TABLE OF CONTENTS

I. INTRODUCTION

The conditions associated with disastrous occasions in developing societies are the focus of this paper. Our emphasis is on future rather than current or past conditions. While social scientists tend to explain past situations, they also have a responsibility to look into the future and to project what will happen in both the short and long run. A true social science approach must not only provide an adequate accounting of what has happened, but it should also forecast generally what is likely to occur. Historical explanations of the past that provide understanding are useful, but analyses that provide knowledge of the future can be undertaken and are more worthwhile. While the past can not be undone, the future can be affected if what is known is applied in acts and policies.

There is an additional reason for taking this point of view. This is because on the global scene we are inevitably faced with more and worse disasters in the future. Irrespective of whether the agents involved be natural or technological, there will be both quantative and qualitative increases in the negative direction for all societies. This will result from two social trends—industrialization and urbanization—inherent in the very dynamics of societal life anywhere but especially prominent in developing countries. The first tendency insures that disastrous agents and occasions will increase. The second trend is raising the risks and vulnerabilities of possibly impacted populations and societies.

II. CURRENT SOCIAL TRENDS

It is very safe to say that although the 21st Century is only a few years off that its social landscape and features will be rather different from that in which we are living in the 20th Century. What is in place now and was in being in recent past decades will be rather different in coming years.

Massive social changes are happening in the political, economic, familial, cultural, educational and scientific areas. These are not only occurring in the developed societies, but also in the developing nations of the world and in Eastern Europe too in the wake of the disappearance of the Soviet Union. The most important structures and activities of human life are drastically changing. This can be seen in many ways. As examples, we can note the new family and household patterns that are emerging, the basic alterations occurring in the role and status of women, the move almost everywhere to a market type economy to produce goods and distribute services, the spread of at least nominal democratic patterns of government, the growing dominance of non-traditional artistic and musical forms as well as a globalization of popular culture, the escalating use of computers and related means for training and educating people, and the growing diffusion and expanding use of applied social science to many areas of life.

Given such existing trends, the developing societies of the 21st Century will mostly have cultural values and beliefs which will primarily emphasize productivity of goods, economic growth, national wealth and international competiveness. This orientation is based on improving technology, especially in its machine aspects, and its application in all spheres: agricultural, industrial and informational. The continuing drive towards technological growth and application means an acceleration of long standing trends towards structural differentiation and complexity which are mostly to be handled by bureaucratic organizations, increasingly centered in urban localities. This will also be accompanied by increasing pressure towards democratization which includes a drive for the rights of citizens, inclusion and participation in the polity, equality, justice, and adequate welfare provisions. Many of these tendencies are further fostered by their presentation in ever more global mass communication systems that are constantly expanding their abilities to expose their contents to world wide audiences through a variety of advanced electronic and high tech means (for a further discussion of future trends, see Smelser, 1991).

Collectively these world wide changes will affect the appearance, characteristics and dynamics of disasters, and the planning and managing of them everywhere. However, we want to single out two of these social trends because they particularly will influence the numbers and kinds of disastrous occasions that will happen.

The two, while not new, are nevertheless massive in their social effects and accelerating in their recent manifestations. They are the ever increasing <u>industrialization</u> as well as the quickening of the <u>urbanization</u> process in most developing societies.

Industry with its accompanying distinctive kind of technology is spreading everywhere. For example, while in 1888 the five most highly industrialized societies were responsible for 83% of the world's industrial production, a century later the output of the top five was only 57% reflecting the continuing diffusion of industrial technology throughout the world (Lenski, Lenski and Nolan, 1991). This trend has been paralleled by an ever swelling involvement of populations in an urban way of life concentrated in constantly enlarging metropolitan areas. Thus by the year 2010, there will be 511 cities exceeding a million inhabitants each and for the first time in history the world population will be predominantly urban, 51.8%; 15 years later, there will be 639 metropolises of over a million persons (Jones, 1992).

These two interrelated trends or processes, industrialization and urbanization, will have consequences for disastrous occasions. They insure we will have both more and worst disasters. Built into the very dynamics of social life as they are, industrialization and urbanization will of necessity quantatively increase and qualitatively worsen the disastrous occasions of the 21st Century.

In the next two sections of this paper we illustrate and explain why this will happen. The evidence and data base we use do not come from any specific study. Instead they are derived from the corpus of the social science literature on disasters (for summaries see Lagadec, 1982, 1990; Covello and Mumpower, 1985; Drabek, 1986; Dynes, De Marchi and Pelanda, 1987; Quarantelli, 1988; Auf der Heide, 1989; Mitchell, 1990; Drabek and Hoetmer, 1991; Kreps, 1991; Britton and Oliver, 1993; Burton, Kates and White, 1993; and Cutter, 1994), as well as general sociological analyses of social change and trends (Bell, 1973; Harrison, 1988; Lenski, Lenski and Nolan, 1991; Perrow, 1991; Smelser, 1991, 1994; Crook, Pakulski and Waters, 1992; Sztompka, 1993; and Kumar, 1994).

Since we are interested in the disaster-related aspects associated with continuing and increasing industrialization and urbanization, we will discuss mostly the negative and problematical outcomes of these two processes of social development. This of necessity ignores the more positive features that are also the consequences of an industrial technology and an urban way of life. It could be easily argued that if on balance there were not more favorable or positive effects than unfavorable or negative ones, the processes would eventually come to a halt, if not reverse.

III. INCREASES IN DISASTER AGENTS AND OCCASIONS

3.1 There are escalating kinds of technological accidents and mishaps that were relatively non-existent prior to World War II and that will increasingly result in disastrous occasions.

To the threat of so-called natural hazards we have been adding at an accelerating rate a relatively newer risk, those stemming from technological accidents and mishaps (for an annotated bibliography see Hughes, 1992). We are faced with ever more disasters in the technological area resulting from human errors and collective mistakes of groups (Perrow, 1984). To the "Acts of God", have been added at an escalating rate the "Acts of Men and Women" or "Society". These technological hazards are a relatively newer class of danger which the contemporary world is only beginning to fully recognize. Disastrous occasions brought about by the unintended consequences of technology have largely been a product of the large-scale development of industry initiated by the 19th century European industrial revolution. Of course, what has been in being in developed societies for some decades now, is rapidly occurring at present also in developing social systems.

Obviously, mishaps associated with technology have occurred since the first tool was produced by a human being. However, in terms of social disruption and the damaging of the environment, the scale of consequences began to reach significant proportions only with the appearance of large industrial complexes to mass produce myriad goods (Britton, 1991: 1-2). And especially dramatic catastrophes such as a Bhopal or Chernobyl have come to be symbolic of a far larger threat beyond the immediate event (see Wilkins, 1986).

The growth and activities associated with industrialization--the invention of new energy sources together with large-scale production and storage requirements; the creation of complex transportation modes, haulage routes and depots; the need for disposal of unwanted wastes; increasing amounts of and dangers from atmospheric pollutants; the development of mass transit modes, networks and stations--have produced environmental conditions which more and more jeopardize public safety and enlarge community vulnerability. Thus, any increase in industrialization creates greater risks and eventual disastrous occasions.

The major newer current technological threats are in the chemical and the nuclear area. The manufacture, processing, transportation or distribution, storage, and the use of many products of these two areas are inherently hazardous. They almost insure quantatively more and qualitative worse future disastrous occasions.

a) The chemical area.

Chemicals have 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 which otherwise could not be achieved. The technology of chemistry has been consciously cultivated and applied because of the perceived and actual benefits involved. This is true not only in developed but also developing societies, as indicated by the fact that in a country like India the chemical industry has become a 20 billion dollar a year industry that accounts for 10% of the gross national product and 40% of the nation's gross industrial output (Ramasubramanian, Mitra and Bandopadhyay, 1987: 180).

But as Bhopal showed, there are multiple risks associated with the production, transportation, storage and use of dangerous chemicals for there are multiple ways in which human and other organisms, plant life and fauna, and physical material objects can be destroyed, damaged or negatively affected. A chemical emergency or disaster can involve many perilous consequences for the environment. The referents of the term "chemical hazard" are many.
Analyses of accidents in petrochemical plants, gas processing plants, terminals and related facilities in the United States are not reassuring. For example, the number of plant emergencies has:

> [been] increasing at a high linear rate over the last thirty years. In fact, the number of these accidents has almost quadrupled during this time period...the cost of these same plant emergencies [adjusted for inflation] has been escalating apparently at an exponential rate over this thirty year time frame...this means that every day, the problem is getting worse at a faster and faster rate. This is a very frightening trend which appears to indicate that our technology is getting out of control (Sullivan, 1993: 1)

As others have indicated (e.g., Dwyer, 1991), workplace accidents and errors are symptoms of some of the dysfunctional aspects of complex, modern organizations. However, there is every reason to believe that such mishaps are also becoming a problem in those countries that are industrializing. As an example, in August 1993, a series of explosions shook the city of Shenzhen in China killing at least 70 and injuring hundreds. The first explosion was set off by a leak of nitric acid from a warehouse for hazardous materials. The fire from that blast then ignited a nearby natural gas plant and in the next several hours eight more warehouses in the area exploded (Kristof, 1993: A3).

Important is the fact that even localities which in the past had none or few risks from natural disaster agents, now are vulnerable if they have roads, railways or navigable waterways in the vicinity of toxic chemical spills, explosions, or fires. In a sense, the creation of major transportation infrastructures reduces the geographic selectivity of possible disastrous impacts. All inhabited areas have now become vulnerable to threats from hazardous chemicals even though there be no manufacturing, storage or use facilities in the vicinity. Not all communities are subject to major natural hazard threats; but now almost all are at risk as they are increasingly subject to dangerous chemicals being more and more moved around. In Cali, Colombia, seven trucks loaded with dynamite exploded in a slum and squatter area in the city center, demolishing around 2,000 buildings and killing about 1,200 people, making it the second largest total after Bhopal of deaths in developing countries from a nonammunition explosion (Cutter, 1991: 276). Even when there are no casualties, a great number of people may be at risk; for example, a toxic sulfur trioxide release in New Delhi, India forced around 100,000 to evacuate (Cutter, 1991: 280).

Furthermore, the threat of greater disasters of this kind is spiraling 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 French coast, the famous <u>Exxon Valdez</u> oil spill off Alaska, and more recently the <u>Aegean Sea</u> tanker oil spill and fire in December 1992 at the harbor of La Courna, Spain, a city of about 250,000 people.

In addition, to the in-plant and transportation kinds of <u>acute</u> chemical hazards types of disastrous occasions, there are the more slowly developing and diffuse types associated with hazardous waste sites. Seveso in Italy and Love Canal and Times Beach in the United States are examples of what we may expect more in the future. In fact, the Seveso Directive issued by the Council of European Communities accepts the probability of such future disasters by setting forth as legal policy the idea that citizens must be adequately informed of the nature of and extent of existing hazards, the planning measures being undertaken, and what might be expected of a disastrous occasion. In the former Soviet Union one estimate is that over a million residents live in contaminated areas, the 300 towns and cities where chemical weapons were once produced, stored, tested or destroyed (Shargorodsky, 1993).

Finally, there are the threats associated with more diffuse and slower moving kinds of incidents. In particular some mass human poisonings from toxic chemicals especially in developing countries have not been widely noticed. For example, 10,000 Moroccans suffered when they ingested cooking oil that was contaminated with degraded lubricating oil; 50,000 people were affected in Iraq from exposure to methylmercury; and 7,500 persons were made ill in Pakistan from a misuse of the insecticide malathion (see Weiss and Clarkson, 1986: 217). There is no reason to think that there will not be such happenings in the future.

b) The nuclear area.

The nuclear power area is another increasing source of danger. It has less than a half century existence. But it was developed because it initially seemed to offer a relatively dependable and inexpensive source of energy for industrial expansion, compared with other energy sources such as oil which was seen as eventually depletable and increasingly costly to obtain. A move in the direction followed made much economic sense. In fact, a number of developing countries are still continuing to build nuclear plants.

However, the risks associated with the development of nuclear power has been exemplified first by Three Mile Island, then Chernobyl. We may expect more along those lines given that there are over 435 commercial nuclear plants in existence at present, and about 100 more under construction (Meshkati, 1991). In fact, in 1992 in a nuclear plant at Mihama, 70 miles from Tokyo, Japan, a reactor core meltdown was only aborted by the last emergency shutdown mechanism in place. It should be noted that such a happening would pale the negative effects of Chernobyl, which contrary to much popular and even official thinking was far from a worst case scenario.

Apart from in-plant nuclear plant problems there are the risks associated with the transport of nuclear wastes. In the United States alone, by the year 2000, there will be about 47,900 metric tons of spent fuel, compared to 12,900 tones in 1985, to be shipped to some deposit somewhere. In addition, in the long run the dozens of societies that presently have nuclear plants will eventually be faced with the problems stemming from their necessary shutting down. The large volumes of radioactive wastes resulting from the dismantling of such nuclear facilities will pose problems of disposal. Keeping the reactor fuel in storage tanks near the plants as is currently done involves possible leaks or spills (Wald, 1993: 1) which newspaper headlines in the United States such as the following indicate have already begun to be a problem:

> Reactor Fuel Storage Tanks Deteriorating. Report Says Radioactive Waste Has Begun To Leak (Wilmington News Journal, December 8, 1993: 4).

That this is not a purely academic issue is indicated by the recent disclosure of a not widely known disaster in the former Soviet Union in 1957. That year, a tank of radioactive waste exploded at a weapons plant near Chelyabinsk, spewing 70-89 tons of waste. At least 270,000 people are estimated to have been exposed to the cloud. While even now few of the negative consequences are known, it has been reported that as a result of the ensuing contamination, 23 villages were razed, over 10,000 residents were permanently resettled, and 17,000 acres of farm land were turned into a nature preserve (Monroe, 1992: 535-6; see also, Medvedev, 1979)

Eventually too, the presently stored material is going to have to be transported from many places to some chosen sites, and naturally that raises the probability of some accident in all societies involved in such transportation (this is complicated by the fact that some European nations ship their nuclear waste overseas to developing countries). In addition, there is the military related problem in a few countries of dealing with the highly radioactive materials that have to be handled and that also accumulate from the increasing decommissioning of nuclear submarines, the dismantling of nuclear weapons, and the closing of nuclear weapon plants.

3.2 There are technological advances that reduce some hazards but add complexity to old threats.

Without doubt modern technology can be used to try to eliminate or reduce some risks. The medical health area is marked by any number of such successful efforts. In fact, some agents in the past such as yellow fever which produced disasters (e.g., Bloom, 1993), have been for all practical purposes eliminated as major threats. Similarly smallpox epidemics no longer occur (Hopkins, 1983) which in certain past time periods were responsible for one death out of every five (Duncan, Scott and Duncan, 1993: 406).

Unfortunately, sometime positive consequences from technological applications are accompanied by negative effects. There are two aspects to this: (1) preventive or protective measures which indirectly can lead to other kinds of risks, and, (2) the scale of chain reactions possible which as a result of network linkages can turn a minor emergency into a major disastrous occasion.

Fires in high rise buildings is an example of the first. In combination with the highly combustible and toxic construction and furnishing materials presently used, they have brought an additional threat dimension to that kind of situation. Buildings are prevented from being burned by raising the probability of their inhabitants being asphyxiated (in addition, the very heights of buildings can create protective and response problems as seen, for example, in some spectacular fires in skyscrapers in Brazil and South Korea a few years ago, and in Nigeria in early 1993).

Technology sometimes is directly used in efforts to improve safety and reduce the possibilities of accidents and mishaps. This is a laudable effort but not necessarily always achieved. This can partly be seen in the following quotation from Lee Thomas, a one time head of the US Environmental Protection Agency. He said:

> 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 some technologies that reduce or prevent the growth of certain kinds of risk or environmental threats do so by solutions that can generate their own dangers.

As another example, in the United States it has been found that to meet the Clean Water Act of 1972, the waste water treatment of sewage can lead to the production of sludge which will contain viruses, toxic substances and heavy metal. The sludge can be treated, but this frequently produces methane gas and carbon dioxide. The latter additionally may contribute to the greenhouse effect which is warming the earth, which can lead to changing climatic and agricultural patterns, and may contribute to the melting of the polar ice caps and the subsequent rise of ocean levels. This last is a very controversial point, but if valid, it indicates the probable flooding of many seaport cities around the world such as Manila, Shanghai, Bombay and Rio de Janeiro (Cohen, 1991: 93). So, an initial good measure may set off a chain reaction of bad effects (see Williams, 1991: 73).

But the linkages between happenings which 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 often been noted that while small scale failure can be produced very rapidly, large scale ones can be generated only if large amounts of time and resources are involved. For example, there have always been electric power system failures; 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. But not only can something in a far distant place have local effects, but the elaborate linkages almost insure that even in societies where the power supply is normally dependable eventually there will be large scale effects as in the widespread blackout in 1965 which occurred in southern Canada and the northwest United Sates, and in France in 1978 and the province of Brittany in 1987 (Lagadec, 1990: 107). In fact, in October 1992, eight of the eleven states in Malaysia and a third of Singapore concurrently lost electricity in an interrelated massive power failure in the two Asian countries.

Massive glitches that impair telephone systems are also becoming increasingly common in many societies. In 1984, such a system outage in Tokyo, Japan affected 89,000 subscribers and cost around 300 million dollars. In 1991, eleven major phone system outages affecting metropolitan areas occurred just in the United States alone. In the report accompanying those figures it is noted:

> modern fiber optics carry 10,000 time more calls than the old copper cables they replace. An accidental cut of a single fiber optics can cut off entire metropolitan areas (Lee, 1992: 8).

Many potential problems are summarized in a statement by an expert (McDonald, 1989) on telecommunications networks. He notes that the switching networks are becoming more vulnerable to disruption because of the introduction of new technologies. Because of economic incentives to cut the costs of normal operations, networks are being designed and established without sufficient attention being paid to emergency preparedness. Accidents threaten the integrated networks of tomorrow with more extensive damage than they did yesterday's simpler network. Thus, as the societies of the 21st Century including developing ones increasingly rely on highly integrated communication networks, the consequences of network failure will be more severe (see also Physical, 1990).

As an example we might cite figures from a recent incident in Hinsdale, Illinois where a fire disabled a major Bell Telephone switching center in the Chicago area. This telephone outage as a result of its links to computers affected both voice and data communications for more than a half million residents and business customers in six metropolitan suburbs for periods ranging between two days to three weeks. In addition, local and long distance communications for both telephone and computer networks were also severely affected since the Hinsdale center affected was an aggregation point for major telecommunications links. The outage:

> affected the normal operations of dozens of banks, hundreds of restaurants dependent on reservations, three large catalogue sales companies...about 150 travel agencies, most of the paging systems and cellular telephones in the affected area, and hundreds of businesses located in the area or others not located in the affected area but conducting business with those that were...At present, a conservative estimate for the business losses and the repair costs of the accident are set at $200-300 million (Pauchant, Mitroff, Weldon and Ventolo, 1990: 244).

3.3 New versions have developed of old or past dangers.

Certain particular forms of danger have been around for centuries. But in the modern world, the versions of the risks involved have taken new forms especially as large cities have come into being. Inevitably these kinds of communities require elaborate lifeline systems or complex physical or mechanical infrastructures. For a small village, a well or two can provide the necessary water; for metropolitan areas, distant reservoirs, dams, pumping stations, pipelines and gauges, monitoring points, etc. linked together in complicated ways are needed to generate and distribute the water. This can create new versions of old or past dangers.

For instance, increasing chronic water shortages are affecting many societies, including developing ones. This is partly related to the great need for water to support the industrialization process. 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, cities and farms are beginning to compete for available water (Postel, 1989: 1)

Droughts used to be mostly a rural problem. This is no longer the case. It was reported in November, 1993 that the water supply of Athens, Greece had fallen so low that severe rationing would have to be quickly imposed if rainfall did not soon increase (Quinn, 1993). Increasingly in different parts of the world, urbanized localities are finding themselves faced with shortages or reduced water supplies. In part this is because their populations and manufacturing activities require substantially larger per capita quantities of water than in rural areas. In particular:

> freshwater resources are being sued 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 (Jones, 1991: 19).

This situation appears to be coming to the fore in China:

> Water supplies are drying up under the relentless demands of new industries, population and agriculture. Of China's 500 cities, 300 are short of water and 100 are seriously short. More than 80 million people have to walk more than a mile for drinking water (Tyler, 1994: E4).

Moreover, additionally there will be an acute disastrous occasion in the future if an urban area runs out of water or has enough only for the most vital of water needs. This 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.

This last probability is escalating because of a deteriorating public works infrastructure of lifeline systems in a large number of older cities in the Western world. The prevalence of decaying bridge and tunnel structures, crumbling highways, obsolete and overloaded waste water and sewerage treatment plants, worn out sewer and water mains, aging pipelines initially put in place for an expanding industrial sector, suggest many potential disastrous possibilities beyond the isolated and occasional accidents of the past. A flood in the downtown area of Chicago in 1992 as a result of the collapse of a 100 year old underground freight tunnel is a specific case in point. It resulted in a major electric power cutoff shutting down the Board of Trade with a resulting loss of billion of dollars in trading, and leading to the evacuation of department stores and hotels, and disrupted businesses for weeks.

Put another way, these problems are starting to appear because the physical infrastructure involved is reaching the end of its normal lifetime. One can project that this will also become a problem for urban areas in developing countries compounded by the fact that there is reason to believe there is even less maintenance and accident prevention measures for the urban lifelines in them than exist in developed societies. This is illustrated by the major failure in 1989 of a pipeline in Russia which killed at least 575 persons, as well as the explosion of a natural gas pipeline in 1984 in Gahri Ohoda, Pakistan which killed 60 people, and the explosion at the liquid petroleum gas plant at San Juan Ixhuatepec near Mexico City in the same year which forced several hundred thousand of nearby residents to evacuate and killed several thousand people.

None of the disasters likely to occur from these factors are totally new in the geophysical or physical sense, but they represent new versions of old threats, either because of where they could occur or the large scale nature which they can assume.

3.4 There is the emergence of new kinds of technological accidents and mishaps that can and will lead to disastrous occasions.

a. Inventions and advancements in computer technology.

A major new threat that is surfacing is associated with all the disastrous consequences that will come from the computer revolution that human society is presently undergoing. Use of computers undoubtedly have improved disaster planning and managing, as well making life easier for most of us in many ways. But our increasing dependence on computer technology will magnify future disastrous occasions and turn some minor emergencies into major crises. This is particularly true in that many governmental and business sectors are increasingly computer based for the data and information they need to function, sometimes literally from minute to minute. Thus:

> It is...estimated that more than 85% of the largest firms in the US are totally or heavily dependent on computer technology and that, on average, a business would lose 25% of its daily revenue after the sixth day of its system breakdown, while this figure is close to 40% for the financial, banking and public utility industries (Pauchant, Mitroff, Weldon and Ventolo, 1990: 254)

These figures are for the United States but comparable figures could be found for countries in Western Europe. To the extent that developing countries move to computerize their businesses and industries, and there are many advantages to doings so, they will also increasingly become vulnerable to computer failures.

Now it can be predicted with certainty that computer systems and their networks will, cease to function, or function incorrectly (and we leave aside deliberate sabotage by the use of computer viruses). We will then have a really new kind of disaster--a computer disaster, with all kinds of negative chain reactions of an economic and social nature. The Hinsdale occasion we discussed earlier is but a simple example of the complex disastrous occasions that may stem from partial failures of computer networks.

b) Biotechnological advances.

There are also going to be disastrous occasions that will be produced by developments in biotechnology, especially genetic engineering. Basically, this technology involves altering the blueprint of living organisms--plant, animal or human--and creating new characteristics, some of which are very useful (e.g., various kinds of oil and chemical waste eating bacteria have been created that can be used to help clean up spills!). However, there clearly are all kinds of potential disastrous possibilities with this kind of technology. There can and will be the creation of or the escape from control of some altered organism that cannot be checked by presently known means. Our ability to custom design living organisms almost insures that one day there will be some almost Frankenstein-like bacteria, plant or animal let loose on the world.
Of course there are constant assertions about the safety of the process. Thus, a National Science Foundation report stated:

> There is a broad consensus among biologists that R-DNA techniques are safe...basic and applied scientists generally agree that many contemplated introductions are either virtually risk free or have risk-to-benefit ratios well within acceptable bounds...no hazard particular to genetic engineering has yet surfaced (quoted in Schmeck, 1987: 7).

The term R-DNA is the scientific shorthand label for recombinant DNA, the technical name for the process of rearranging genetic material-DNA-or combining genes from diverse sources.

But as was written in a letter that same year:

> The advocates of recombinant DNA technology claim that it is safe because they cannot see how a disaster would occur and because no disaster has ever happened yet. That amounts to saying that the technology is as safe as the Titanic, the Chernobyl nuclear reactor or the space shuttle (Robert J. Yaes letter in 1987 The New York Times).

Such assertions of absolute safety of course reminds some of the statements issued by the Atomic Industrial Forum just a few months before the Three Mile Island nuclear plant accident, namely:

> Nuclear power plants are designed and built to withstand every conceivable Acts of God--and some inconceivable ones as well (quoted in Chronicle of Higher Education, 4/1/79, p. 20).

We are confident in making the assertion that biotechnology will similarly bring us a major catastrophe sooner or later. In fact, just as the 1970s was the time when the world became aware of nuclear power threats, the 1980s of the chemical hazards risks, the decade of the 1990s could very well be when we will have a Chernobyl or Bhopal-scale like biotechnological disaster.

Actually a forerunner of what could occur in the biotechnological area is suggested by a related although slightly different kind of disaster in 1979. In that instance, biological toxins were accidentally released at a Soviet research center. Probably 1,000 workers were killed and a 20-square mile area around the city of Svardlovsk was contaminated by the release of highly toxic anthrax spores. To the extent that any country anywhere in the world sets up facilities for biotechnological purposes, it will create risks in the production, storage, transportation, distribution and use of the products involved (see the discussion of future biological hazards of all kinds by Bradford and her colleagues, 1993).

3.5 There will be an increase in multiple or synergistic type disastrous occasions resulting in more severe impact consequences.

Little recognition has been given to the fact that natural disasters will increasingly generate or magnify concurrent technological ones. Increasingly so, because of the accelerated production, transportation and storage of hazardous substances of all kinds, natural disaster agents which in the past would have simply been natural disasters can now create technological ones.

There already have been instances of this. For example, the inundation of chemical plants occurred in the 1993 midwest American floods. An earthquake in Ecuador triggered massive landslides that destroyed six miles of the Trans-Ecuadorian pipeline, shutting off the flow of 250,000 barrels per day resulting in lost revenue and reconstruction costs of perhaps one and half billion dollars (Eguchi and Seligson, 1993: 80). The convergence of a tornado and a radiologically active cloud could pose a very threatening situation. But something of this kind already occurred in 1961 when windstorms spreading radioactive material (plutonium and strontium) in the Lake Karachay region increased by about 30 to 50% the land area previously contaminated by an earlier nuclear disaster in Russia. The initial technological disaster was magnified by a later natural disaster agent (Porfiriev, 1992). Also, the dumping of radioactive wastes into Lake Karachay and several artificial reservoirs created to contain them had negative effects when droughts impacted the area. Thus:

> droughts occurred in 1967 and 1972, exposing dried former shoreline of the lake, allowing the wind to scatter radioactive particles. In 1967 particles...were strewn over an area of 2,700 km2, raining down upon 63 settlements and 41,500 people. The combination of the Techa dumping, the Kyshtym cloud, and the droughts are believed to have exposed over 400,000 people to radiation and to be the cause of at least 935 diagnosed cases of chronic radiation illness in the Chelyabinsk region (Monroe, 1992: 538)

Not often noticed is that this process can also go in the other direction. Several examples can be cited. It has long been known, for instance, that the injection of fluids into the soil to recover oil and dispose of waste can trigger surface land faulting. In 1963, this led to the collapse of a dam, the emptying of the Baldwin Hills Reservoir and some deaths and property loss in metropolitan Los Angeles (Hamilton and Meechan, 1971: 333). Or the building of dams for the purpose of creating reservoirs to impound water for residential or industrial uses may also set off earth tremors. In one of the least seismic areas of the world, a reservoir behind Koyna Dam appears to have triggered a series of shocks that devastated Koyna Naga, India in December, 1967 killing 177 residents, injuring around 2,300 and damaging or destroying most of the buildings in the community (Earthquake, 1972).

There is another possibility on a larger scale (the relation between weather and disaster agents which we will discuss later). But for an example here, an MIT study recently said that continuing pollution of the air could result in stronger hurricanes. According to this research, continued air pollution that increase carbon dioxide levels might make some hurricanes stronger in the next century. If the atmosphere's carbon dioxide content doubles, the maximum possible intensity for hurricanes could rise to 40 to 50 percent generally, and 60 percent in the Gulf of Mexico. This last example suggests that not only are disaster agents and occasions increasing, but that because of human and group behavior, there will be an enlargement of social risks and vulnerabilities in the future, a matter which we will now discuss.