8. Urban Vulnerability and Technological Hazards in Developing Societies

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Introduction

This paper deals with the question of urban vulnerability and technological hazards in developing societies. It could be questioned if this is a significant focus. The available statistics would not seem to support such a contention. For example, since 1950, only 13 acute chemical disasters in developing countries have resulted in more than 100 fatalities or 1,000 injured, and they include some major ammunition explosions (Cutter 1991). The figures, while undoubtedly underestimating those sudden technological disasters that have produced few fatalities or casualties, do not suggest a major overall problem. Put another way, the highly visible chemical poisoning that killed at least 2,000 people, made tens of thousands ill, and made Bhopal (India) a household word for toxic crises (Bogard 1989) is atypical. Few technological disasters have occurred in cities, and their effects have generally been similar to those of the chemical explosion in Port Kelang, Malaysia, in 1980, which killed three, injured about 200, and forced the evacuation of about 3,000.

Even if the focus were broadened to include more diffuse and slower-moving kinds of events, the picture would change little. Some mass human poisonings from toxic chemicals have not been widely noticed: (a) 10,000 people in Morocco in 1959 suffered from cooking oil contaminated with degraded lubricating oil, (b) 50,000 people were affected in Iraq in 1971 from exposure to methylmercury, and (c) 7,500 people were made ill in Pakistan in 1976 from a misuse of the insecticide malathion (see Weiss and Clarkson 1986: 217). Such incidents have affected mostly rural populations, and in all have not involved high absolute numbers of different incidents.

Thus, it cannot be said that technological agents are currently major sources of many disasters in urban areas in the developing world. The consequences of technological accidents that occur pale in significance to the consequences of natural disasters that recurrently devastate communities and whole societies in Latin America, Asia, and Africa—which have affected more than 900 million people, caused over 3 million deaths in two decades, and in 1990 alone produced at least US$45 billion of property damage and economic losses (Krumpe and Sullivan 1991: 1). This, however, is a short-sighted view of technological disasters. The future will not simply be the past revisited; it will get worse.

A major finding of disaster studies is that crisis-relevant organizations tend to look at the last, biggest emergency or disaster that happened in their jurisdiction. Such an event is usually viewed as most probable to occur, as well as the kind of disaster for which there should be planning. Societies and communities that take this unwarranted stance may suffer its dysfunctional consequences (for an example, see Forrest 1979).

This kind of thinking is not peculiar to crisis-relevant government agencies. The nondisaster organizational literature indicates that most companies and industries tend to look to the past to plan for whatever they will undertake. Studies, however, also conversely show that the more successful firms are those that look to the future. Such companies and industries almost always have strong research and development programs that project into the future and plan to meet upcoming needs.

Usually, too, social science researchers are asked to say something *after* problematical issues emerge in an area. They often look at recognized difficulties—those already in existence—and indicate the nature of the difficulties and how they might be dealt with.

However, another major responsibility of scientific research is to look into the future and say something about yet unrecognized issues—those that are latent and not yet fully manifested. Thus, this paper focuses particularly on urban vulnerability and technological hazards in developing societies. In coming decades, cities in such societies will suffer not only more, but worse technological disasters. This paper documents why this will be the case.

Discussion will center on disasters that result from accident, failure, mishap, or misuse of some kind of technology—particularly those crises generated by the threat of or the actual impact of relatively sudden technological disasters (brought on by such agents as toxic chemical spills, radiation fallouts, explosions and fires, structural failures, transportation wrecks and crashes). Thus, the observations may have to be selectively qualified for their applicability to related kinds of crises that entail slower-moving or highly diffuse agents (for example, those in social occasions, such as toxic poisonings through hazardous wastes, radiation contaminations through radon gas, air degradation from automobile and industrial emissions, and water pollution episodes through the misuse of pesticides). Crises arising from social conflicts that may have a technological component—such as in wars, riots, revolutions, terrorist attacks, acts of sabotage, and product tampering—will not be discussed. Despite occasional claims that they are the same (e.g., Meyers 1991), such conflict situations last much longer and affect a much wider scale than the typical natural or technological disaster; they are also driven by an explicit intention to do harm to other parties.

All social crises have certain characteristics in common. Thus, many observations about technological disasters should apply across the board. The problem in extrapolating these observations is that presently, because of the research base used, we cannot clearly discern what is generally applicable across all crises or what is only partially applicable or not at all applicable in the slower-moving or conflict-type disasters.

For purposes of this paper, it will ignore the growing argument among disaster theorists that all disasters can be attributed primarily to human and group actions and decisions, and that there is no distinction between "natural" and "technological" disasters per se that is particularly significant for general planning or managing purposes. (See, for example, Wijkman and Timberlake 1984; Quarantelli 1987 and 1991b; Bolin 1988; Smith, North and Price 1988; Stallings 1988; Mitchell 1990; and Rochford and Blocker 1991. For a contrasting view, see Baum, Fleming, and Davidson 1983; and Kroll-Smith and Couch 1991.) Some aspects of natural disaster planning in developing countries have been discussed elsewhere (Quarantelli 1990), and an earlier, unpublished paper for the World Bank examined major institutional and organizational aspects of natural disaster recovery in developing countries. Some of the observations made and implications drawn will be partly revisited in the present discussion.

The existing social science research literature—somewhat uneven, but nonetheless fairly extensive—has been used for the present analysis. (For English language sources on field work studies done up to 1979, see Quarantelli 1984a; for the work done in Japan up to 1979, see Yamamoto and Quarantelli 1984; for an inventory of research findings, see Drabek 1986 and Kreps 1991.) For this paper, examples and statistics are drawn from the various cited sources—especially from publications listed in the extensive annotated bibliography on hazardous materials disasters by Hughes (1991). Most of the unreferenced illustrations and figures are drawn from earlier works of the author (Quarantelli 1991b, 1991c, and 1991d), as well as from some unpublished material from the work of the Disaster Research Center (DRC), which alone has made over 530 field studies of disasters and mass emergencies, of which about a third are technological in nature.

This paper will discuss the social factors directly involved in bringing about more and worse technologically derived disasters in the future in metropolitan areas in developing countries. For the most part, the focus will be on the more immediate or proximate factors, which exist within a larger social macroscopic context. The implications of these factors, however, will be considered only in the section on recommendations for policy and planning.

This paper focuses on developing societies and uses as many examples and data from them as could be found. However, a major thrust of the thesis is that if developing countries follow the industrializing and urbanizing paths of developed societies, they will produce at the very least the same kinds of problems, risks, hazards, and disasters. Thus, in some instances, examples and data are used from Western-type societies to suggest what the future might bring for developing societies.

Developing societies can be characterized in many ways. For purposes of this paper, however, they all exhibit varying degrees of two trends—movement toward becoming industrialized and toward becoming urbanized social systems. Accompanying these processes, however, are other social features manifesting more and more the characteristics of developed societies at the macro level, since there is a perceptible but slow and uneven movement toward a "world society" and global culture (see Smelser 1991).

For example, as part of the trend toward industrialization, developing countries have been adopting cultural values and beliefs that emphasize economic growth, the productivity of goods, and the increase in national wealth and international competiveness. This orientation is based on improving technology and its extensive application in all spheres—agricultural, industrial, and informational, as well as the service sector. The continuing drive toward technological growth and application means an acceleration of long-standing trends toward complexity and differentiation in social structure, which will mostly be handled by bureaucratic organizations.

These related features are paralleled by the growth of a cluster of others associated with the second major process—that of urbanization—which is resulting in ever-growing urban centers in developing societies. This includes an increasing pressure toward democratization (identified by de Tocqueville as a driving force in the West in the nineteenth century, but now very prevalent in developing countries). This social inclination also embodies a drive for the rights of citizenship, inclusion, and participation in the polity, equality, justice, and adequate welfare provisions (see Meyer, Boli, and Thomas 1987). Of course, many of the characteristics exist far more as surface symbols than in actuality in many developing societies. For example, little modern technology is really used, and there is no real political democracy in place. Nonetheless, the cluster of features associated with industrialization and urbanization are factors in the social systems involved.

These factors—as well as the more proximate ones discussed in this paper—affect the appearance, characteristics, dynamics, planning, and management of disasters. Any full understanding of what will happen requires taking into account both the indirect background factors and the more immediate ones. However, this paper focuses primarily on the more immediate factors, particularly the increase in technologically risky agents and the ever-growing hazards of modern city living.

Since we are looking for disaster-related problems associated with continuing industrialization and urbanization in the developing world, this paper will discuss mostly the negative and problematic aspects of the two processes. This necessarily ignores the more positive features that are also the consequences of industrialization and urbanization in developing societies. It could easily be argued that if on balance there were not more favorable or positive effects than unfavorable or negative ones, then the processes would eventually come to a halt, if not reversed. This should be kept in mind in reading what follows.

The next section discusses the socially generated increases in technological disaster agents and occasions that certainly can be expected in the future, some that are already occurring, and others that are yet to appear in full form. There simply will be more risks that can turn into hazards and disasters as a result of the industrialization that is going on. The section on the urbanization process describes some of the more social characteristics and processes of urban life in developing countries. Vulnerabilities that stem from the urbanization process generally magnify the negative impacts of technological disasters. The section on recommendations for policy and planning discusses the disaster planning that would be necessary and desirable to have in place to deal with technological disasters in cities in developing countries. Community mitigation, preparedness, emergency response, and recovery planning are separately examined (see McLoughlin 1985 for distinctions between the four). Almost all consequences of disasters are worse in developing societies because of the different evolutionary path that industrialization and urbanization follow in such social systems compared with that of the West.

The paper concludes with some policy and program recommendations for developing countries and the World Bank. The focus is on setting forth appropriate relevant policies and implementing good disaster programs.

Trends in technological hazards

Almost all developing countries are attempting to build domestic industries, particularly building manufacturing plants in cities. This effort primarily involves borrowing and using the various technologies that have transformed Western societies in the last 150 years, essentially introducing in the productive activities of the society a variety of machines powered by newer inanimate sources of energy such as coal, electricity, petroleum and natural gas (Lenski, Lenski, and Nolan 1991: 225). That there has been a measure of success in the effort at industrialization is partly indicated by the fact that in the last 40 years, the combined gross domestic product of developing societies has increased more than 500 percent compared with 300 percent for developed countries (Lenski, Lenski and Nolan 1991: 236). But even in the West, the

> . . . activities associated with industrialization—the discovery and invention of new energy sources together with large-scale production and storage requirements; the establishment of transportation modes, haulage routes and depots; the need for disposal of unwanted or unintended wastes; increasing amounts and danger of atmospheric pollutants; the development of mass passenger transit sources, networks and stations—...produced conditions which, albeit inadvertent by-products of the push for 'progress', jeopardized public safety and increased community vulnerability to a range of hazards. (Britton 1991b: 1)

While this statement was made of developed societies, it can be applied equally to developing countries.

1. The accelerating increase of technological accidents and mishaps that began four decades ago—particularly in the chemical and nuclear areas—will generate more and worse disasters.

The efforts of developing countries to industrialize by adopting modern technology—whatever the genuine gains in the standard of living—will be at a price. The history of the West strongly indicates what is likely to occur. To the category of natural hazards has been added a relatively newer category of technological accidents and mishaps. These are the disasters resulting from human errors and collective mistakes of groups in the technological area (see Lagadec 1982 and Perrow 1984), which did not occur on any significant scale before World War II. To the "Acts of God," the human race has now added the "Acts of Men and Women."

The advent of this change has been described in various ways. An Australian disaster researcher wrote the following:

> In many respects, technological hazards are a relatively new class of danger to which contemporary society is only just beginning to face up. Disaster wrought by the unintended consequences of technology has largely been a

> product of the large-scale industrial developments instigated by the eighteenth century 'industrial revolution'. Mishaps associated with technology have occurred ever since the first implement was developed by a human. However, the scale of consequences, in terms of social disruption and the threatening of the social infrastructure, did not reach conspicuous proportions until the development and concentration of large industrial complexes to mass produce a myriad of goods.

He notes the following in developed societies:

> As pre-conditions for disaster, however, their significance has not penetrated the collective consciousness to the point where they have sufficiently influenced specific thinking and subsequent practices of relevant public sectors such as emergency services agencies, land-use and planning departments, environmental protection bureaus, or occupational health and safety branches. (Britton 1991b: 1-2)

The above observation was written about developed societies. However, if there is little sensitivity to the probability of technologically generated disasters in such social systems, there is clearly even less in developing countries, perhaps because in many such societies, there has not yet been the massive technological growth and associated risks Britton mentions. There is actually little reason to believe that as developing social systems move increasingly toward urbanized and industrialized patterns, they will show much greater awareness of the technological hazards. The paper will discuss the awareness of the risks involved and the difficulty of implementing relevant disaster planning policies.

The major technological threats have emerged in the chemical and nuclear areas. The manufacture, processing, transportation or distribution, storage, and the application or use of many products of these two areas are inherently hazardous, almost ensuring more and more worse disasters.

Chemical Hazards

The chemical industry is massive. In the United States alone, it generates over US$200 billion a year and manufactures tens of thousands of different chemicals annually, with more than 20,000 of them produced in amounts exceeding 1,000,000 pounds every year. Thousands of new chemicals are created every year adding to the more than four and half million types currently registered by *Chemical Abstracts*. These created substances have truly transformed the world and modern societies are impossible without them; their use reflects a widespread desire to have higher standards of living and particular lifestyles that otherwise could not be achieved. The technology of chemistry has not imposed itself on the human race; it has been consciously developed and applied because of the perceived and actual substantial benefits involved. Modern lifestyles are impossible without a chemical industry. Thus, it is not surprising that in a country like India it has become a US$20 billion-a-year industry that accounts for 10 percent of the Gross National Product and 40 percent of the nation's gross industrial output. (Ramasubramanian, Mitra, and Bandopadhyay 1987: 180).

The chemical industry, however, is not a totally benign enterprise. Multiple risks are associated with producing, transporting, storing, and using, and disposing of dangerous chemicals (U.S. law identifies over 1,000 of them as hazardous; see Pavia 1990: 2). The heterogeneity of the threats is not always recognized. In the instance of chemicals we have references to substances that can be liquid, gas or solid; we are talking of material that can explode, burn, asphyxiate, poison, corrode, and otherwise damage and destroy property, lives or the environment. Or put another way, there are multiple ways in which human and other organisms, plant life and fauna, and physical material objects can be destroyed, damaged or other directly negatively affected by a dangerous chemical. In short, a chemical emergency or disaster can involve many perilous happenings unlike a typical earthquake or a volcanic eruption. The referents of the term "chemical hazard" are multiple (Quarantelli 1991a: 53).

Even in the developed world, it has taken time for recognition of the existence of such threats. Although the first systematic social science study ever undertaken was of a munitions explosion from a ship collision in the harbor of Halifax, Canada, in 1917 that killed nearly 2,000 people and destroyed a two square mile area (Prince 1920), when we started research about 40 years ago, chemical disasters were simply not mentioned as a major or frequent risk. Some work on isolated instances of such disasters was finally undertaken starting in the early 1960s by DRC; similarly, a major fire at the refinery at Feyzin, near Lyons in 1966 also led to a pioneering French social science study, see Chandessais 1966. But highly systematic and continuing research did not occur until DRC launched a massive three-year research effort in 1978 that looked at local preparedness for sudden chemical emergencies in 19 communities, and studied 20 actual chemical disasters in the United States and Canada (see Gray and Quarantelli 1981).

Since those studies, existing statistics show that the incidents of chemical emergencies and disasters have continued to increase around the world. For our purposes, several interesting aspects of their more recent appearance as socially problematical issues should be noted.

It is said that "geophysical hazards are neither uniformly distributed in space nor in time" (Wallis 1989: 295). In one sense, this is relatively less true of technological hazards. Thus, even localities that in the past had none or few risks from natural disaster agents, are now vulnerable if they have any roads, railways, or navigable waterways in the vicinity of toxic chemical spills, explosions, or fires. To some extent, the growth of major transportation infrastructures has partly reduced the geographic selectivity of possible disaster impacts. Almost any inhabited areas of societies have now become vulnerable to disasters from hazardous chemicals even though there be no manufacturing, storage or use facilities in the vicinity. Not all developing societies or communities within them are subject to major natural hazard threats; but now many more are likely to be increasingly subject to risk as dangerous chemicals are more and more moved around.

Furthermore, the threat of greater disasters of this kind is increasing because of the greater amounts of dangerous material involved. For instance, from 1960 to 1980, not only has the number of seagoing tankers carrying petrochemicals doubled, but their shipping tonnage has expanded sevenfold. Economic considerations are leading to the use of ever larger tankers. So, increasingly, there is something bigger to spill, explode, or burn on waterways as illustrated by the Amoco-Cadiz oil spill off the Brittany coast and even more dramatically the Exxon Valdez oil spill near Alaska. Port cities in developing countries are going to have this risk.

Moreover, not only are there more trucks on the roads then ever before (e.g., 413,000 tank trucks regularly transport hazardous materials in bulk in the United States), but they are increasingly larger. There as been the advent of double and triple length trucks. Furthermore, at any given time around 10 percent of all trucks on roads will be carrying some hazardous materials. But "with the large number of trucks on the roadway system, an accident involving the release of dangerous substances is inevitable" (Kozub and Stone 1990: 1).

While the just cited statistics refer to the United States, there is every reason to think that the riskiness of truck transportation in developing societies is almost certainly higher, given the training of drivers, road construction, safety measures in loading, etc. In fact, a recent USAID analysis of seven road projects they had supported overseas found that both routine maintenance and preventive periodic maintenance were recurrent problems (Wunsch 1991: 6). While this was said mostly about rural roads, as will be noted later, city streets are not necessarily better treated. In any case, even as early as 1958, seven trucks loaded with dynamite exploded in a slum and squatter area in the center of Cali, Colombia, demolishing around 2,000 buildings and killing about 1,200 people, the second largest total after Bhopal of dead in developing countries from a nonammunition explosion (Cutter 1991: 276).

It might be argued that there has been only one Bhopal scale type disaster so far in developing countries (and only one Seveso scale type in developed societies). But it will be astounding if we do not have others eventually. Now the safety and accident prevention programs of the chemical industry in many developed societies are elaborate and impressive (see Quarantelli 1984b). Moreover, according to the National Safety Council, for example, in the United States the chemical industry yearly has the lowest serious accident rate—deaths and days away from work among 42 reporting manufacturing industries. But the safety programs and the accident picture is far less positive in developing countries (see Shrivastava 1987). Furthermore, the indiscriminate or inappropriate deployment of chemical technology as well as the mismanagement of complex technologies creates numerous hazards in such social systems (Bowonder and Kasperson 1988: 104).

In addition, the multiplicity and range of what can go wrong in the chemical area has so increased, that statistically there is increasing vulnerability in all societies. (A good and detailed description of the multiple things that went wrong at Bhopal is given in Bowonder, Kasperson, and Kasperson 1985). In view of all this, not surprisingly, some scenarios for an LPG explosion in or near a major port area in Southern California have projected casualties of 70,000 and US$325 million of property damages (Bahme 1978: 189); a similar risk analysis around even more densely populated seaport urban areas in many developing countries would undoubtedly project even higher figures.

Additionally, to the in-plant and transportation kinds of acute chemical types of disasters, have been added the more slowly developing and diffuse types associated with hazardous waste sites (see Peck 1989), which sometimes necessitate relatively quick emergency responses. Love Canal and Times Beach in the United States are examples of disasters expected more frequently in the future.

Developing countries will not only have the chemical risk problems that have appeared in developed countries, but additional ones. They are not likely to be able to create as effective safety and accident prevention programs for their own industries as has been done in the West, and they also are recipients of hazardous industrial wastes from developed societies. As such, it must be anticipated that they will have future chemical disasters. Furthermore, while chemical hazards are more randomly distributed than natural disaster agents, they are nonetheless more likely than not to be in urban areas because of the location of plants, storage depots, and user industries.

Nuclear hazards

The nuclear power industry was developed because initially it seemed to offer a relatively dependable and inexpensive source of energy, especially for industrial expansion. Certainly it seemed so compared with other energy sources, such as oil, which was judged to be eventually depletable and increasingly costly to obtain. Unlike the chemical industry, the nuclear industry has a much shorter history: less than half a century.

Inherent major risks, however, are associated with nuclear power. Particularly with the accidents at Three Mile Island and Chernobyl, it has increasingly come to be seen as a source of danger. For instance, in June 1987, a retiring member of the Nuclear Regulatory Commission predicted a 45-percent chance of a meltdown in a nuclear plant somewhere in the United States within the next 20 years (James K. Asselstine, quoted in *The New York Times*, June 7, 1987). This possibility exists not only in the United States: in February 1991 at the nuclear power plant in Mihama, Japan—one of 40 in the country—after tons of mildly radioactive water poured into the steam generator, "an emergency system flooded the reactor to prevent a meltdown" (Sanger 1991). Such an event would probably have made the negative effects from Chernobyl pale in comparison, since—contrary to popular and official thinking—Chernobyl was far from a worst-case scenario.

> More important for us is the following: an increasing number of developing countries are embracing nuclear power to gain greater economic independence and to achieve a permanent relief to their worrisome balance of payment and foreign debt burden, which is aggravated by their continuously increasing need for imported energy. Attesting to this is Cuba's aggressive nuclear program—two nuclear power plants under construction and two [under] planning . . . nuclear power will reduce Cuba's heavy need of imported energy and her dependence on Soviet oil and economic aid . . . . India, another developing country, has recently announced that 32 new nuclear reactors will be operating by the year 2000.

In fact,

> This emerging phenomenon among the developing countries prompted the IAEA [International Atomic Energy Agency], in 1986, to establish the Senior Expert Group to assist developing countries in the promotion and financing of nuclear power programs . . . . Also, according to a study . . . of the IAEA, developing countries' present share of the world's installed nuclear power plants is 7.1 percent. A total of 21 developing countries either have nuclear power plant(s) in operation, or have plants in the construction or planning stage . . . . This number will certainly increase at a "modest rate" in the future.

The report goes on to note the following:

> Based on a recent estimate by the IAEA, nuclear energy production will grow an average of 2.8 to 3.9 percent per year, worldwide from 1989-2005 . . . . The estimated average range of annual growth rates of nuclear power production for developing countries in the Middle East and South Asia (combined), and Latin America are 19.5-24.2 and 12.8-16.5 percent, respectively (Meshkati 1991: 134-135).

Larger global events and trends may affect what will occur. For example, the disintegration of the Soviet Union and the Eastern European bloc with its accompanied by the elimination of aid and oil to certain developing countries, could work both ways with respect to establishing a nuclear power industry. The loss could undermine efforts to set up nuclear plants, or it could spur attempts to create national independence on outsiders.

Apart from in-plant nuclear plant problems, risks are associated with the transport of nuclear wastes over long distances, including the increasing byproducts of the deactivation of nuclear plants. In the United States, by the year 2000, there will be about 47,900 metric tons of spent fuel, compared with 12,900 tons in 1985, to be shipped to some deposit. In addition, there will be hundreds of shipments of military generated radioactive material. In 1979, there were 1,904 separate shipments totaling about 25 tons. Finally, hazardous wastes will be associated with the closing or deactivation of nuclear plants, some of which are now reaching the end of their lifetimes. The material will have to be transported from many places to some chosen sites, which naturally raises the probability of some accident. As developing countries increasingly adopt nuclear power, and to the extent that they become recipients of nuclear wastes (some nations ship their nuclear wastes overseas), the risks of transporting such wastes will increase, primarily in urban areas.

With 435 commercial nuclear plants in existence at the start of this decade and with nearly 100 more under construction (Meshkati 1991), the problems will not go away by themselves. Because nuclear power is politically so controversial, its use has been slowed around the world. However, this energy source, which has a number of significant advantages compared with other sources, will continue to entice some developing societies.

A highly problematical area has been overlooked: There are at least several dozen nuclear power and weapons facilities in existence; some developing countries will likely build more. These facilities, often close to urban areas, have been plagued in the United States by a series of technical and process failures that "make some of the errors in the civilian nuclear reactor program appear benign" (Hohenemser, Goble, and Slovic 1990: 196).

2. Some technological advances reduce hazards, but add complexity to old threats.

Of course modern technology can and is used to try to eliminate or reduce some risks. The medical health area is marked by any number of such successful efforts. Unfortunately, sometime the positive consequences are accompanied by negative effects of a different kind. There are two aspects to this: (a) preventive or protective measures that indirectly lead to other kinds of possibly disastrous occasions, and (b) the scale of chain reactions possible in modern societies that, as a result of network linkages, can turn a minor emergency into a major disaster.

An example of the first is that fires in high-rise buildings, in combination with the highly combustible and toxic construction and furnishing materials presently used, have brought an additional threat dimension to that kind of situation. People are prevented from being burned by raising the probability of their being asphyxiated. The MGM Hotel fire in Las Vegas several years ago, which killed 85 and injured more than 600, is an example of what is more likely to occur in the future (Best 1982). Apart from that, the very heights of buildings can create protective and response problems. Some spectacular fires in high-rise buildings in Brazil and South Korea a few years ago indicated this emerging possibility in developing countries as they build ever taller structures in urban areas. The 1974 fire in Sao Paulo in a 25-story building killed 189 people.

Lee Thomas, a former Federal Emergency Management Agency official and later the head of the U.S. Environmental Protection Agency, said the following:

> It is entirely possible that somewhere in the country toxic metals are being removed from the air, transferred to a waste water stream, removed again by water pollution controls, converted to a sludge, shipped to an incinerator and returned to the air. (*New York Times*, May 11, 1986)

He is pointing to the fact that many technologies that reduce or prevent the development of certain kinds of risk or environmental threats do so with solutions that often generate their own dangers or hazards.

In fact, at times the hazard is merely redirected elsewhere. For example, laws have been passed in developed countries to prevent industries from discharging any constituents into surface waters. Businesses have frequently met this requirement by building large surface impoundment containers to hold wastes. But the impounded material often results in air discharges through evaporation and groundwater discharges through leaching. Thus, the initial problem is primarily deflected elsewhere (Williams 1991: 73). In meeting the Clean Water Act of 1972 in the United States, the wastewater treatment of sewage was found to lead to the production of sludge that contains viruses, toxic substances, and heavy metal. Sludge can be treated, but methane gas and carbon dioxide will frequently be produced. Production of such gases in turn probably contributes to global warming, which can lead to changing climatic and agricultural patterns, and which could contribute to melting polar ice caps and subsequently raising ocean levels. This last point is controversial, although if accepted, flooding could occur in seaport cities such as Bombay, Rio de Janeiro, Manila, and Shanghai (Cohen 1991: 93). Hence, an initially good measure may set off a chain reaction of bad effects. To the extent that developing countries apply such Western technologies to reducing risks, they will ultimately have the same negative balance of hazards and dangers as Western nations.

Even plane crashes show similar bad effects arising from initially good measures. Research has shown that the ensuing fires generally kill more passengers than the crash itself. Eighty percent of those who die from the fire actually succumb to the gas and smoke produced by the more economical, lightweight cabin material as it burns (FAA, Airline Industry 1987: 7). The airlines of developing countries buy almost all their planes from developed countries. In addition, for various reasons, plane crashes are proportionately more likely to occur in airports in such countries, which tend to be located in or near urban areas. However, given the overall advantages of air travel and transport, especially for an industrial society, the developing world is likely to use this form of modern transportation increasingly.

Now the linkages between events that may have ultimate negative effects can be even more direct. This is because as technologies are elaborated and enlarged to meet the economics of scale, a small mishap at one point can bring down the total network or system. It has sometimes been noted that small scale failure can be produced very rapidly, but that large scale ones can only be produced if large amounts of time and resources are involved.

For example, there have always been, since their coming into being, accidents and failures in electric power systems. In fact, outages occur on a small scale almost every day even in developed societies. They are recognized as such, and coped with as normal emergencies by the public utilities. However, the 1965 blackout in the northeastern United States suggests how, in the modern world, large areas of a country are vulnerable to electric grid system malfunctions. Nothing of this magnitude has occurred recently, although New York City had major power blackouts in 1977 and 1989, as well as all of France in 1978 and Brittany in 1987 (Lagadec 1990: 107). They have been relatively minor compared with what could happen, given the extensive grids and networks that are involved. Not only can something in a distant place have local effects, but the complicated linkages almost ensure that sooner or later, there will be large-scale effects. Of course we are assured in the United States that such a crisis as that of 1965 cannot happen again; but then, before that, we also had similar assurances.

Presently, many developing countries have serious trouble with their urban telephone and electric power systems. Outages and "brownouts" are everyday occurrences in many cities. As in the West, in a partial and reasonable effort to reduce such problems, developing countries are linking these systems into larger grids and networks. These linkages will probably reduce routine emergencies somewhat, but they almost ensure a large-scale disaster because of the possibilities of chain reaction inherent in the use of larger-scale, linked technologies.

Perhaps many of the potential problems are summarized in a statement by an expert on telecommunications networks, the core of which tend to be located in cities. He stated:

> My basic message . . . is quite direct. First: Our public switched networks are becoming more vulnerable to disruption because of the introduction of new technologies. Second, because of economic incentives to cut the costs of normal commercial operations today's networks are being designed without sufficient attention to emergency preparedness. Third: Accidents, disasters and attack threaten tomorrow's networks with more extensive damage than they did yesterday's integrated network. Fourth: Our Information Society relies absolutely on smoothly functioning communication networks and thus the consequences of network failure are more severe (McDonald 1989:4-5).

This is more than a possibility. In 1991, eleven major phone system outages affecting major metropolitan areas occurred just in the United States alone. In the report accompanying those figures it is noted that: "modern fiber optics carry 10,000 times more calls than the old copper cables they replaced. An accidental cut of a single fiber optics can cut off entire metropolitan areas" (Lee 1991: 8).

There are many positive consequences of most technological advances. They may also set the stage for disastrous occurrences. To the extent that developing societies move to use modern technology to reduce risks along certain lines, they will probably increase hazards along other lines, and hence multiply negative effects.

3. New versions have developed from old or past dangers.

Certain dangers have been around for centuries. However, in modern societies, the risks involved have taken on new forms as large cities have evolved. Inevitably these kinds of communities require elaborate lifeline systems that are the actual physical or mechanical infrastructures on which they rest. For a small village, a well or two can provide the necessary water. For metropolitan areas, on the other hand, distant reservoirs, dams, pumping stations, pipelines and gauges, monitoring points, and other technological apparatuses linked together in complicated ways are needed to generate and distribute the water. This can create new versions of old or past dangers.

For example, increasing chronic water shortages are affecting many societies, including developing ones. This is partly related to the great need for water to support the process of industrialization. A recent report of the Worldwatch Institute noted that besides parts of the western United States:

> Many areas could enter a period of chronic shortage during the '90s, including northern China, virtually all of northern Africa, pockets of India, Mexico, much of the Middle East . . . . Where scarcities loom, cites and farms are beginning to compete for available water. (Postel 1989: 1)

Droughts used to be thought of as mostly a rural problem. This is no longer the case. Increasingly, urban and metropolitan localities around the world are faced with shortages or reduced water supplies. In part, this is because their populations and manufacturing activities require larger per capita quantities of water than in rural areas (Jones 1991:19).
In particular,

> . . . freshwater resources are being used up at such rapid rates that groundwater supplies are dwindling and surface waters are fouled with pollutants from industries, municipalities and agriculture. In much of sub-Saharan Africa, the Middle East and parts of Asia, water consumption will reach 30-100 per cent of available reserves in 10-15 years—a result of population growth and inefficiencies in use (*Population and the Environment* 1991: 5)

So far in America, the drought emergencies have been coped with by reducing industrial water usage, but in coming years there will be a disaster if a major section or all of an urban area runs out of water or has enough only for the most crucial of water needs. This kind of crisis is most likely to occur in combination with the collapse of a major tunnel, pumping station or other critical facilities of a water supply system. In the Western world, there are the risks associated with a deteriorating physical and public works infrastructure of lifeline systems in a large number of older cities. The prevalence of decaying bridge and tunnel structures, crumbling highways, obsolete and overloaded wastewater and sewage treatment plants, worn-out sewer and water mains, aging subway systems and stations, and outdated pipeline networks suggest a variety of many potential disastrous possibilities beyond the isolated and occasional accidents of the past (for the existing hazards of this nature in New York City, see Sims 1991: 6E). Bridge collapses in 1983, 1987, and 1989, as well as major water main breaks in several U.S. cities, and the Kings Cross underground station fire and the Cannon Street train crash in London—all happenings in the last few years—are forerunners of more such disasters in the future.