/HumanResonance/HumanResonance.htm
Credit: Sven-Olof Emanuelsson.
Source: //hyperphysics.phy-astr.gsu.edu/HBASE/thermo/imgheat/bodycool3.gif).

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*. For engineers who had been advocating for solar energy since the 1960s, the oil embargoes and energy crises of the 1970s opened a small opportunity for engineers to get involved in the development of renewable energy and hence in an early form of sustainability. Unfortunately, this opportunity was short-lived. 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). The election of Ronald Reagan to the US presidency closed any possibility of federal funding for renewable energy or appropriate technology transfer to the "Third World" (Laird, F., 2001, Friedman, T., 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.

2.5 ENGINEERS AND THE "LOST DECADE OF DEVELOPMENT" (THE 1980s)

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. These policymakers argued that the market, not the state, ought to decide what is best for education, health, technological innovation, and international development. In the US, 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, J., 1989). The AT movement suffered the consequences of this political shift (Winner, L., 1986, Ch. 6).

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. Since the rise of neoliberal economics in the 1980s, many in the North and South have come to question the assumption that the market is a "neutral" or even "rational" arbiter of economic relations. See Saad-Filho and Johnston (2004); Greenhouse, C. (2009); Martinez, M. (2009).

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.

The rise of neoliberal economics in many parts of the world brought a transformation of international development by eliminating the basic-needs strategy and forcing countries into policies of *structural adjustment*,where most social programs in health, education and employment would be significantly reduced, eliminated or transferred to the private sector. International development programs focused on poor national governance, reducing government intervention, shifting control of public services from the state to the private sector, and hence increasing privatization. Local communities often became disempowered as they faced the challenges of free-markets under unequal competition and the diminishing of state functions, mainly health, education and other forms of social protection. 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, G., 2004, Ch. 10).

Consequently, the UN 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).

Exercise 5 *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 a couple of projects that interest you. 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.* `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 the US 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 US 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 Brundtland Report (produced by the UN-appointed World Commission on Environment and Development in 1987), US 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, G., 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, J., 1992; Pudlowski, Z., 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. Design courses were first legitimized as countering overly theoretical engineering curricula that produced inflexible engineers incapable of competing in a global marketplace (Lucena, J., 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, R., 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 curricula have battled for more space for design courses. As expected, the design models and practices that emerged were for industry, not for community development; hence, they contained many problematic assumptions about the ways engineers have engaged communities through their designs:

1. Design projects should strengthen connections between engineering schools and private industry (not local communities).

2. The relationship between engineers (students supervised by faculty) and those in "need" of a product parallels that of expert and clients (not as equal partners in a collaboration).

3. Budgetary and legal constraints should be considered high priorities in design considerations (instead of ecological sustainability and community empowerment).

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

5. Team-work is viewed as division of labor among students of different engineering disciplines and forms of expertise or knowledge (not as partnership with people who hold different perspectives than your own).

In Chapter 3, we discuss how most community development and humanitarian engineering initiatives that have come to rely on existing engineering design courses have inherited some of these problematic assumptions. We will expand on this tricky relationship throughout the book, particularly as it affects engineers in ESCD projects.

2.6 ENGINEERS MOVE TOWARD SUSTAINABLE DEVELOPMENT (1980s-1990s)

Sustainable development was a trend that developed largely out of the failures of the development strategies 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.

We have identified two dominant views of sustainable development—the weak and the strong (Neumayer, E., 1999). *Weak sustainability*, also called "constrained growth," emphasizes economic models that do not differentiate between natural and human-made resources. Proponents of this view assume that scientific and technological advancement will address natural resource depletion and emphasize the importance of economic and social gains in the face of environmental degradation. Due to its reliance on technological solutions, most engineers have traditionally supported this approach (See Figure 2.10).

By contrast, proponents of *strong sustainability* acknowledge that natural resources cannot always be treated like human-made resources because of natural constraints such as irreversibility of ecological damage (e.g., you cannot bring an animal species back to life once it is gone). This view argues for the protection of natural resources even at the cost of development opportunities (e.g., saving the spotted owl even if it means losing growth opportunities for the timber industry).

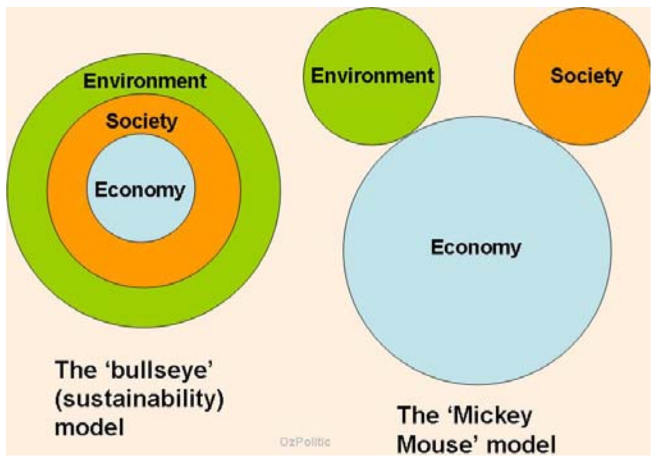

Figure 2.10: Strong sustainability can be depicted with the economy as dependent on social and economic activity which in turn are dependent of the natural environment. Activities that are harmful to the environment damage both society and the economy (the "bullseye" model). Weak sustainability can be represented with the economy as the main focus of human activity and both society and the environment as relevant but tangential considerations. In the 'Mickey Mouse' model, protecting the environment might be desirable but not essential to society or the economy.
(Source: http://www.ozpolitic.com/articles/environment-society-economy.html Credit: OzPolitic).

Key Terms

Weak sustainability: This conception of sustainability sees natural resources much the way we see economic ones—as something to be priced, bought, sold and managed. It views nature in terms of markets, economic worth, and technocratic management. Its appeal is that it does little to challenge prevailing beliefs about economic growth and human consumption, assuming that natural resources can simply be incorporated into existing economic models. Its disadvantage is that it doesn't take into account important characteristics that make natural resources different from human-produced resources such as their finite nature and our utter dependence on them for survival. The cap and trade approach to CO2 emissions is an example of weak sustainability.

Strong sustainability: This model assumes that environmental or natural resources have intrinsic value in relation to other forms of capital and human-made resources. While pollution is often "externalized" in the weak model, it would be accounted for in the strong model because it represents damaging of natural capital, or the commons. The advantage of this model is that it makes good ecological sense; we cannot have a timber industry, for example, if there are no trees to harvest due to over-logging. On the other hand, it has proven very difficult to change the economic system to include "externalities" because the weak model is so in line with our deeply ingrained assumptions about what has worth.

Lacking the nationalistic luster of economic competitiveness, which placed engineers at the center stage of technological innovation in the 1980s, sustainable development was only a marginal preoccupation for engineers in the 1990s. Among a myriad of reports linking technological development to economic competitiveness, one on *Technology and Environment*, by the US National Academy of Engineering (NAE), called for "[engineers as] creators of new technological developments and policymakers…to develop guidelines and policies for sustainable development 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).

Despite such calls, sustainable development did not provide the market demand that would justify investments in new sustainable technologies. By contrast, economic competitiveness clearly challenged engineers to develop technologies for ever growing international markets. Most corporate employers of US engineers were simply not willing to take sustainable technology investment risks. New markets for sustainable technologies had to be created with government incentives and through policy decisions such as those highlighted by President Clinton's Council on Sustainable Development (1993-96) (Zwally, K., 1996). Unfortunately, neither the Clinton nor the Bush administrations provided sufficient incentives to create these markets. It remains to be seen whether the commitment of the Obama administration towards renewable energy materializes in such markets, products, and jobs—which could attract future generations of engineers.

In engineering education, sustainable development did not become a major theme in the 1990s, marginally appearing 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). In 1991, ISTAS held a symposium entitled "Preparing for a Sustainable Society." Sustainable development became a theme around which a handful of 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 proposals became secondary in engineering programs, largely because economic competitiveness was challenging most engineering faculty to focus curricular development in areas that US engineering students seemed to be lacking, such as design, manufacturing, and international education. The calls for "flexible engineers" that would help the US compete in a global economy did not include competencies related to sustainable development (Lucena, J., 2003).

2.7 ENGINEERS HEED THE CALL TO SUSTAINABLE DEVELOPMENT (LATE 1990s-PRESENT)

In contrast to the preceding decades, engineering organizations in the early 21st century heeded the call to sustainable development and have begun taking actions, ranging from hosting regional and world conferences to declaring their position with respect to sustainable development, to revising their codes of ethics and challenging members to address sustainable development 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 sustainable development," which is defined as "the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development." Other professional societies and organizations have followed suit.

Although sustainable development did not challenge engineers to compete in the international arena in the same way that economic competitiveness has done since the 1990s, it became an interesting problem for some engineers to solve through a *systems approach*. Some 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, J., 1993). Ironically, the systems approach that emerged in the 1950s out of military technological development (Hughes, et al., 2000) was favored again as a key engineering tool to solve the challenges of sustainable development. This 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`). Figure 2.11 is an example of a systems approach to modeling a lake that reveals the complexity of the relationship among biophysical and socio-economic parameters.

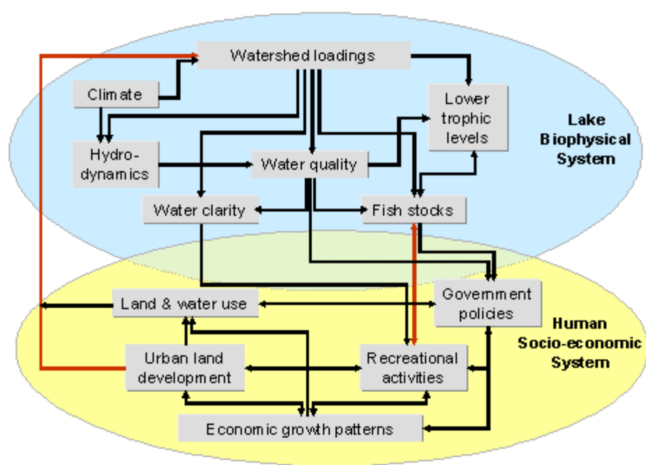

Figure 2.11: Modeling of coupled parameters in a lake system (Fiksel, J., 2006).

This is a welcome improvement in engineers' understanding of how human systems interact with ecological ones. Yet excessive analysis of these interactions can lead to inaction. In his excellent summary of systems approaches to sustainability, including those developed by engineers and other scientists, Joseph Fiksel warned us that "[w]hile improving modeling techniques and establishing a rigorous science of sustainability is important, a caveat is in order. Excessive modeling efforts may become an excuse for delaying effective political action, leading to 'paralysis by analysis'…. Progress in theory-based research needs to be balanced with exploratory policy implementation that will enrich our understanding of sustainability issues in real-world systems" (Fiksel, J., 2006, p. 20).

As the end of the 20th century approached, some engineering educators incorporated sustainable development in the desired set of knowledge and skills for the engineer of the 21st century (Velazquez, 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).

Despite these commitments to sustainable development, there is little evidence showing that most engineering students are learning about it. Although engineering students nowadays seem to show more awareness of environmental issues, they lack knowledge of definitions of and approaches to

- sustainable development,
- key sustainable development principles and concepts such as the precautionary principle and inter- and intra-generational equity,
- social justice in general,
- and how to deal with stakeholder participation in sustainable development (Azapagic, et al., 1999).

In a recent workshop on engineering design and sustainability, education researchers confirmed that students see the application of tools for sustainability, such as Life-Cycle Assessment (LCA), and the practice of 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, et al., 2009, p. 11).

This book cannot address all of these knowledge gaps; but it hopes to provide plausible answers as to why these gaps exist. We will analyze how traditional engineering design courses might be contributing to these knowledge gaps in Chapter 3.

Exercise 6 *Following Azapagic et al's survey of engineering students (Azapagic, et al., 1999), assess your own knowledge of the following topics related to sustainable development:*

- *Intergovernmental Panel on Climate Change (IPCC)*
- *ISO 14001*
- *Kyoto Protocol*
- *Montreal Protocol on CFCs*
- *Rio Declaration*
- *Eco-labelling*
- *Industrial ecology*
- *Product Stewardship*
- *Tradable permits*
- *Precautionary principle*
- *Inter- and intra-generational equity*
- *Stakeholder participation*

Use a scale of 0 to 4 where 0= not know; 1= know a little bit; 2= know somewhat; 3= know quite a bit; 4= know a lot.

2.8 THE EXPLOSION OF "ENGINEERING TO HELP" (ETH) ACTIVITIES (2000-PRESENT)

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 sustainable development 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, 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, B., 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, J., 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, et al., 2008, p. 5). In short, ETH initiatives have emerged at an opportune 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, J., 1995; Friedman, T., 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, et al., 2009).

Key Terms

North-South Divide (or **Rich-Poor Divide**): Proposed as a more accurate division of the world than the widely (mis)used First-Second-Third Worlds division, this socio-economic division shows the economic gap that exists between the wealthy countries known collectively as "the North," and the poorer countries, or "the South." Although most nations comprising the "North" are in fact located in the Northern Hemisphere, the divide is not only defined by geography but has come to reflect political power in the world stage. The North is home to four out of five permanent members of the UN Security Council and all members of the G8.

Also in the 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, B., 2007, p. 37). Engineers have not remained distant from this exposure and appropriation of images of the poor and dispossessed (See Figure 2.12). 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., number of people without water, number of people earning 1 dollar a day… etc.) and showing pictures of the poor in the South.

Exercise 7 *What underlying assumptions regarding the North's attitude toward people in the South are (explicitly or implicitly) conveyed by the following:*

- *World Vision TV commercials (Search for these at* `youtube.com`*).*
- *EWB Website (See* `http://www.ewb-usa.org/`*).*
- *UNICEF commercials (Search for these at* `youtube.com`*).*

2.9 THE EMERGENCE OF *COMMUNITY* IN SUSTAINABLE DEVELOPMENT AND ETH INITIATIVES

After many years of development failures and the emergence of sustainable development in the 1990s, some engineers and development workers, and even bureaucrats, have begun to recognize the need to engage communities in more inclusive and participatory ways. As we have seen, since

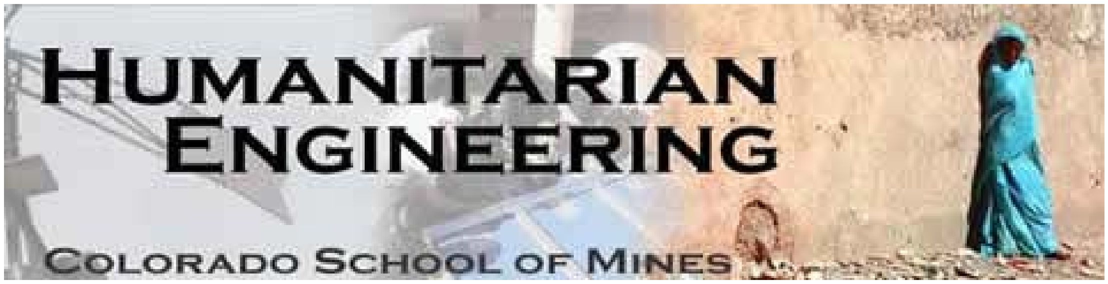

Figure 2.12: The banner of the humanitarian engineering program's website at the Colorado School of Mines shows an image that perhaps needs no explanation since, in the US, we have been socialized by the media to immediately assign meaning to a picture like this. What does this image tell you about the person standing against the wall?
(Source: `http://humanitarian.mines.edu/` Credits: Colorado School of Mines).

the relationship between engineering and development began to take shape in the 19th century, engineering work with local communities has been problematic at best. Throughout most of this history, 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, A., 1995; Heron, B., 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, L., 1987). Some have gone as far as to claim that sustainable development is unattainable without the participation and empowerment of local communities (Blewitt, J., 2008). We explore this relationship further in Chapter 4.

Yet 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. We have come to realize that this history continues to shape many of the practices of engineers in development projects and the approaches that even students take toward communities.

One engineering professor involved in the development of the EWB handbook confirmed this realization when describing the language in the first edition as condescending toward communities, communicating the idea that "we will go and we will teach them [the villagers] how to be sustainable." An article on community service planning for engineering students, published in a journal of a major engineering society and written by a student leader, 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 community development, humanitarian engineering and/or sustainable development 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"). In sum, engineering educators and administrators might be supporting ETH programs and initiatives in order to

- increase student recruitment and retention, particularly of women who seem to demand more that engineering be relevant to societal problems,
- comply with accreditation criteria,
- enhance students' international and team-work experiences,
- and address increasing focus on engineering ethics (Manion, M., 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 the 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.

Sustainable development and ETH programs that do not shine a critical, self-reflective light on their work may risk replicating the dangers found in this historical relationship between engineers and development which, for the most part, has disempowered the communities that engineers were meant to serve. We hope that this book will provide 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 listen to and engage communities in effective ways.

2.10 SUMMARY[3]

Historical period	Engineers' primary emphasis	Engineers' main view of community
Engineers and the development of empires (18th and 19th centuries).	To transform nature into a predictable and lasting machine that could be controlled to ensure their imperial patrons a return on investment and display superiority over indigenous people.	Communities as sources of potential imperial subjects to be organized in ways that made it possible to tax them, convert them to the religion of the empire and often force them into labor for the construction of imperial projects.
Engineers and national development (19th to 20th centuries).	To map territory and natural resources of new countries; to build national infrastructures to connect dispersed populations into a national whole and integrate their productive capacity for national and international markets.	Communities as part of a larger national whole (national subjects) that needed to be brought into functional *order* with other parts of the nation to ensure its *progress*.

[3]These are broad historical generalizations that perhaps apply more to engineers from certain countries than from others. For example, beginning in 1980s concerns about economic competitiveness with Japan were more prevalent among US engineers than among engineers from other countries. See Lucena, J. (2005). Defending the Nation: US Policymaking in Science and Engineering Education from Sputnik to the War Against Terrorism. Landham, MD, University Press of America.

Historical period	Engineers' primary emphasis	Engineers' main view of community
Engineers and international development (20th century).	To develop and modernize the world through science and technology; 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).	Communities as obstacles to "efficient" economic production and mass consumption. Local communities to be convinced, transformed or coerced to join the modernization path by abandoning their subsistence economies, increasing their extraction of natural resources and manufacturing capacity to eventually reach a stage of high-mass consumption.
Engineers and the questioning of technology (the 1970s).	Development engineers focused on providing communities' *basic needs* in shelter, food, and water with the goal of making them productive and incorporating them into the economy.	Communities viewed in terms of what they lacked (*deficiencies*) and humans in terms of basic need parameters (e.g., minimum body temperature; maximum number of days without water or food, etc.).

Historical period	Engineers' primary emphasis	Engineers' main view of community
Engineers and the "lost decade of development" (the 1980s).	Most US engineers began to embrace economic competitiveness as Japan emerged as a technological threat; development engineers engaged in structural adjustment, i.e., expansion of free markets, reduction of government regulations in the marketplace, and encouraging privatization of public services.	Local communities disempowered as they faced the challenges of free-markets under unequal competition and the diminishing of state functions, mainly health, education and other forms of social protection.
Engineers move toward sustainable development (1980s-1990s).	Most in US continued to embrace economic competitiveness; few began to consider sustainable development through a systems approach but mainly in its "weak" form.	Same as in the 1970s and 1980s.
The explosion of "Engineering to Help" (ETH) activities (2000-present).	Most still embrace economic competitiveness; some committed to help the poor and disposed in problematic ways.	Same as in the 1970s and 1980s but with some attempts as incorporating communities through participatory practices.

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