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I. SUMMARY

This short paper will provide an introduction to the synergistic linkages between natural and technological disasters and make a plea for a new conceptualization of disaster to accommodate the environment as a stakeholder in disaster management. The issue of risk assessment in technology and disaster policy assessment is examined from an environmental perspective. Four basic conclusions are stressed:

- that there are often close synergistic links between natural and technological disasters (known as Na-Techs)
- that disasters need to be more widely managed on a multi-hazard, multi-agency basis
- that more consideration needs to be given to the environmental implications of disasters and more research undertaken to improve environmental risk assessment methodology and application.
- that Na-Tech disasters need to be assessed in the context of sustainable development

II. INTRODUCTION

A recent report by the Center for Risk Management from the US based Resources for the Future (RFF) organization found that since the end of World War 2 over 1200 natural disasters have killed more than 2.3 million people around the world and caused widespread damage and economic losses. Since 1945, some 300 major industrial accidents have killed over 15,000 people. (Glickman, Golding and Silverman 1992). The report found that natural disasters are more significant than technological accidents as a source of human suffering. Natural disasters;

- occurred four times more frequently than major industrial accidents
- took over 150 times as many lives each year
- claimed over 30 times as many lives per event. (Glickman, Golding and Silverman 1992)

Such statistics perhaps go someway to explain why the Decade was named for "Natural Disaster Reduction"; however, recent research has shown the need to consider technological disasters as well as those of natural origin. Many countries are industrializing rapidly - some would say too rapidly - and the rising trend of chemical and industrial accidents in the developing world has overtaken natural events as the prime disaster scenario for some nations. As an example, a UN Disaster Management Team found that large parts of the Thai population are subject to greater danger to their health and safety from emergencies involving hazardous substances than from natural hazards.(UN Working Group on Disaster Management 1993). To provide an indication of how the need for an effective mechanism to cope with technological hazards increases, when the Ontario provincial Spills Action Center was established in Canada in 1985 it responded to 9,000 calls during the first year of operation. By 1992, the same Center dealt with 14,600 calls, resulting in 5,000 active interventions. (Belling 1994).

For the purposes of this paper the term "disaster" is used with reference to impact rather than causal agent. It will also become apparent that distinctions between natural and man-made are not always clear-cut.

The RFF report "Acts of God and Acts of Man" followed the traditional approach of assessing disaster severity - how many people died and were counted. For the report to count a disaster, 25 or more people must have perished. While very interesting, disturbing and important, such studies have always ignored a hidden victim - hidden because it is not understood, cannot be easily counted and because it suffers in relative silence - that victim is the environment.

III. DEFINITIONS OF DISASTER

There are many different definitions of disaster; to a large extent it appears to vary with the viewpoint of the definer. For example, a "disaster" for the UN Department of Humanitarian Affairs (DHA) is

"a serious disruption of the functioning of society, causing widespread human, material, or environmental losses which exceed the ability of the affected society to cope using only its own resources" (DHA 1992)

Similarly, a businessman would have a different perspective;

"our definition of a disaster is any unplanned occurrence which seriously affects an organisation's ability to trade" (Reynolds 1994)

Most disaster managers, whether from the social sciences, engineering or earth sciences, tend to focus very closely on the human, societal or economic impact and very little else. From this traditional perspective, a chemical leak without human impact is simply a chemical leak; similarly, an earthquake in an uninhabited area is simply an earthquake rather than a disaster. Even when studies are carried out on "Environmental Disasters", the criteria for assessment has often been human death. Fore example, a report carried out for the OECD identified 197 industrial accidents of "environmental significance". The criteria for inclusion was 25 or more deaths, 125 or more injured, 10000 or more evacuated or deprived of drinking water or US$10 million or more damages to third parties.(OECD 1992).

From an environmental perspective, disasters can exist irrespective of human impact, even though such disasters may be caused or aggravated by human actions and policies.

The common perception of a disaster as requiring human impact to earn the title is as much a response to our ignorance of the effect of external stress on natural ecosystems as to any more rigorous analysis. We can see, empathize with and quantify human suffering, social disruption and economic damage and consequently respond well as a species.

Because we often cannot see, empathize with or quantify environmental damage we often assume it either doesn't exist or, even worse, doesn't matter. There is only very limited understanding of the complexities of environmental responses and so impacts on the environment are marginalised. However, the need to incorporate environmental considerations into concepts about disasters is gaining acceptance within some areas. In many areas of scientific and policy-making debate, the need to consider environmental influences and impacts is accepted as common sense as much as ethically sound. Whether the environment is examined from the Deep Green perspective as having equivalent and independent rights to exist or from the more common perception that damage to the environment invariably damages us (whether individually or communally) the basic conclusion is that the environment is important. It is time the disaster management community gave the environment the respect it has earned in other fields of human activity. That respect starts with incorporating it into the language, so a definition is required. Most traditional definitions of disaster incorporate the following aspects:

- **Disruption** to normal patterns of human life - usually severe and may also be sudden, unexpected and widespread.
- **Human effects** such as loss of life, injury, hardship and adverse effects on health.

- **Effects on social structure** such as destruction of or damage to government systems, buildings, communications and essential services.
- **Community needs** such as shelter, food, clothing, medical assistance and social care. (Carter 1992).

Such elements of a definition can be equally applicable to the broader environment where the ecological scale of individual-community-ecosystem can provide parallels:

- **Disruption** to normal ecological behaviour patterns - usually severe and may also be sudden, unexpected and widespread.
- **Species effects** such as loss of life, stress and adverse affects on health.
- **Effects on ecosystem structure** such as alteration of food chains through selective impacts on individual components of the chain.
- **Community needs** such as requirement for food/nutrients, light, water, shelter, territorial integrity etc.

In some scenarios the environmental implications of an event can be seen as allied to a human disaster. For example, Chernobyl had, and still has, profound impacts on both the human and environmental populations. However, many disasters affecting humans have little environmental impact and vice versa. For example, Bhopal, a classic case of a technological disaster, had little long term impacts on the environment whereas the pollution of the Rhine by a chemical spill caused by fire in Switzerland had no human casualties but caused enormous environmental damage to the river.

While it is easier to equate environmental damage with pollutants because we can see, smell or measure the presence of pollutant, it is more difficult to accept environmental damage caused by natural events such as floods, storms, earthquakes. However, what might appear as a natural phenomenon such as a hurricane might be caused by an anthropogenic input such as pollution. Similarly, a flash flood might appear natural but could be caused by poor planning or deforestation. If an ecosystem structure is irreparably altered, it is semantic to argue whether the cause of it's demise was chemical such as pollution or physical such as a flood. The fact remains that, for that habitat or ecosystem, it's viability to thrive has been severely disrupted and has therefore suffered a disaster.To stimulate discussion on this important topic the following definition is suggested as a conceptualization of environmentally-significant disasters:

"An event, or series of events, of any cause that leads to, or threatens, serious disruption of human, social or environmental systems where the integrity and viability of that system is impaired requiring urgent response and recovery measures."

As with any definition, there needs to be more attention paid to the terms "serious disruption" and "integrity and viability". The accurate assessment of environmental impact is very difficult and will be examined further in Section V.

IV. NA-TECHS - SYNERGISTIC DISASTERS

As well as it being time to consider a less anthropocentric perspective on disasters, it is also time to highlight the relationship between natural and technological disasters. As mentioned above, the distinctions between the two are appearing increasingly blurred. The basic premise is simply that a natural event such as an earthquake or flood can directly cause a technological accident such as a pipeline rupture, a chemical plant spill or de-rail a freight train carrying hazardous substances. The *vice versa* is also true, with anthropogenic influences altering natural events such as flooding and storms. Such complex, synergistic disasters have been titled "Na-Techs" by researchers at the Natural Hazards Research and Information Center at the University of Colorado.(Showalter and Myers 1992).

Two factors have brought the natural disaster and technological disaster closer together - often literally. The twin increases in population growth, especially in urban areas, and industrialization throughout the world means that the consequences of any natural event are magnified. Similarly, as more and more chemical plants, pipelines and storage areas spread to service the demands of those communities so the potential for a disaster increases. As one author noted;

"huge flows of fuels and chemicals are the life-blood in the tissue of industrial society, with as much capillary and ubiquitous end-distribution as for water or electricity: practically no location, population group or activity is entirely immune" (Vilain 1989)

Unfortunately, with many countries prone to natural disasters, the life-blood is in great risk of being spilt if care is not taken. The addition of chemicals or radioactive material to a natural disaster event complicates the response and recovery phase and can leave permanent scars - human and environmental.

There is, as yet, little concrete data available on such Na-Techs, but what work has been carried out suggests that these synergistic disasters present significant problems in their complexity of cause and effect. The research to date has focused on the USA and Canada, but the results could be extrapolated to any industrialized or industrializing country where there is an infrastructure of technology. The researchers discovered that in the USA alone a technological incident such as a chemical spill occured for every three natural hazard events. An example of one of the most studied Na-techs is the tornado that struck Edmonton in Canada in July 1987 where the tornado caused fourteen separate hazardous materials spills. This is in a country with some of the highest standards of building natural hazard resistant buildings and tight legislative controls on chemical operations.

Despite the sophisticated legislative and operational structure in the United States, the researchers noted that;

"the general consensus derived from the data is that the number of incidents where natural and technological disasters interact is rising while preparations, which recognize the complications inherent in such combined events, remain cursory." (Showalter and Myers 1992).

If even highly developed countries are facing difficulties recognizing the complexity of these incidents, then the problems are even worse in developing countries where the ability to prevent, prepare for, respond and recover are much worse than in the developed world. In some countries the following conditions ensure the impacts of natural hazard events on technological infrastructure will be more significant than in developed countries:

- High population density, especially in the emerging Mega-Cities;
- poor standards of housing in slum areas;
- inadequate zoning and planning of technological development locations;
- inadequate construction and maintenance standards for pipelines and facilities;
- inadequate capability to prevent, prepare for and respond to natural and technological disasters;
- often these conditions are found in areas of high natural hazard risks such as coastal areas and flood plains;
- reliance on obsolete and inappropriate technology.

The potential for disaster is obvious. Many developing countries have insufficient capacity to respond to natural disasters, without having to cope with the complicated impacts of technological disasters. (see sectionV.2.ii) A recent UNEP/UNCUEA [1]report found that many countries have absolutely no capacity to respond to accidents involving hazardous materials.(Le Claire 1993). Therefore, even the mainstream chemical accidents can escalate to become disasters. If the impacts of a natural disaster are added to this confusion, the problems to be faced will be considerably worse.

An essential element within the Na-Tech concept is consideration of the environmental implications of such events; environmental conditions such as wind and water are often the trigger for the events and the environment is also a prime source of impact, with possible long term implications for the ecosystem, as well as public, health. There are four major categories of disaster which will contain an environmentally significant element:

- Natural disasters with no impact on technological infrastructure such as a forest fire in a ecologically fragile area.
- Mainstream technological disasters or major industrial accidents such as the Schweizerhalle chemical fire which led to the pollution of the Rhine, Europe's premier river.
- Natural disasters providing the trigger for a technological disaster (Fast or Systematic Na-tech) -e.g. an earthquake rupturing an oil pipeline.
- Technological/human activities providing the trigger for a natural disaster (Slow or Incremental Na-Tech) e.g. poor land use aggravating drought conditions.

For the purposes of the conference, this paper will concentrate on the last two categories - the Na-Techs. It can be seen that the relationship between natural and technological disaster varies both in terms of the prime trigger agent and also in the temporal context. For example, a Fast Na-Tech will involve a natural hazard such as an earthquake damaging the technological infrastructure to the point where a hazardous material spill occurs. This will generally, although not always, happen very quickly and will require urgent assistance at the appropriate level.

A Slow Na-Tech results from the several anthropogenic influences:

- Technologically- related releases and spills such as pollution of air, water and soil.
- Resource use such as deforestation, overfishing and agricultural practices.

4.1 Fast Na-Techs

Here the major trigger events are likely to be:

- Hurricanes and typhoons.
- Earthquakes.
- Tsunamis.
- Riverine Flooding.
- Landslides.
- Heavy snow and rainfalls.
- Lightning.
- Forest fires.

[1]United Nations Centre for Urgent Environmental Assistance of the United Nations Environment Programme.

The available data are limited, but a survey of 20 states in the United States concluded that the largest proportion of Na-Techs were caused by earthquakes. The next most frequent trigger-events were hurricanes, floods, lightning, winds and storms. This is despite the fact that the most frequent natural hazard event in the US is flooding. The authors concluded that there is therefore;

"no correlation between the frequency of occurrence or annual damage caused by a specific natural hazard and its ability to create a Na-Tech event. A low probability /high consequence earthquake appears far more likely to create a low probability /potentially high consequence Na-Tech event."(Showalter and Myers 1992).

This means that in countries where earthquakes are high probability events technological development will need to be even more carefully planned to prevent and prepare for such events.

The effect of a fast Na-Tech is the sudden release of a hazardous substance into an environment already disturbed by a natural disaster. The main environmental implications include:

<u>Transient or short term pollution of air, water or soil</u> - this could have serious implications for groundwater supplies, habitats for species and even livelihood of workers such as artisanal fishermen. An oil spill would be a classic case of a short term pollutant where the initial impact is dramatic and environmentally damaging. Some of the oil might be cleared up and the remainder will eventually degrade, but the impacts on the reputation of the resource, for example in tourism areas, can be harmed for years.

<u>Cumulative or long term pollution of air, water or soil</u> - a classic case of a group of persistent pollutants which could easily be lost during a na-tech incident are heavy metals such as cadmium, mercury and lead. Once they have found their way into the environment they can accumulate through the food chain, thereby threatening the integrity of the habitat. Such impacts are extremely damaging from an environmental perspective, with the potential implications extending into apparently unrelated areas such as agriculture and fisheries. It only needs one link in the food chain to be broken and the impacts can be wide reaching and long term.

As well as causing significant environmental disruption, Na-Techs can also have serious implications for economic growth. For example, recent flash floods in Nepal damaged two power production projects, cutting the country's electricity supply by half. Power officials estimated that repair could cost about $10 million and take nine months to complete.(Down to Earth 1993). This suggests the need to fully consider Na-Tech scenarios in policy decisions on sustainable development, as a component in the continuum from relief to development.(see section V.3).

4.2 Slow Na-Techs

This carries forward the concept of a Na-Tech to examine the impacts of man's activities in causing, or aggravating, natural disasters and hazardous conditions.

Examples of slow Na-Techs include:

- Pollution of air, water and soil leading to stress on the environmental conditions.
- Over-use or poor management of a resource that leads to alteration of natural environmental responses.
- War and conflict (depending on local circumstances, this could obviously also be regarded as a fast Na-Tech!).

Such events obviously tend to be cumulative events rather than transient. The classic case, if proven, would appear to be global warming; which many scientists see as the natural response to an increase in so called "greenhouse gases" in the atmosphere. The result of such global warming may be rising sea levels, which increase risk of flooding in low lying areas such as deltas and small islands. If the predictions of these scientists are correct, the impact of rising sea levels on both the natural and human environment could be enormous. Some see the supposed recent increase in climatic extremes as a manifestation of global warming. Examples would include the 1989 Big Wet in Australia which brought the worst flooding in the region in 200 years; in the same year an extreme typhoon season struck South East Asia. The Philippines were hit by three typhoons in October, including Typhoon Elsie with its peak winds of 200km/hr. More than 1000 people drowned a month later when southern Thailand was struck by the most powerful storm in fifty years.

While it is understandable to try to find simple reasons for such extreme impacts, we cannot blame pollution and poor environmental standards. There is simply not enough scientific evidence for such a sweeping judgment. The climate varies naturally and the increase in natural disasters in recent years might be more the result of increased vulnerability of populations forced to live in disaster prone areas, or that improved communications have made us all more aware of the situation. However, despite the "ifs" and "buts", there is growing awareness of the potential impacts of greenhouse gas emissions and the environmental effects they can have; e.g. a study by the Massachussetts Institute of Technology in the US suggested that continuing emissions may result in hurricanes increasing in intensity by 40-50 % if the atmosphere's carbon dioxide content doubles. (Quarantelli 1992).

As well as causing pollution and environmental damage, there is evidence that natural events can also redistribute existing pollution. For example, forest fires in Russia have been noted to redistribute radiation that had accumulated in vegetation and soil. The fires re-released the radioactive contamination which resettled elsewhere, therefore increasing the extent of pollution. Similarly, floods in Belarus in 1993 resulted in the redistribution of heavy metal contaminants that had accumulated in the soil. (Le Claire 1993). Similarly, in 1961 windstorms spread plutonium and strontium from a nuclear accident in the Southern Urals, increasing the area of contamination by some 30-50%. The technological disaster that had happened earlier was magnified by a later natural disaster agent. (Quarantelli 1992).

Another example of a slow Na-Tech can be linked with poor resource management that aggravates natural conditions. It might initially seem as though flooding must be natural, but there is strong evidence to suggest that man's activities could have a significant role to play in increasing their impact. For example, deforestation in the hills and mountains of Nepal has been linked with damaging flooding lower in the valleys. The reason put forward is that rain runoff is increased because the vegetation that used to control infiltration has been destroyed. As a result, the water travels faster through the soil and builds up into a flood in the valleys. Such flash floods have killed thousands of people in mountainous regions over the past few years and caused enormous erosion of soil. Another problem is the effect of large areas of concrete and tarmac in cities covering the natural flood drainage path and causing flash flooding.

It appears to be a similar story of anthropogenic causation with the increasing occurrence of landslides in the Indian subcontinent and other areass. Indiscriminate tree felling, construction, mining and quarrying, combined with heavy rainfall have increased susceptibility to landslides in the Himalayan region. A survey conducted by the South Asian Association for Regional Cooperation found that 30% of all the world's major landslides occur in the Himalayan region and that some 75 major incidents occur annually in just central and western Nepal. The Nepalese government have blamed land use policy for such disasters. (Down to Earth 1993).

Another cause of environmental degradation is war and civil strife. The 1991 Gulf War caused widespread speculation about impending environmental disaster. The deliberate release of oil into the Gulf and the burning of hundreds of oil wells created major short term pollution. There were serious concerns that the dense smoke from the fires could have an impact on the monsoon in the Indian subcontinent and even that the entire global weather pattern could be affected. Thankfully, on this occasion the fears appear to have not been realized, but the episode highlights the lack of predictive capability of current environmental risk assessments as much as the potential impact of conflict on natural processes.The potential for a massive Na-Tech caused by conflict can be easily recognized. Even if combat does not occur, the preparations for war have the potential for siginificant impacts on natural hazard processes;e.g underground nuclear test explosions, although currently banned, have the potential for significant geological disturbance..

Refugees also have considerable potential for inadvertently causing environmental stress which could have implications on natural disaster conditions. There are more refugees in the world today than at any time in history; the concentration of large numbers of people into limited areas with insufficient carrying capacity to accommodate their needs quickly leads to over-utilization of water, fuelwood and soil resources. The result is that the area is left sterile, with major soil erosion and possible drought conditions - in many cases increasing the existing problems of desertification. The refugees are then forced to move on to yet another area where the cycle repeats itself, helping the spread of desertification. Such important issues need to be considered as yet another example of a Na-Tech - the interlinked results of natural conditions responding to anthropogenic influences. Whether the influence is chemical, political or social - there is a need to view the whole range of disasters in this framework.

4.3 Spiraling Na-Techs

It is perhaps interesting to note that the original cause of the natural hazard that causes a Fast Na -Tech might be a Slow Na-Tech such as land use policies. So here we could see a downward spiral of disaster starting with seemingly innocuous resource use and pollution policies for example deforestation that eventually trigger natural hazards such as floods which in turn cause fast na-techs such as the destruction of a chemical plant.

This sort of holistic overview is required to identify seemingly unrelated factors such as land use policy and siting of industrial infrastructure. However, the evidence suggests that such issues need to be taken into account at the very earliest levels of development planning. The concept of Spiraling Na-Techs could have a significant impact on questions such as sustainable development.

V. IMPLICATIONS FOR DECISION-MAKING AND POLICY

The need to incorporate environmental concerns more fully and the recognition of the synergy between previously independent disaster scenarios has several implications for the decision-making and management processes, including:

- Risk assessment.
- Disaster management
- Development policy - at national and interagency level such as UNDP, World Bank etc, as well as industrial decision-making.

5.1 Risk Assessment - refining the process

"The spreading potential for cataclysmic outcomes, and the difficulty of forecasting and avoiding their occurrence, creates the likelihood that modern societies will be faced with a series of disasters that will be costly in terms of capital and lives. The odds are complicated by the further possibility that cataclysm might occur as a spiral of interlocking events and processes, [unfortunately] our understanding of low probability/high consequence events...is highly conjectural and inconclusive" (Orr 1979, quoted in Showalter and Myers 1992).

At the basis of the recognition of Na-Techs and attempting to come to terms with their implications is the recognition of risk in both technology and policy. Risk, which can be defined as;

"the probability of the potential of a hazard becoming realised as damage" (Stonehouse and Mumford 1994),

is inherent in any human activity and the acceptance of that risk depends in part on the criteria examined, either intuitively or formally, as to the frequency and consequence of that risk. Even the Mesopotamian priests, long before the time of Christ, have been recorded as evaluating the possible impacts of proposed technological projects. (Rejeski no date).

The basic approach and considerations of risk assessment have not really changed much since those times, although the tools and methodologies have been honed somewhat! However, although the basic approach is similar today compared with two thousand years ago, the technology under scrutiny has changed beyond recognition. In only the last fifty years, mankind has developed the potential to alter the face of the planet - nuclear energy, chemicals and the spread of mega-projects ensure that today society has to assess risks that have never before been contemplated. For example, in 1992 there were approximately 70,000 substances included in the US Environmental Protection Agency's Toxic Substances Control Inventory, yet only 9600 (less than 14%) of these had any health effects information on file. Despite this some 2000-3000 new chemicals are being registered yearly, and this does not include pesticides, pharmaceuticals, cosmetics or food additives. (Manning and Rejeski. no date)

Despite a lack of detailed information about the potential effects of such technology, society allows such developments to continue - the risk is acceptable. Identifying, and hopefully quantifying, the risks of a policy, an accident or an event is a technical problem. Assessing the acceptance of that risk becomes a political problem. Obviously, if a risk is difficult to quantify then the decision for acceptance of that risk itself becomes more difficult. Researchers have found that assessment of risk varies considerably between laypeople and "experts". There is also significant variation in risk perception on the basis of religious and cultural differences. For example, in some cultures a natural disaster is seen as fate that must simply be endured rather than avoided. However, despite such cultural variations there appear to be a series of factors - so called "outrage factors"- that are widely encountered in the perception of risk. Research has shown that in many societies a risk is likely to be unacceptable if;

- the personal benefits of taking that risk are unclear;
- the risk is imposed rather than voluntarily assumed;
- the risk is outside personal control;
- the risk is seen to be unfairly distributed among the population;
- the risk is artificial or technological rather than natural;
- the impacts of an accident are seen as insidious e.g. poisoning;
- the duration of the risk is unknown;
- the risk is unfamiliar;
- the risk is associated with memorable events such as disasters. (Pidgeon et al 1992, Slovic 1993).

The above list could help explain why car driving, with a very high accident rate, is an acceptable risk whereas many people think nuclear energy is unacceptable. Perhaps if the human relationship with the environment became more personal - as it must have been centuries ago and still is with many indigenous cultures - then risks to that personal relationship by technology and policy outside personal control become less acceptable and the criteria to be attached for acceptance become more rigorous. Basically, it means making the individual becoming a stakeholder in the environment, thereby allowing the environment to become a stakeholder in the decision-making process. As populations become increasingly urbanised, this relationship with the natural world becomes more distant. To many children raised in large cities (and especially the Mega-Cities of the developing world), nature is seen as something alien to their own experience. In such circumstances, developing a personal stake in the future of the environment becomes difficult.

This acceptance or rejection of an industrial development or policy- whether it be a new process plant, a new transport system or policy that would allow industrial operations involving hazardous materials to be undertaken in an area prone to natural hazards will depend on the process undertaken to assess the risks. The usual risk assessment procedure has four major steps:

- **Hazard identification** — the formal listing of what hazards exist and how risk situations might arise.
- **Probability assessment** — technical assessment of likelihood of event either based on historical data with regards to natural hazards or on basis of failure rates for technological plants and processes.
- **Consequence modeling** — identification an quantification of impacts.
- **Assessment of acceptability** — political decision.

To date, very little is known about the environmental implications of disasters, even those of technological origin, that obviously pollute;

"for environmental risks, involving ...complex and loosely bounded systems, the process is more a question of imagination, to consider problems which may arise, within an attempt to bound the exercise to prevent the consideration of risks spreading ever-outward to the limits of the environmental field" (Stonehouse and Mumford 1994).

It is one thing to identify the implications at an individual level; it is much harder to extrapolate impacts at the larger scale population level. At the ecosystem level there are so many gaps in our knowledge that it is extremely difficult, if not impossible, to accurately predict impacts. This ignorance of cause and effect is manifested in the following problems:

- Difficulty in <u>identifying</u> causative impact on environment.
- Difficulty in <u>measuring</u> and quantifying degree of impact.
- Difficulty in <u>assessing</u> ecosystem response to stress and therefore the long term implications of a disaster.

One simple example of the complexity of environmental systems is the process of feedback. There are two basic forms of feedback - Negative Feedback where ecosystems recover from stresses by ecological processes lowering the stress levels. Positive Feedback occurs where the departure from the equilibrium point accelerates, so that relatively small initial departures can spiral uncontrollably into a collapse of the system. (Stonehouse and Mumford 1994). The classic example would be role of cloud cover in global warming. As the earth warms, the air can hold more moisture which in turn lead to the formation of more clouds. In a negative feedback process the presence of clouds can help reflect back the sun's heat, thereby helping to regulate the temperature. However, there is also a positive feedback process involved whereby the clouds act as a blanket to prevent the heat from the earth escaping. What is not yet known is the which feedback process is the most significant! (Williams 1994).

This inherent difficulty in understanding the complexity of environmental systems often results in the relevance of the environmental implications being marginalised or totally ignored by the policy makers. It is important that more research is undertaken to further our understanding of environmental impacts caused by development policies and disasters and how to apply that information into a workable cost-benefit decision-making framework that would be applicable for both developed and developing countries. In fact, such a move could redefine the terms "developing" and "developed" away from economic criteria to sustainability criteria! As many economists argue, Gross National Product (GNP) was never designed to measure wellbeing of a society; it was;

"originally designed to calculate Allied production during World War II. While it did the job admirably, it's still in use 50 years later, transmuted into the single most influential measure of economic well being in the world." (Holing 1994).

Many would argue that the measure is no longer a valid yardstick for the true wealth of a nation. There is a growing debate about the possibility for moving away from inappropriate economic tools to a new framework that would not attempt to squeeze values outside the scope of economics into a book-keeping ledger.

Any new yardstick of wealth should aim to recognize and describe the environmental baseline characteristics, assess the consequences of a policy, product or process and compare the ecological significance of the site with the economic value of the development. Obviously this is a very new field and a great deal of work is still to be accomplished but trying to hammer the round environmental peg into the square hole of economics may not be the most appropriate way of proceeding.

5.2 Disaster Management - Completing the Circle

"Rational decisions about catastrophe require an inventory of its sources, probabilities, geographic distribution and trends. An inventory might help to clarify the social costs of disaster including those of prevention, reconstruction, as well as the less easily calculable social-psychological costs." (Orr 1979, quoted in Showalter and Myers 1992).

Disaster management is arguably a combination of science, art and luck. Dealing with the problems and stresses of a disaster situation are fraught with difficulty and it is vital that the odds between success and failure are narrowed as much as possible. Two principles are particularly relevant to coping with Na-Techs:

- Multi-hazard, multi-agency integrated management irrespective of causal agent.
- Disaster management cycle.

5.3 Multi-Hazard Management

Disasters often show more similarities than differences -the impact on population, economy and environment, the need for cohesive and targeted planning, the problems of command and control under the stresses of a disaster situation, the need for efficient logistics and communications, the requirements of adherence to the disaster planning cycle - all are traits that are common to disaster situations irrespective of cause. The use of an integrated, multi-hazard, multi-agency approach allows:

- Full examination of issues without being constrained by a narrow mandate;
- the broadest overview of the situation in a disaster;
- an ability to prioritize responses in an appropriate manner so that at different stages of the disaster the focus will move from relief of suffering to provision of accommodation and services to examination of long term environmental damage and the consequences for future development;
- most effective and efficient use of limited manpower, equipment and financial resources;
- the ability to bring a wide range of personal and collective experience to bear on a complex problem;
- early anticipation of potential hazards can provide long term economic benefits - prevention is always cheaper than cure;
- cross-fertilization of ideas from one specialty to another;
- a more complete perspective on the disaster management process, especially for complex disasters.

5.4 Disaster Management Cycle

To benefit from a fully integrated disaster management system, there is a vital requirement for managers to adopt more widely the cycle of Prevention, Mitigation, Preparedness, Response, Recovery and then incorporate the lessons learned as feedback. The cycle can be illustrated with regard to the acceptability of risk of a technology or policy and how events can alter the perception of that acceptance:

•Prevention defined as *"action taken to impede the occurrence of a disaster event and/or prevent such an occurrence having harmful effects on communities".(Carter 1992).* At this stage the risk of an identified potential disaster is perceived as unacceptable and therefore attempts are made to prevent such a risk becoming a reality. e.g. construction of dams or levees to prevent flooding of settlements and industry on flood plains.

•Mitigation defined as *"action intended to reduce the effects of disaster on a nation or community" (Carter 1992).* Here the risk of an event such as a flood is accepted and priority turns to mitigating the effects of that event rather then preventing the event itself. e.g. building regulations to protect chemical stores in times of flood.

•Preparedness *"measures which enable governments, organizations, communities and individuals to respond rapidly and effectively to disaster situations" (Carter 1992).* e.g. a contingency plan is prepared, practiced and reviewed for coping with the impacts of a flood.

•Response *"measures taken immediately prior to and following disaster impact"(Carter 1992).* At this point of impact the risk of disaster is realized and ociety copes (or not) with the event through the implementation of plans, activation of the counter-disaster system, etc. However, the reality of the event might not bear much resemblance to the impacts predicted by a paper plan. e.g the flood could affect the plant in an unexpected way leading to a major chemical spill.

•Recovery *"the process by which communities and the nation are assisted in returning to their proper level of functioning following a disaster - this includes restoration, rehabilitation and reconstruction (Carter 1992).* In this phase the lessons of the disaster are assessed and incorporated into the future prevention and preparedness planning. e.g. it could be seen as unacceptable to allow chemical plants to be built in disaster-vulnerable areas.

•Prevention Completing the cycle, the acceptability of the risk could have changed as a direct result of the experience. e.g. this change in acceptance could lead to changes in development or operational legislation such as a ban on building chemical plants in disaster-vulnerable areas.

It is within this framework that societies can see the progression from Relief to Development as a continuum, moving towards appropriate and sustainable development. However, we have to realize that a simple paper plan is not the only requirement for success in disaster management. In the illustration used above, the pre-incident phases were obviously not successful because they failed to identify the actual hazard. Obviously, one would hope that a real disaster vulnerability assessment and contingency planning programme would not miss eventualities but it must be stressed that paper planning is not infallible. Even if the risks are well understood and accurately predicted, it is another thing altogether to be in a position to cope with it. Lagadec noted the difficulty in transfering good ideas to good practice:

First, no matter what efforts are made in the area of prevention, the possibility of grave events persist; second, the processes that are unfailingly set in motion immediately after the acute breakdown are generally very poorly handled. From a breakdown, we regularly find ourselves slipping rapidly out of control and into crisis - which means, roughly speaking, a situation in which any corrective efforts made are hampered by a sense of confusion, helplessness and aggravation. (Lagadec 1990)

While this particular observation was aimed at technological incidents, the management implications are equally applicable to the natural disaster scenario. Even when developing countries realize the risks, many simply have no ability to cope. This was the finding of a recent UNEP/UNCUEA report into environmental emergencies. The report, carried out in 1993, was based on questionnaire returns from forty-five developing countries. The relevant competent authorities were asked to provide information about major accidents that had occurred in their country which had, or threatened, major environmental impact. Information on over 800 incidents were provided. The countries were also asked to assess their ability to respond to accidents that involved the release of hazardous materials into the environment.

It is vital that responders have adequate training, equipment and information available on specific response techniques and problems. A detailed contingency plan, effective communications and management are also vital as is specialized backup in environmental and public health assessment.

However, many countries replied that they could not meet even the most basic requirements. A sample of the responses is shown below:

COUNTRY	RECORDED RESPONSE CAPABILITY
Barbados	*"no hazardous chemical spill contingency plan and no clean-up equipment or trained personnel"*
Ethiopia	*"as far as emergency response capability in the country is concerned, there is no such organization set up which is organized to handle such responses etc. Furthermore, the human resource in this area of practice is very much limited"*
Jamaica	*"at present emergency response is limited to the Fire Department: They are hampered by low levels of training in responding to hazmat incidents- lack of equipment to adequately deal with these incidents- lack of knowledge of the types of material being used by some of the facilities"*
Jordan	*"there is no capacity to deal with major accidents"*
Kenya	*"there is no emergency response capability in my country"*
Mongolia	*"all accidents involving hazardous chemicals will exceed the national as well as the local level capability since no such exists"*
Nigeria	*"institutional provision for response exists but the capacity is far from adequate"*
Philippines	*"do not have sufficient resources e.g. trained personnel and equipment, to respond to a major accident"*
Poland	*" in case of major accident the amount of available specialized equipment might pose a limit for fighting the results of accident"*
Uganda	*"grossly inadequate with no expected improvement in capacity"*

(Le Claire 1993)

It can be appreciated that many countries have no ability to respond to incidents that would be regarded as a minor or routine incident in a developed country. With this serious shortfall in ability to respond, it becomes even more important that attention is focused on prevention and preparedness policies. (Le Claire 1993).

It is vital to incorporate as much real data into the planning exercise as possible - to work with facts rather than theories. This means that there is an important role for post-incident analysis to try to fill in the gaps in knowledge not only about how disasters occur but also how communities and the environment respond to such stress.

Real events - real accidents, real disasters, can significantly help in the identification process. The use of post-event analysis of exactly what happened, why it happened, what was affected and how could it be prevented all provide extremely useful information to enable decisions on the acceptability of risk to be made based on facts rather than calculation. Post-disaster analysis allows:

- Failures in the risk evaluation process to be rectified;
- predictions to be checked;
- the capacity of environmental systems for recovery from impact to be evaluated;
- unforeseen ecologically mediated effects to be evaluated;
- information to be gained that can assist the all-important understanding of ecosystem processes.(Stonehouse and Mumford 1994).

This is particularly important for environmentally significant technologies and policies where we have little data that can be used in desk study analysis of possible risks.
However, the same UNCUEA/UNEP report highlighted the lack of knowledge that is available, even in the developed countries with regard to technological accidents in general and environmental impacts in particular. The study contacted thirteen dedicated databases around the world. The conclusion found a disturbing trend in reporting:

- The truly major disasters such as Chernobyl and Bhopal were included in all databases;
- there was only limited information available about nationally important emergencies;
- there was very limited information, if any, about the majority of accidents involving hazardous substances. (Le Claire 1993).

Therefore, serious inadequacies were identified in accident reporting systems. Many other database searchers have concurred with the UNCUEA/UNEP finding, for example;

"serious shortcomings exist in the way that natural disaster and major industrial accident data are generally reported. Until these are remedied, further research will be hampered by omissions, errors and ambiguities in the data. We found that none of the sources had a complete record of papers, and that there were often gaps in the reports that were given. Reports of the same event often differed significantly from one source to another and sometimes it was difficult to determine whether two sources were reporting the same event" (Glickman, Golding and Silverman 1992)

Although the validity of post-facto analysis is widely accepted, unless more serious attention is paid to the development of databases, industrializing countries will be forced to learn from their own mistakes rather than learning from other people's. Such a "re-inventing the wheel" approach is both inefficient and dangerous.

These issues of acceptability of risk could have profound implications for development policy. An example is the 1993 Mississippi flood; on the basis of post-event analysis, the US government debated the options to change policies that allowed development in flood-prone areas. With hindsight, many observers noted that the use of levees and dams simply delayed the problem of flooding rather than solving them. The crux of acceptability of a policy option is the understanding of the implications of that action. Unfortunately, with environmental impacts, it can be argued that we simply do not have sufficient understanding of the natural systems yet. On that basis, allowing development of hazardous technology in disaster-prone areas could be seen as extreme folly or an unavoidable development risk that must be taken to meet the development aims of the country.

5.5 Development Policy - juggling the arguments

"People who are already barely eking out an existence will not avoid a risky flood plain or the shadow of a volcano any more than they will eschew the squatter settlements around a pesticide factory in Bhopal or a liquified gas facility in Mexico City. In short, the poorest of the poor are probably likely to reside in the path of both natural and technological hazards." (Bowonder and Kasperson 1988)

The major trends which are likely to see the problems associated with natural and technological disasters increase are population growth, especially in urban areas, and industrialization which will increase the potential for a technological or Na-Tech disaster. Ninety-six per cent of future population growth is expected to occur in developing countries with estimates of 511 cities with more than a million occupants by the year 2010. By the year 2030 it is predicted that there will be an extra 3.7 billion people on the planet. Of this figure, 3 billion of them will be found in cities in developing countries. (UNCHS 1994). These areas already suffer the impacts of disaster more than the developed world. As Quarantelli noted;

any disaster, technological or otherwise, will be worse in cities in developing societies than elsewhere, because they will impact localities already burdened by numerous everyday problems. (Quaratelli 1992)

For many countries facing a rapidly growing population, with many more mouths to feed and limited land to grow that food on, there is a inevitability of development policy accepting the risks of settlement and industry spreading into disaster-prone areas. In an argument of feeding starving children or suffering the possibility of a disaster in the future by growing crops or building a chemical plant on disaster-prone land, there are few people who would not address the immediate needs as a priority.

However, from a long term perspective, it is important that the very real dangers of technology and the relationship with disasters are addressed. While it remains difficult to avoid natural disasters altogether, anthropogenic influences can be removed, but at a price. One author noted simply that:

"The most simple strategy for human protection from chemical danger is not to produce and not to use highly toxic and biologically persistent substances" (Dolezal and Pokorny 1989)

Such a move would certainly help prevent many Na-Techs and more mainstream technological accidents! Many Deep Green environmentalists would support such a point of view, but such an affirmation is not likely in the current development circumstances. The aim, at least in the mid-term, should be to move towards a safer approach to industrial development that allows opportunities for countries to develop along the lines that their population desire without squandering the resources for future generations.

The guiding force for sensible development policy is one that places the economy, the people and the environment in a long term perspective rather than use short term political goals as an excuse for development. The keyword is "Sustainable Development". This term has been bandied around so much over the last few years that there is a great confusion as to what it actually means and the implications of using such a term as a long term goal.

With the global move towards the realization of the concept of sustainable development, the knowledge of environmental responses to stress caused by pollution, disasters and Na-Techs could provide the stimulus for significant alterations of the perception of acceptable risk. Sustainable development has been defined by the Brundtland Report as:

"development that meets the need of the present without compromising the ability of future generations to meet their own needs".

The concept was carried forward and enshrined in Principle 4 of the Rio Declaration which states:

"In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it".

As our knowledge base grows on the environmental implications of pollution and environmental degradation in general but Na-Techs in particular, there is conceivably a point that could be reached where the cumulative impacts of polluting accidents are no longer regarded as acceptable. This could lead to moves to improve safety by strengthening policies such as improving design and operations