

The Ecology of Natural Disaster:
Implications for development planners.

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Preface

"Research on the alterations in the environment resulting from man's activities which may lead to an increase or decrease in the risks of the occurrence of disasters" is one of four sub-sections in the programme area of Prevention and Mitigation identified in a Memorandum of Understanding between eight UN bodies on the Environmental Aspects of Natural Disasters (UNEP et al 1978).

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It is usual for measures for disaster prevention to emphasise technological or mechanistic, essentially national level undertakings, often exogenous or even alien and usually superimposed upon, the region, or country, for which they are recommended and introduced; and consideration of "man's activities" which may lead to alterations in the environment is too often approached with the same pre-conception. This article attempts to redress an apparent imbalance, therefore, by concentrating on those indigenous and often traditional activities, upon or within which, pressures and inducements may bring about environmental change and a consequent exacerbation of natural disasters and their severity.

Introduction

Traditional study of disaster and disaster response has focused upon the extremes of environment, such as earthquake, tropical cyclone, flood or tsunami, which may create disaster (Lewis 1977) or upon the aftermath of social conditions that disaster has brought about; and upon ways of analysing them in individual and corporate behaviour; or of relieving them through relief management; and sectoral and mono-disciplinary study of, for instance, shelter, refugees, nutrition and epidemiology; under the collective heading of disaster technology (Manning 1976).

Ecological study of disaster (Lewis 1978a) has focused on prevailing socio-economic conditions and human activities, recognising them as being potentially and significantly responsible for the creation of disaster, and has made possible the consideration of longer time scales, inclusive of recurrent disaster, and inclusive of comprehensive strategies of multi-disciplinary measures to mitigate them. Recognition of the socio-economic causes of disaster and of the long-term measures to counter them, means that policies and programmes for disaster mitigation must be firmly integrated with socio-economic development programmes.

Interaction between man's activities and his environment has created an upsurge of concern for the protection of the environment itself, whereas an equally important and significant area of concern is for the protection of man from environmental extremes - triggered or exacerbated by his own activities in some degree, or not. Were man to recognise himself as a component of environment, rather than as separate from it, his own protection might be more assured; and man must realise that, to achieve protection from environmental extremes, what he himself does, what activity patterns he follows and where, may condition the degree of his own protection.

90% of natural disasters occur in developing countries (UNDRO 1972). Programmes which seek to prevent disaster must concentrate on the accrued conditions for disaster; and preventive measures must be identified for inclusion within social and economic programmes for planned change; but without ecological awareness in development there is the danger that development projects themselves may destroy delicate man-environment systems and exacerbate causative conditions for, and risks of, natural disaster.

Human ecological contexts for famine and flood

In response to the enormous size and scale of the famine associated with drought in the Sahel countries in the early 1970's, the resulting wave of international concern included numerous writers who expressed alternative views concerning the causative origins of the disaster. The unique slow onset of drought and its consequences facilitated retrospective analysis over time scales not directly afforded by other disaster types, and ^{of} the involvement of prevailing activities ^{of man} ~~given~~ - with ^{in which} causative aspects of famine could be identified. Analysis of previously successful man-environment systems gave clues to some causes of failure from subsequent interventions.

Where sizes of herds have been maintained to a level acceptable to an ecosystem, if the size of herd is increased, or if the management system is changed then environmental degradation may be the result:

"The key to the Sahelian way of life was a remarkably efficient adaptation to the semi-desert environment. Although the nomads' life-style may seem enviably free to those who dwell in cities, there is nothing random about their migrations. The dry season finds them as far south as they can go without venturing within range of the tse-tse fly. Between the nomads and the sedentary farmers who also inhabit this area, there is symbiotic arrangement; the nomads' cattle graze the stubble of the crops and at

the same time manure the fields. In exchange for manure the nomads receive millet from the farmers. With the first rains, the grass springs up and the herds move northward. The rains also move north and the cattle follow behind in search of new grass. . . . When that grass is eaten off, the return to the south begins. This time the cattle are grazing a crop of grass that grew up behind them on their way north, and they are drinking standing water remaining from the rainy season (Wade 1974).

The nomads were faced with enforced settlement, which with the same size of herds, had the effect of over-intensifying grazing and land-use. Subsequent reduction of herds meant economic hardship for herdsmen which, when drought came exacerbated by environmental changes by then taking place, meant the difference between survival and defeat. Environmental degradation leads to further economic deprivation.

Economic fragility exacerbated by increased populations, brings about the over-intensive use of scarce natural resources, to act as an agent for the destruction of the very basis of livelihood. Desertification has been at least partly due to the expansion and intensification of land-use in marginal dry lands during wet years, wind erosion during subsequent dry years, and water erosion during the next rainstorm (UNEP 1977). Intermittent or occasional movement of people subject to population and/or economic pressure, has probably occurred more widely and with even more severe consequences. High levels of rainfall during the 1950's and 1960's encouraged the northward movement of peasants into lands previously devoted to herding. The unusually good weather conditions of this period helped to obscure the dangers inherent in this strategy which may have become one of the main causes of desertification. When dry years follow years of relative plenty which have encouraged population movement, ploughed soil, or soil from which natural cover has been removed by cultivation, becomes quickly and irrevocably eroded. Ultimately, herders moved south as rainfall decreased, only

to find that due to higher than normal rainfall, cultivators had moved north and taken over former pastoral reserves (Ball 1978) and

" . . . it is significant to note that much of the economic development and population expansion in the (Sahel) took place during a period of abnormally good rainfall; in 27 of the 39 years, from 1920-1958, rainfall, throughout this semi-arid zone, was above the long-period average" (O'Keefe 1975).

The contrast here between the sophisticated social practices of the nomads and the clumsy attempts at exploitation by normally sedentary farmers emphasises the beauty of the nomadic system as much as it emphasises the foolhardiness of the later's peregrinations.

Agricultural systems traditionally had fail-safe practices similar to those of the nomadic herdsmen. Land was left fallow for up to 20 years before re-cropping, and an extraordinary number of varieties of staple crops were maintained, each adapted to different growing seasons and situations. Economic pressure to concentrate on a smaller number of crops for cash purposes, and the pressures of increased populations, have caused the fallow period to be reduced to five years or even one. As a result:

"Fertility declines, slowly at first, and then in a vicious spiral. Poor crops leave the soil exposed to sun and wind. The soil starts to lose its structure. The rain, when it falls, is not absorbed but runs off uselessly in gulleys. Desertification has begun" (Wade 1974).

Western influence in the form of development assistance, has to be recognised as having taken part in this same process more recently; for instance:

"It would be absurd to blame the collapse of this intricate social and ecological system solely on Western interference, and yet rather few Western interventions in the Sahel, when considered over the long term, have worked in the inhabitants' favour. Those who have studied the farmers' and herders' traditional methods, says an FAO report on the Sahel, believe that the destructive practices that are now frequent are due to the cumulative effects of "over-population, deterioration of the climatic conditions, and above all, the impact of the Western economic and social system" (Wade 1974).

For example, the drilling of wells for artesian water supply, where possible and technically feasible, may appear to overcome many of the disadvantages of more primitive water supply systems. Where wells can be considered singly, this may be so; but collectively, they may have the adverse effect of lowering the normal water table, thus making deeper wells necessary for a maintained supply and exacerbating the process of water-table lowering. Over-intensification of well drilling, brought about by unplanned concentrations of human or animal population, and increased and easier availability of the necessary technology, may quickly create uninhabitable areas where some habitation had previously been possible. Furthermore:

"A thousand feet or more beneath the Sahel lie vast reservoirs of water that can be tapped by deep wells. Thousands of these boreholes, costing up to \$ 200,000 a piece, have been drilled across the Sahel by well-intentioned donors. The effect of the boreholes was simply to make pasture instead of water the limiting factor on cattle numbers, so that the inevitable population collapse, when it came, was all the more ferocious. . . . Enormous herds, converging upon new boreholes from hundreds of miles away, so ravaged the surrounding land by trampling and over-grazing that each borehole quickly became the centre of its own little desert forty or fifty miles square . . . the boreholes threw into chaos the traditional system of pasture use based on agreements among tribal chieftains (Wade 1974).

The drilling of boreholes may, therefore, have an effect in reverse of their intended purpose. They may be the cause of a desertification process and severely reduce capacity to withstand dry periods, thus drastically exacerbating the effects of drought.

Additionally, the introduction of cash economy, colonial division, and improved application of Western medicine are blamed for results such as:

". . . herd numbers increased hand over fist in the decade following independency (1960), aided by 7 years of unusually heavy rains. According to the FAO, the number of cattle grew from about 18 to 25 million between 1960 and 1971. The optimum number, according to the World Bank, is 15 million. While herders were overtaxing the pastures, the farmers were doing the same to arable land" (Wade 1974).

The need to take over previously unfarmed land has in some cases caused deforestation for the clearance of land suitable for subsistence crops, but with severe environmental degradation and increased hazard as a result:

"The most important reason for the destruction (by Hurricane 'Fifi' in 1974) was the deforestation which has taken place since 1965. The river valleys on the north coast have been increasingly cleared of forest for the banana plantations of the multi-national corporations. . . . As a result of this economic development the Campesinos moved to cheaper land on the hills where they cleared forest to grow maize;

The destruction of the forests and the protective cover of the soil are factors which exaggerate floods and precipitate a chain of disasters in our country. . . . When the forests are well conserved, they constitute a complete and efficient protection for the soil. The combination of plants and other organic materials that are decomposing acts under the surface to improve the porosity and increase the capacity for absorption by the soil. When heavy rain falls . . . A part of the rainfall is

absorbed by the humus and mould of the forest soil, which acts as a giant sponge. (Any surface water) is slowed by the action of all the vegetation. In the change to an area cleared of vegetation, the rainwater falls tumultuously down the hillsides. The penetration of rainwater is reduced and the surface stream is much greater . . . the water flows in a muddy, highly erosive, torrent which fills the streams until they overflow their banks" (Honduran Forestry Engineer Jorge Arevalo in Westgate and O'Keefe 1976).

Deforestation may be on such a scale that it may not always have been undertaken for common or specific purposes, but the results have been similarly damaging. The origins of the 1978 floods in northern India have been reported as being:

"in the persistent mis-management and neglect over the past 10 years of the country's vast land and water resources . . . (given) the deforestation of the Himalayan foothills, the denudation of watersheds of the Ganges and the Jamuna, and the frequency with which the country suffers monsoon flooding, (it is) estimated that 60 per cent of the entire land surface now requires urgent attention if it is to be saved from further degradation. It is already under the strain of a still-growing population" (Wigg, reporting B B Yohra, 1978).

In addition to the environmental alterations and consequent increase of hazard due to man's activities in food production, is the erosion of social awareness to climatic change and environmental hazard and the new impossibility of exercising traditional options in the face of recurrent adversity, due to superimposed external systems or to economic pressure exacerbated by increased population.

The Man and Biosphere (MAB) Programme on Ecology and Rational Use of Island Ecosystems in the Eastern Islands of Fiji recognised similar human ecological conditions of vulnerability to environmental hazards:

". . . certain places and populations are, in a real sense, more vulnerable to natural events than others. A population living on the edge of poverty, a population occupying an ecologically-marginal environment, a population dependent on a single source of sustenance - all these are more vulnerable than wealthy people with good land and a range of alternative means of gaining a living. This is at the aggregate level; within a population, the poor are more vulnerable than the rich, the very old and very young are more vulnerable than the adult and the strong . . . the eastern islands are more vulnerable than the nation as a whole, because the effect of natural events tends to be more serious on small islands dependent on only a few sources of livelihood than on larger islands with a more diverse resource base" (UNESCO/UNFPA 1977).

Human ecological contexts for tropical cyclone and earthquake

Realisation of the ecological nature of all types of disaster has received considerable impetus from attention focused on drought, much of the conclusion in respect of drought and consequent famine being applicable to other forms of disaster:

"A disaster can be defined as a combination of factors of a political, social, economic and environmental nature which work to undermine the ability of a system to cope with new stresses. The interaction of these factors, which are generally long-term in nature, creates the conditions for disaster; that is, they make it inevitable that at some point a breakdown will occur. The conditions for a disaster can exist for a long period of time before catastrophe strikes. Very often it is the impact of some natural phenomenon which overloads the system. It is this close association between breakdown and natural phenomena which gives rise to the tendency to describe these events as 'natural' disasters" (Ball 1975).

Drought and dry periods are normal in arid zones and must be recognised as such in the selection of systems for man's survival. Similarly, so are

tropical cyclones and earthquakes in many other regions and their occurrence must be similarly incorporated. Just as man's systems must resist pushing the use of land to its limits in periods of favourable rainfall, with resulting great cost in subsequent periods of drought, so also, for example, must development be discouraged away from coastal areas subject to tropical cyclone, and slopes prone to landslide, in years between the occurrence of these phenomena.

Discussing the intermittent effect of tropical cyclone on some island communities the MAB Programme Report observes:

"Sawana village . . . was again overflowed and destroyed by the sea in 1912, and soon afterward the site was abandoned in favour of Lovonivono on the hill above. These events are worth recalling in view of the present commercial and tourist development along the undefended flat coastal strip south of the eroded site of Sawana" (UNESCO/UNFPA 1977).

In a village of Guatemala, severely damaged by earthquake in 1976 (Glass 1977), changes in house construction, from wood to adobe, may have been significantly responsible for the increase in numbers of deaths related to dwelling collapse between the 1976 earthquake, and the earthquake of 1918. Vulnerability of the area to earthquake damage changed over time for social and economic reasons. The vulnerable condition of 1976 had accrued for at least 600 years.

More recent changes in building construction form and technique brought about by the introduction of "western" methods in Tonga created conditions where the moderate earthquake of 1977 caused more damage to dwellings than experienced ever before, in a country where severe earthquakes are recurrent (Lewis 1978b).

Settlement in disaster prone areas has been accelerated in recent years by rapid increases in population and consequent increased demand for housing (UNEP 1976). The results of this increased demand have often led to land, previously recognised as hazardous, being taken over for planned or spontaneous use. This has occurred in rural areas, as well as by expansion to existing urban areas. In the morphologically transient land formations of the Ganges-Brahmaputra-Meghna rivers of Bangladesh, economic and socio/cultural pressures were responsible for an increase in the population of certain islands at a higher rate than in the country as a whole, up to the end of June 1970 (Islam 1971). Vulnerability to natural disaster was severely increased to the cyclone of November 1970 in which 300,000 people died.

Migration from rural to urban areas has been more noticeable in terms of the spontaneous "squatter" developments that have resulted on the periphery of many cities, than in the effect it has had on rural areas. In less developed major areas of the world the proportion of the total population of the region that is urban (living in places with a population of 20,000 or more) has doubled since 1940 and tripled since 1920, and although this rapid urban increase has no doubt been at least partly responsible for spontaneous and hitherto unplanned development, less than a quarter of all the regions' total population was urbanised in 1975. (With the exception of Latin America where urban populations are over one-third of the total) (Roberts 1978).

The obviousness of urban increases in population, which have occasionally led to impressive disasters of large magnitude, should not be allowed to obscure equally serious, but less immediately evident, rural situations where frequent but lesser disasters are endemic, and occasionally of vast consequence. Much of the migration which has resulted in urban concentration

may have been caused by environmental degradation in rural areas and inability of rural areas to support increased population. Writing of the earthquake in northern Pakistan of 1974, Hewitt observes:

". . . the scale and frequency of such disasters in high mountains is not merely a result of seismic conditions but rather the worst expression of recent socio-economic pressures and environmental deterioration. Rapid deforestation, over-grazing and the extension of cropping to ever more marginal areas, all of which accelerate erosion, flooding and silting of bottom lands, are spreading rapidly throughout the world's tropical and sub-tropical high mountains. One of the effects of this convergence of environmental damage and socio-economic stresses is to greatly enhance the risk from pests, disease, landslides, floods and earthquakes" (Hewitt 1976).

The mountain dwellers of north Pakistan, the Pathans, were easily distinguishable in the squatter settlements of Karachi due to their skilled use of stone, their traditional building material. The only available land for their use had been the previously dry bed of the Malir and Lyari Rivers, until they were the first to be destroyed in the flooding of 1977 (Tapner 1977) and suffered serious disaster, of a different kind. Disaster in one place may be the ultimate cause of migration, possibly to another disaster prone location, leading to increased vulnerability of the second settlement; a vulnerability caused by social and physical marginalisation:

"In many cities the areas occupied or set aside for the urban poor tend to suffer from one or more major deficiencies which have prevented them from either being developed or re-developed. The better lands tend to be developed for other uses. Typical problems are areas subject to frequent flooding (or permanently under water), areas difficult to supply with services for technical/cost reasons, areas with steep slopes or weak soil conditions, and areas particularly prone to occasional natural hazards such as hurricanes, earthquakes, or tidal action" (Shankland Cox 1977).

More recently, it has been the 1,700 people evacuated from the volcano of 1946 in Niua Fo'ou and their progeny, who suffered the Tongan earthquake on 'Eua in 1977 (Lewis 1979b); and an analysis of the distribution of damage from cyclone in Sri Lanka in 1978 has identified the rural areas as having suffered larger numbers and percentages of destroyed dwellings, than the urban centres (Lewis 1980).

The more obvious and most easily observable examples of migration and exacerbated vulnerability are urban, but they should be taken as illustrations of a process which is both urban and rural.

Furthermore, the activities undertaken by settlement inhabitants, migrants or not, may contribute to environmental degradation. The local gathering of firewood for fuel may collectively cause adverse environmental change, depleting tree growth and increasing soil deterioration:

"The acacia tree, ubiquitous in many arid zones and useful for firewood and forage, was common around the Sudanian capital of Khartoum as recently as 1955; by 1972, the nearest such trees were 90 kilometres south of the city . . . the combination of over-grazing, accelerated erosion, and the indiscriminate use of fire is responsible for this costly biological march (of the desert)" (Eckholm 1975).

The indiscriminate use of trees is not restricted to arid zones. In the mountains of northern Pakistan:

"the incessant search for firewood, the energy source for cooking and keeping warm, has over-reached the supply even here, although not to as extreme a degree as farther out in the foothills. The ever present herds of goats have also taken their toll through over-grazing and destruction of young trees. So most farms and villages are surrounded by deforested slopes. Many are terraced, of course, and may rise more than 2,000 feet

without a break. In winter, bare soil and loose rock - unstable debris easily set in down-slope motion by earthquake - are conspicuous around and above settlements (Hewitt 1976).

Whilst in this latter case the similarities with environmental degradation in arid lands is plain, the difference is between long term progressive decline in the desert, and the possibility of sudden and violent catastrophe in sub-tropical and temperate mountains.

Over-emphasis on cash-cropping, to the exclusion of local food production, may also have dangers in that the inherent stability of the agricultural system, which in the past provided for a local population with adequate safety margins, will be damaged or destroyed causing populations to be dependent on cash for subsistence food. In turn, should "outside" supplies fail due to normal seasonal contingencies or extreme events, then populations are at greater risk to disaster. Available cash is useless if the food it would be spent on is not available (Lewis 1976 and 1978b).

Over-emphasis on cash cropping in favoured ground, to the exclusion of food crops obliged to relocate in marginal ground, may produce increased vulnerability for food crops - just as it may for people in a similar disadvantaged situation. A Pacific Island illustration describes the process:

"The present staple crop, cassava, is more vulnerable to wind damage than yams or taro . . . the growing dependence on an income from copra has been accompanied by much greater plantings of coconuts. Since coconuts are planted as part of the cultivation of food gardens and eventually replace them, there has been a change in land-use. . . . Since the best soils are on the coastal flats and in the lower valley bottoms, increasingly the most favoured areas have been used for coconut plantations. . . . The gardens have had to extend up-slope and up-valley into areas formerly regarded as too steep, difficult,

poor or remote to be cultivated. . . . These slopes are, however, very exposed to wind and storm damage. In 1975 a larger proportion of the crops was destroyed by the hurricane or subsequently rotted in the ground than was the case in 1948 . . . (before the process described had become so well established) (Bayliss-Smith in McLean et al 1977).

The immediate environment of man may be altered by the construction of dwellings, the planting of crops, and the rearing of animals. At what point do environmental alterations such as these lead to an increase, or decrease, in the risk from, or occurrence of, natural disasters? Alteration is a change from one condition to another. The answer to "alteration from what?" will be a key to assessment of changes to the degree of risk. Questions concerning the relative scale of environmental alteration relate in turn, to definitions of "disaster" itself.

Disaster vulnerability and development planning

International concern is usually in response to the magnitude of big disasters, because it is big disasters that most qualify for news-media treatment. Other, more numerous but small disasters, where few people die, will not make news headlines outside the country of occurrence and as far as the international community is concerned, these disasters will not have happened, even though accrued losses from numerous small and unreported disasters may exceed the losses sustained in one single major event. Nevertheless, to the common component of all disasters, the community and family group, disaster will have occurred. Big disasters are made up of countless simultaneous small ones. Whilst in some countries, small local disasters may be endemic, absorbable and normal (Lewis 1979c), in some small countries, "small" disasters, by international comparison, may be catastrophic. Small countries often do not have the population to produce

"big" disasters (Lewis 1979a). Disasters must be considered in terms of relative scale and not only in terms of magnitude. Through assessment of scale, by comparison with national area, population or economic resources, will come an understanding of national concept and content of disaster, and national capacity for mitigation and self-reliance, together with an understanding of how decision makers in developing countries might best be assisted in their responsibilities for mitigating strategies within development planning. By doing so they will be taking mitigative measures that will not only serve the big disaster when it occurs, but measures that will serve to mitigate the small ones as well.

Just as big disasters comprise numerous small ones, so small scale environmental alterations at domestic, farm, compound and community levels accrue to create large environmental alterations. Some of these changes have accrued to exacerbate natural disaster. Deforestation for domestic cultivation on valley sides created accrued conditions for soil erosion and consequent mud-flows in Honduras in 1974, which greatly exacerbated the effects of flooding in valley bottoms and the numbers of people who were affected (Westgate and O'Keefe 1976). Planning method cannot afford, therefore, to ignore man's activities at the domestic level in mistakenly focusing only on activities at corporate or national levels.

Increased risk of disaster may mean increased numbers of people at risk; or increased risk for a fixed number of people; or increased risk for an increased number of people. Vulnerability is both a matter of increased spread of risk and of increased occurrence of disaster events themselves. Not only is there a need to reduce the number of disasters, but also to reduce the degree of losses sustained in each. Realisation of the long-term nature of ecological change must be established so that some short-

term measures designed to decrease risk do not become the cause of long-term increase in risk. For example, the construction of a dam as a measure of flood control in an area of seismic risk may create an additional hazard, which with subsequent growth of flood protected development, may cause increased risk of greater disaster in an earthquake. Short-term measures aimed at reducing the effects of disaster itself, after it has happened, may also exacerbate longer term vulnerability. Where the provision of disaster-relief brings about conditions of dependency, indigenous capacity for self-reliance may have been eroded, thus increasing vulnerability to subsequent disaster. In most disaster prone countries, disasters are recurrent (Lewis 1980).

It is perhaps unlikely that it will become possible to quantify increases or decreases in probable disaster losses as a result of specific measures in the less developed countries. The effectiveness of measures for mitigation will therefore be ascertained in theory and there is a danger that measures for preparedness and prevention will be implemented piecemeal as a result of a theoretical separation of a total strategy. To be effectively implemented, prevention and preparedness measures must be integrated at the practical level to gain full advantage of their comprehensive and inter-related value. In separation, for instance, short term preparedness measures for "unavoidable" disaster may be cost-ineffective if measures are not taken at the same time to mitigate or prevent disaster. Alternatively, the long-term nature of many preventive measures will render them apparently ineffective for considerable time, during which it will be imperative for established communities to apply measures for preparedness. A comprehensive package of measures for short-term and long-term application must be realised in the context of man's own relationship with the ecological time scales of his environment.

Environment is the total habitat of man, taking into account natural, living and working conditions (Sachs 1976), and preventive measures must not be pre-conceived as only long-term, or only large scale. Preventive measures must recognise the inclusion of ecological adjustments in the activities of vulnerable people to maintain a resilience and self-reliance to counter the effects of disaster, rather than only as technological resistance to the forces of environmental extremes themselves (Lewis 1979a).

In addition to achieving mutually supportive integration of measures over varying time scales of effectiveness, is the need to avoid the risk of making one measure compensate for fecklessness by another. The introduction of major physical change will require integrated social adjustments, but not simply as compensation for increased risk that the major change may have brought about.

The location of people, whether optional or not, will probably have overall and primary predominance in terms of disaster increase or decrease. Therefore, planners have to recognise that the majority of potential victims will already be in situ, usually without realistic alternatives; that increases in population in these circumstances may be one factor of an increase in vulnerability; and that the planning of future communities in new locations will affect only a very small proportion of present populations. Vulnerability factors of each location will include the environmental conditions within which, in his ecological context, man's activities may increase or decrease the risks of natural disaster by bringing about alterations in the environment. Thus there can be said to be a primary locational vulnerability related to place, and a secondary "vocational vulnerability" related to activities within a given place. Mitigative adjustments in vocational vulnerability may be the only available option

in a pre-existing condition of primary vulnerability. Vocational adjustments may be for instance technological, in improved building construction, or social, in the provision of emergency shelters and contingency plans. They must all come within the purview of comprehensive social and economic development planning if disaster mitigation is to be effective, but reservations concerning irrevocability of most conditions of locational vulnerability have to be recognised.

Political, social and economic pressures may pre-condition choice of, or obligation to, place; and environmental alteration, degradation, and increased risk of natural disaster may be caused by, as well as be the cause of, migration and economic and social marginalisation (Ninan 1977). Unplanned migration, brought about by economic or political pressure resulting in rural depletion and urban concentration; movement of people from fertile plains, preferred by mega-combines and multi-nationals, to previously unused valley-sides, may be the very context in which planning has to operate and where attempts at control may be unrealistic or impossible. Social movement of this kind, brought about by economic and political forces, may create fundamental environmental change at the macro-level, against which attempts which seek to control or influence micro-change of vocational vulnerability can only be ^{secondary} ~~necessary~~.

The number of people in a given place will directly affect the risk of increased or decreased losses in natural disaster, or may cause migration to other more vulnerable areas, or cause over-intensive use of resources. Macro-considerations must be the first to be recognised by development planners seeking to reduce vulnerability to and risk of natural disaster. Awareness of the factors which determine place are as important as awareness of the activities which are undertaken within a place. But once place

has been determined (and for the majority of cases that will have become historical) awareness at all levels of constraints necessary to preserve ecological balance in all its variety of place, is pre-requisite if imbalance is not to create disaster for man:

"Man interacts with the other components of ecosystems which he inhabits; he affects them, and is affected by them. He may convert wild ecosystems into crop ecosystems, but if the self-regulating feedback mechanisms which serve to maintain the essential variables of a system in operation are interfered with beyond a certain point, then the resources on which man depends may be destroyed" (UNESCO/UNFPA 1977).

As may man himself be destroyed, we might add.

Some responsibilities for development planners

Preventive measures against disaster must be considered as ecological adjustments by vulnerable people to maintain a resilience and self-reliance to counter the effects of disaster, rather than only as technological resistance to the forces of environmental extremes themselves; and development planners must be as aware of those activities undertaken at domestic level where they accrue to national proportions, as they are of activities undertaken directly at national level. Not only must effective monitoring be maintained to prevent or arrest the environmentally negative aspects of development, but positive initiation of ecological measures against environmental extremes, for example, to increase natural defences particularly with the implementation of programmes for the planting of trees for protection, on slopes prone to landslide (Hewitt 1976), coastlines, and adjacent to dwellings vulnerable to tropical cyclone and tsunami (Islam 1971; UNDR0 1978) and for incidental use as fuel (Eckholm 1975); for soil and sand stabilisation of sand dunes as sea defence (McHarg 1971). And as in India against flooding,

". . . the only lasting answer is envisaged as a £30,000 million national afforestation, soil conservation, and irrigation programme to be spread over the next 30 years. . . . Much of the money would be paid to labourers and would bring a corresponding injection of purchasing power into the rural sector" (Wigg 1978).

Programmes for the greater diversification of agricultural food crops (Lewis 1978b), for the wider use of equipment closely appropriate to local methods without running down fertility in the long term (Eckholm 1975), the use of contour ploughing to regulate water run-off (White 1974) and in the promotion of indigenous methods of agriculture to form the basis of developed crop production through irrigation, improved ^{stock} breeding and by the development of village co-operatives (Ball 1978) and by general improvement in the quality of agriculture through a focus on the "basic needs" philosophy of development by improvements and repairs to terrace construction, improved forestry management, orchard development to include fruit and nuts providing shade, fodder, food and fuel (Hewitt 1976). Consideration must also be given to the development of alternative forms of fuel for heating and cooking purposes which must be able to resist upset and the causing of fire in the event of earthquake. The encouragement of the use of solar energy in place of wood fuel for forges, kilns, ovens and stoves as well as a source of power for irrigation pumps, for instance, might be developed.

As a most essential activity in the reduction of risk from natural disaster, is that of maintenance of all technological and infrastructural systems such as motor engines, irrigation and catchment systems, building construction and drainage systems. Without adequate maintenance, damage and consequent loss in disaster will be the greater (Lewis 1978b) but it is often a short-coming of development projects that, not only do they not include

financial provision for maintenance after completion, they place an often unbudgeted burden for maintenance on the recipient organisation or government which often cannot be adequately managed.

The most crucial and significant of man's activities for a positive decrease in the risk of natural disaster occurrence and severity is an effective planning strategy within informed and carefully constructed planning policies. The objectives of policy formulation will be to provide a unified conceptual framework in which resources, energy, population, and development and environmental constraints, including hazards, can be appropriately related to one another within their national, and trans-national, contexts. Alternative development strategies must be formulated for different regional ecosystems in arid zones, plains, mountains and islands for example; and local systems and methods must be integrated with development policies to provide safeguards against the erosion of successful indigenous techniques. Current practices which promote environmental degradation must be identified and where practical, prevented.

With specific reference to environmental extremes, detailed assessments of national climatological and seismic normals must be accumulated to facilitate the planning of development programmes to known environmental constraints. The improvement at local levels of all systems and methods of life support, in accordance with the "basic needs" approach to development, and in carefully ~~simulated~~ evaluated contexts, with the view that improved "normal" conditions will create increased self-reliance in disaster. Systems for consideration will be for food supply and storage, agriculture and fishing, water supply and irrigation, and regeneration of planting material.

Complex though some of the implications of these recommendations are, measures to take account of them to arrest, adjust and to prevent accrued conditions for disaster are matters for balance in development which, where policy is implemented at an early stage, incur no heavy expenditure or financial commitment.

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