

## The Responsibility of Engineers, Appropriate Technology, and Lesser Developed Nations

Eugene Schlossberger, *Purdue University Calumet, Hammond, Indiana, USA*

---

**Keywords:** appropriate technology, responsibility, engineering ethics, lesser developed nations

**ABSTRACT:** *Projects importing technology to lesser developed nations may raise five important concerns: famine resulting from substitution of cash crops for subsistence crops, the use of products banned in the United States but permitted overseas, the use of products safe in the U.S. but unsafe under local conditions, ecological consequences of technological change, and cultural disruption caused by displacing traditional ways of life. Are engineers responsible for the foreseeable hunger, environmental degradation, cultural disruption, and illness that results from the project? Are engineers guilty of paternalism if they refuse to accept the project for that reason? Criteria are given to help engineers assess the extent of their responsibility when working in lesser developed nations.*

How far does an engineer's responsibility go for the foreseeable long term effects of the projects in which he or she engages? Obviously, engineers who build an unsafe dam bear blame if the dam collapses. But if the engineers build a safe and durable dam, can they be blamed for the dam's remote consequences?

The issue becomes particularly troublesome in Lesser Developed Nations (LDNs), since major technological projects in LDNs often have dramatic long-term effects, both good and ill. Construction of the Aswan High Dam, for example, displaced 120,000 people. Because the dam traps 98% of the silt washing down from Ethiopia and the Sudan, Lower Egypt is no longer replenished by this silt. As a result, Egypt now employs large amounts of chemical fertilizers. Trapping of the silt also led to Nile Delta erosion and reduced the phytoplankton population, contributing to radically reduced harvests in the fishing industry. Reduction in Nile flow permitted ocean

---

Address for correspondence: Eugene Schlossberger, Associate Professor of Philosophy, Dept. of English and Philosophy, Purdue University Calumet, Hammond, IN 46323

Paper received, 10 November 1996; revised, 14 May 1997; accepted, 15 June 1997.  
1353-3452 © 1997 Opragen Publications, POB 54, Guildford GU1 2YF, England

saltwater to back up into the groundwater, a problem exacerbated by intensive irrigation. (Egypt now spends millions on drainage systems to counteract this salinization process.) Rapid increase in the snail population in the lakes created by the dam led to deadly outbreaks of schistosomiasis. Finally, flooding from the dam threatened the rock temples of Abu Simbel. Although this site was eventually rescued, many other archeological sites were lost. On the other hand, the Aswan High Dam provided desperately needed food and hydroelectric power for Egypt's expanding population.<sup>†</sup> In general, without modernization, LDNs cannot provide modern health care. Polio, preventable with a vaccine, claimed 100,000 lives worldwide in 1993. In sum, potential effects of major projects in LDNs range from life-saving to devastating.

When deciding whether to accept such projects, engineers must make some difficult ethical decisions. What long-term effects will the dam project have? To what extent are the project's foreseeable harms the responsibility of the engineer? On the other hand, would refusing the project violate the client nation's autonomy by saying, in effect, "We know better than you do what is good for you?" Could the engineers be blamed for the hardships that result from foregoing modernization (such as a preventable outbreak of polio) if, as a result of their refusal, the project is not built?

### SAMPLE CASE

Addressing these questions is easier with a clear example in mind. Consider the highlands of Kenya, which consist primarily of scattered small villages whose inhabitants engage in labor-intensive subsistence farming. Suppose the government plans to replace those family farms with large-scale coffee plantations employing heavy machinery, pesticides (including DDT) and chemical fertilizers. Since these changes require an extensive irrigation system, the government plans to build a large dam, financed by loans from the International Monetary Fund (IMF). The IMF projects that sale of the coffee on world markets will yield enough money for Kenya to make its loan payments and still buy enough corn to feed the villagers. A firm of US engineers is asked to design the dam and oversee its construction. The firm concludes that the dam can be safely built within budget.

Because the Kenya dam project is a hypothetical example, we may assume (as part of the hypothesis) both that the dam is necessary for Kenya's development as a modern nation and that the project is likely to produce five major effects: 1) the substitution of cash for subsistence crops, 2) the use of products banned in the United States 3) the use of products that are safe in some settings but unsafe under local conditions, 4)

---

<sup>†</sup> <http://arachnid.colgate.edu/jeffo/dams/assfull1.html>; Encyclopedia of World Problems and Human Potential (P J5494) <http://www.uia.org/uiademo/pro/j5494.htm>; Sayed El-Sayed and Gert L. van Dijken <http://www-ocean.tamu.edu/Quarterdeck/QD3.1/Elsayed/elsayed.html>; 1996. World Resources Institute, 1709 New York Avenue, NW, Washington, DC [http://www.wri.org/wri/wr-96-97/bi\\_txt5.html](http://www.wri.org/wri/wr-96-97/bi_txt5.html); Sarawak's Unwanted Huge Dam Panchar Penemu, Sept-Oct Issue, Issue 25 (a bimonthly newsletter), <http://bioc09.uthscsa.edu/natnet/archive/nl/9310/0295.html>.

environmental degradation, and 5) cultural disruption caused by changing traditional ways of life. In short, the Kenya dam has the potential to cause famine, environmental degradation, cultural disruption, and injury or illness, while not building the dam will deny Kenya entrance into the modern world.

The issues raised by this case go far beyond Kenya. The five effects mentioned above surface in numerous engineering projects across the globe. Not all projects in LDNs have these effects. Some projects are fairly benign, but there is often considerable uncertainty involved in predicting the long-term effects of a project. However, the five concerns raised by the hypothetical Kenya dam are sufficiently common that engineers should be aware of them. Therefore, engineers accepting a project in an LDN should scrutinize their project to see if any of these five problems concerning appropriate technology apply. Moreover, the issue of responsibility for long-term effects of a project applies potentially to everything an engineer does. The Kenya dam example is a useful tool in examining an ethical issue that all engineers face to some extent.

## **FIVE ISSUES REGARDING APPROPRIATE TECHNOLOGY**

Five problems concerning modernization in LDNs apply to Kenya's proposed dam project.

### **Replacing Subsistence with Cash Crop Farming**

When families grow crops and live on those crops, food supply is independent of world markets. An LDN is often encouraged to substitute cash crops, such as coffee, for subsistence crops such as corn, since its coffee harvest can be sold on world markets for more than a corn harvest would bring. The government can then sell the coffee and buy corn to feed its people, leaving a small profit to be used to pay back the loans incurred in purchasing technology, such as agricultural machinery or weapons. World markets, however, are not stable. Even when the price of coffee drops relative to the price of corn, the LDN must repay its loans. The remaining funds cannot purchase enough corn to feed everyone. LDNs rarely have sufficient cash reserves or excess harvest to fill the gap. Since people cannot subsist on coffee, tractors, or tanks, famine results. Thus construction of our hypothetical dam may well lead to famine.

### **Products banned at home**

In order to avoid famine, LDNs using cash crops must make enough per acre to buy food and repay debt. Thus it is critical that fields produce the greatest yield at the lowest cost. As a result, LDNs are frequently driven to use products such as DDT, a long-lived pesticide banned in the U.S. that is highly effective in the short run. A

E. Schlossberger

shorter-lived pesticide is more costly since it must be applied frequently, but is friendlier to the environment since it degrades before it accumulates at the top of the food chain (e.g., affecting birds) or spreads to distant parts of the globe. When American farmers use short-lived pesticides instead of DDT, their profit margin decreases. If an LDN uses short-lived pesticides instead of DDT, people are likely to starve. In the long run, of course, DDT decreases yield, since the small number of insects immune to DDT can repopulate rapidly, while birds and other predators cannot. The eventual result, thus, is a large insect population immune to DDT and a decreased population of predators. Yet few governments would choose famine now over the possibility of a greater famine twenty years hence. Construction of our Kenya dam is, foreseeably, likely to lead to the use of products such as DDT.

### **Use of products safe in the United States but unsafe under local conditions**

Pesticides meant to be applied from aircraft by pilots wearing protective equipment are often sold to LDNs without an adequate supply of planes and protective gear, such as gloves and masks. Unprotected workers apply the pesticide by hand, causing significant illness. (In smaller villages the large packages shipped from developed nations are often broken down by hand and sold in available containers, such as old soda bottles.) In the hypothetical example, Kenya cannot afford to purchase sufficient equipment to apply safely the inexpensive pesticides it must purchase to make large-scale farming competitive in world markets. Thus, construction of the Kenya dam will foreseeably lead to illness.<sup>†</sup>

### **Environmental effects of technological change**

The pressure on LDNs to use technologies and techniques that degrade the environment is not limited to pesticides. LDNs need cash and high yields at low cost to avoid starvation. The potentially lower yields or greater cost of farming techniques other than traditional large-scale agriculture make these techniques life-threatening in LDNs, and thus LDNs are prompted to use chemical fertilizers on plowed fields. The resulting run-off, with its rich nitrogen content, threatens the ecology of rivers, streams, and lakes. Overhasty deployment of an irrigation system may cause irreversible drying up of major lakes and rivers.<sup>††</sup>

The only way out of the dilemma is to increase available farmland and/or accumulate sufficient cash for investment in industries that will one day earn enough to provide a safe margin should the price of coffee fall. For this reason, cutting down

---

† An oft-cited example of this sort of problem is Nestle's marketing of powdered baby formula in India. While the formula itself is safe, the local water with which the formula must be reconstituted is often not. Cf. Shaw and Barry,<sup>1</sup> pp. 204-6).

†† The Aral Sea project provides a good example of harm caused by ill-conceived irrigation. See Schlossberger.<sup>2</sup>

rainforests to produce both timber and farmland is perceived as essential to a secure future, as are cheaper, polluting factories. Construction of the Kenya dam is very likely to lead to environmental degradation.

### **Cultural disruption caused by displacing traditional ways of life**

Traditional ways of life frequently center on indigenous technology. The religious and social calendar of a village of family farms often centers on harvest and planting, while family and social structures are often defined by farm ownership. When family farming is replaced by modern industrial agriculture staffed by anonymous employees working for cash, the religion, traditions, and social structure of the village frequently cannot survive. Modern Western culture, based on innovation and disposability, is adept at rapid change and absorbing foreign influences. Deep-rooted traditional cultures, with a strong sense of history, are not. The result is often a cultural vacuum, frequently leading to crime, apathy, and rampant use of drugs. Construction of the Kenya dam is likely to produce cultural disruption.

### **THE ETHICAL PROBLEM**

Because of these potential consequences, building the Kenya dam is ethically problematic: the engineers can reasonably foresee that famine, environmental degradation, cultural disruption and illness are likely to result from their work. On the other hand, there are tangible benefits to modernization, and it is at least arguable that Kenya will be better off, in the long run, with modern technology. There is room for legitimate disagreement about whether, all things considered, the dam would be a boon or a bane.

If the engineers asked to build the dam feel strongly that, all things considered, the harm caused by the dam outweighs the benefits, should they refuse to work on the project? Clearly, an engineer should not sign off an unsafe dam. But the ill effects of this project are tangential, indirect, and the subject of considerable disagreement. Moreover, modernization is more or less inevitable.

In the modern world, it is virtually impossible to maintain a sizable traditional society engaged in subsistence farming for any length of time—the pressures for modernization are too great. For example, a neighboring nation may be persuaded to replace subsistence crops with cash crops in order to purchase military hardware. When famine hits, that nation will be armed and hungry while its unarmed neighbors have food. Thus, to avoid invasion, all the nations in the region must purchase weapons. Again, when one region within a country modernizes, displaced family farmers migrate to the cities, creating a pressing need for additional housing, industrial jobs, and infrastructure, all of which requires cash. Raising this cash requires modernizing other regions of the country.

E. Schlossberger

Does the inevitability of modernization absolve the engineers of responsibility? Are they responsible only for the immediate effects of the dam, or are they also responsible for foreseeable long-term effects of social change? How far does an engineer's responsibility go?

### **ENGINEERS' RESPONSIBILITY FOR EFFECTS OF THEIR PROJECT**

While there is no easy answer to how far the responsibility of an engineer goes, there are ethical factors that can be applied and weighed in a given case. Four ethical considerations are of particular relevance to this case: the utilitarian perspective, respecting others' autonomy, the doctrine of intervening wills, and the duty to leave the world no worse than one found it.

The **utilitarian perspective** suggests that the primary consideration in ethics should be promoting good consequences. While many ethicists argue that utilitarianism is not an adequate and all-inclusive moral theory, even utilitarianism's foes grant utilitarian considerations some importance.<sup>†</sup> Numerous competing versions of utilitarianism populate the literature, but most plausible versions agree that the remoteness of a foreseeable consequence is morally unimportant (except insofar as remote events are less likely to occur): whether an engineer's work harms someone directly, by collapsing, or indirectly, by producing famine, the harm is equally real and thus equally the engineer's concern. However, most versions of utilitarianism would take seriously the inevitability of modernization. Whether or not one agrees to build the dam, famine, environmental degradation, and cultural disruption will occur, and so, for a utilitarian, refusing to build the dam is a pointless exercise. Rather, the engineer should consider whether his or her building the dam is the least bad way in which modernization of the highlands will occur.

The next two concerns stem from the fact that each person is, ultimately, responsible for his or her own life. First, it is important to show **respect for other people's autonomy**, to allow other people to make for themselves major decisions about their own lives. Engineers who refuse to build the dam out of concern for the foreseeable consequences are, in effect, denying the people of Kenya the ability to decide for themselves (through their government) whether the benefits of the project are worth the foreseeable harms.

On the other hand, even when we are not entitled to prevent other people from harming themselves, we should, in general, avoid helping them do it. While ripping the cigarette out of the hand of a 40 year neighbor recovering from lung cancer violates her autonomy, assisting and encouraging her smoking is morally unsavory. "If she is going to kill herself," one might say, "she must do it without my help." Similarly, an engineer may feel ethically uncomfortable about assisting the people of Kenya in harming themselves.

---

<sup>†</sup> Kant, for example, thought that utilitarian considerations are relevant when duty is not involved.

Moreover, respect for autonomy has limited application. Small children lack the maturity and knowledge to make certain kinds of decisions for themselves so, for example, parents are entitled forcibly to prevent their seven year old children from dropping out of school or hitchhiking across the country. Yet the young children of Kenya will suffer if the dam is built. Engineers might thus refuse to build the dam out of concern for the infants of Kenya, whose autonomy is not a relevant issue.

However, responsibility for the welfare of the children of Kenya, it might be argued, rests with the parents and government of Kenya, not with engineers in the United States. Difficult issues arise when adults disagree about a child's welfare, as our courts have discovered when adjudicating cases concerning the education of religious fundamentalists' children, blood transfusions for children of Jehovah's Witnesses, etc. Parent-centered views emphasize the autonomy of parents in raising their children, while society-oriented views emphasize the fact that children should not be victims of their parents' unwise decisions. The issue is further muddled in this case by the fact that two societies are involved, the society of Kenya and the society of the engineer asked to build the dam. Even if "it takes a village to raise a child," which "village" should take charge? Further discussion of autonomy may be found in Sartorius<sup>3</sup> and Kleinig.<sup>4</sup>

Finally, autonomy-related questions concerning a risk include:

- 1) do those who bear the risk receive the benefit?
- 2) do those who bear the risk do so voluntarily?
- 3) are those who bear the risk aware of the full extent of the risk?

In this case, the risk is borne mostly by the highlanders of Kenya. Will they receive the benefits of modernization, or will the benefits accrue mostly to the wealthy? Is the government of Kenya democratically elected, or is the decision to modernize one in which the people of Kenya had no voice? If the government is democratically elected, did the voters have an opportunity to become aware of the risks of modernization? The answers to these questions are relevant to an ethical engineer's decision. Further discussion of these three questions may be found in Schlossberger.<sup>2</sup>

Another ethical consideration stemming from people's autonomy is **the doctrine of intervening will** (*novus actus interveniens*). The idea behind this doctrine is simple. If Jones throws a stone at a window, Jones is responsible for breaking it. But if Jones says something that makes Smith angry, and, in his anger, Smith throws a stone at a window, it is Smith who is responsible for breaking the window, not Jones. Even if Jones knew that her remark would prompt Smith to throw stones, it was Smith's decision to throw the stone. More technically, a person is not responsible for the effect of her action when another person's will (freely) intervened between her action and the effect. In the example above, Jones is not responsible for the effect (the broken window) of her action (making the remark) because Smith's will intervened—Jones' remark led to a broken window only because Smith freely chose to throw a stone. Similarly, it may be argued, the engineer who builds the dam is not responsible for the

famine, environmental degradation, cultural disruption, or improper use of pesticides that may result, since the free will of people in Kenya intervenes between these effects and the construction of the dam.

As a universal doctrine, the doctrine of intervening will is surely false. For example, the doctrine of intervening will says that if Jones asks Smith to murder her aunt, Jones is not responsible for her aunt's death, since Smith freely chose to kill her.<sup>†</sup> Nonetheless, the doctrine of intervening wills makes a valid point. People can't be blamed for everyone else's wrong decisions. If, on the witness stand, I tell the truth and testify that I saw Jones kill Smith, a member of organized crime, in self-defense, I am well aware that Smith's organization will almost certainly kill Jones in retaliation. I know that my testimony will cause an innocent person (Jones) to die. But organized crime is not my fault, and I cannot be blamed for telling the truth on the witness stand. By way of contrast, should I seek out a member of organized crime and gratuitously tell him what I know, Jones' family would be justified in resenting me.<sup>††</sup>

While there is no clean line to be drawn, four factors may be articulated: 1) Is the activity that foreseeably leads to harm one that I am morally entitled to do? To avoid blame, I must have clean hands. After all, I am not morally entitled to ask someone to kill my aunt, while I am morally entitled to answer truthfully a question on the witness stand. 2) Does the activity have an important point and purpose other than the foreseeable harm? There is a good reason to tell the truth on the witness stand, a reason quite independent of organized crime's desire for revenge. Similarly, the pursuit of knowledge constitutes a good reason to publish one's research, even if one foresees that other people may misuse and misrepresent the data. By contrast, there is no good reason to seek out and inform organized crime that Jones killed Smith. 3) How severe, widespread, and likely is the foreseeable harm resulting from one's action? Publishing data that one knows will result in the end of life on earth is inexcusable, however scientifically valuable the data might be. 4) How important is the activity that leads to the harm? How much will one suffer by abstaining from the activity? Refusing to tell the truth on the witness stand, for example, renders one liable to incarceration, a serious harm. By contrast, one loses nothing by keeping quiet instead of seeking out organized crime.

In this case, building the dam is not, in itself, an unethical activity. However, there is no independent reason for building the dam—the only reason for building the dam is that a dam allows large-scale agriculture, with its foreseeable benefits and harms. The foreseeable harm of the project is severe, likely, and widespread, but possibly offset by compensating benefits. The harm to oneself from refusing the project is loss of income. How great a harm this turns out to be depends on the financial situation of the

---

† Donagan<sup>5</sup> deals with cases of this sort by claiming that the doctrine of intervening will does not apply to voluntary or involuntary agents of an actor. This move raises further problems about who counts as an agent. In any case, an example not employing an agent is given below.

†† Note that, in this case, organized crime is not acting as my agent.



firm: a prosperous foreign firm will suffer less harm by turning down the project than a struggling local firm. In sum, the application of the principle of intervening wills to this case depends on how much the firm needs the business and how much one thinks the harms outweigh the benefits. Further discussion of the principle of intervening wills may be found in Donagan<sup>5</sup> and Feinberg.<sup>6</sup>

The fourth ethical consideration concerns each individual's **duty to leave the world no worse** than he or she found it. We each, as individuals, have a responsibility to ensure, to the best of our abilities, that what we do in life does not make the world a worse place, that the world is not the worse for our existence. However, when a particular harm is inevitable, one may help bring about the least bad form of that harm. In such a case, although one is helping to make the world a worse place than one found it, the result will be less bad than it would have been without one's intervention. A more detailed discussion of this principle, its rationale, and its exceptions may be found in Schlossberger.<sup>2</sup>

This principle suggests that engineers asked to build the dam should refuse the project if they feel that, all things considered, building the dam would make the world a worse place than it was before. Engineers who feel that the effects of the dam's construction are so harmful that they outweigh the benefits should, thus, refuse the project. On the other hand, if the harms are inevitable, if the engineers' building the dam produces harms no worse than would occur anyway, the engineer may feel justified in choosing the "least bad" scenario. Thus the extent and inevitability of the harms become deciding factors.

## CONCLUSION

When participating in projects in LDNs, engineers must consider the long-term effects of the technological changes resulting from those projects. Modernization confers the benefits of technological advance, but may lead to famine, environmental degradation, cultural disruption, and illness. When deciding whether to participate in such projects, engineers must weigh these long-range benefits and harms. In addition, engineers should consider whether they adopt a parent-centered or society-centered view of responsibility for children, as well as the extent and inevitability of the harms, whether the project is, in itself, a defensible project, whether the project has a purpose independent of the foreseeable harms, how much the firm needs the business, whether those who bear the risk reap the benefits and undertake the risks voluntarily, and whether the risks are known to those who bear them.

While there are generally no easy answers to these questions, they are questions an ethical engineer must address.

E. Schlossberger

## REFERENCES

1. Shaw, A. & Barry, V. (1989), *Moral Issues in Business*, 4th ed., Wadsworth, Belmont, CA.
2. Schlossberger, E. (1993), *The Ethical Engineer*, Temple University Press, Philadelphia.
3. Sartorius, R. (1983), *Paternalism*, University of Minnesota, Minneapolis.
4. Kleinig, J. (1984), *Paternalism*, Rowman and Allanheld, Totowa, NJ.
5. Donagan, A. (1977). *The Theory of Morality*, University of Chicago, Chicago.
6. Feinberg, J. (1970), *Doing and Deserving: Essays in the Theory of Responsibility*, Princeton University, Princeton.