NATURAL HAZARD RESPONSE AND PLANNING IN TROPICAL QUEENSLAND

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July 1978

Working Paper 33

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This paper analyzes the problems of natural hazard response and planning in tropical Queensland, Australia. It examines whether concepts and findings developed by natural hazard studies, particularly in the USA, are applicable to other hazard prone areas, in this case that of tropical Queensland.

Comparative studies require, first of all, the examination of the nature and behavior of the natural hazard. Attention is directed to the particular complex of hazard conditions which result from tropical cyclones, so that it can be assessed whether any distinctive features characterize their behavior in the Queensland area. A survey of the relevant circumstances of the economy and society is then undertaken. From this it is possible to examine the particular effects upon the coastal communities that may arise in the Queensland area from the occurrence of tropical cyclones.

These preliminary surveys lead to the main analysis of hazard response and of the forms of adjustment that are available in the circumstances discussed in the first part of the paper. It becomes apparent that a number of final assessments must await further investigations in depth. In the case of tropical Queensland, as elsewhere, the importance of additional natural hazard research is evident. Nevertheless the paper can contribute to the comparative understanding of the significance of the tropical cyclone hazard.

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PREFACE

This paper is one in a series on research in progress in the field of human adjustments to natural hazards. It is intended that these papers will be used as working documents by the group of scholars directly involved in hazard research as well as inform a larger circle of interested persons. The series was started with funds granted by the U.S. National Science Foundation to the University of Colorado and Clark University but now is on a self-supporting basis. Authorship of papers is not necessarily confined to those working at these institutions.

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Requests for copies of these papers and correspondence relating directly thereto should be addressed to Boulder. In order to defray production costs, there is a charge of $2 per publication on a subscription basis or $3 per copy if ordered singly.

ACKNOWLEDGEMENTS

The interest and the encouraging advice of Professor G. F. White and the facilities provided at the Natural Hazards Research and Applications Information Center of the Institute of Behavioral Science of the University of Colorado, Boulder contributed significantly to the preparation of this study and are most gratefully acknowledged.

INTRODUCTION

The impact of natural disasters in different parts of the world has demonstrated the disorganizing and distress-causing capacity of extreme natural environmental conditions, despite the greater organizational and technological sophistication of human society. Whilst man has realized that inadvertently he can adversely disturb his natural environment, it is clear that he is far from achieving dominance and that in the meantime, he will be better advised to attempt to harmonize his activities with the environment. Natural hazards occur where people and extreme natural events coincide and where the preparations and organization of the affected society cannot deal adequately with the stresses produced.

Whilst awareness and perception of natural hazards and adjustments and adaptations to their effects represent but a part of the continuum of the whole man-environment interaction process, there are differences in degree, intensity of impact and response which justify the identification of a separate field of natural hazard studies. The goal of such studies has become accepted as the attainment of the understanding of the environmental interactions, which result from the interrelationship of man and extreme natural events, with the final purpose of defining the optimal adjustments or adaptations by which the natural hazard can be minimized or eliminated (Burton, Kates and White, 1968). An extreme meteorological or geophysical occurrence can be considered to be a natural hazard when some aspect of the health, social or economic life of a community is faced with severe and unexpected disruption.

The linkages involved in natural hazard systems can be modeled at a variety of levels of sophistication and comprehensiveness. Our concern

can be directed towards the refinement of the conceptualization of the model. This process can be undertaken at an abstract or theoretical level. The output of such analyses should then be applicable to any hazard study and thereby permit the use of common methodologies and the development of hypotheses which have general applicability. The nearer to perfection the modeling process reaches, the more we should approach a blueprint which we could employ in practical natural hazard planning. With this ideal model at our disposal we should require only the appropriate and precise inputs of data in order to obtain the understanding we need to answer the planning questions. We should still need to assemble the details about the hazard and about the area in which it was experienced, and we should require such information to be precise and representative.

The diversity of academic viewpoints on the philosophy of natural hazard interrelationships, and the frequency with which serious gaps in community preparedness are brought to light in individual hazard situations, emphasize the fact that the basic models themselves require further development. This, in turn, provides an additional reason for a regional and comparative inquiry into hazardous conditions in different socio-economic systems. Through the pursuit of such investigations there is the potential for improving the basic models to the point where the apparently distinctive local features will be encompassed in the general theory and no longer require an unique treatment.

The present situation in the United States has been attained after some fifteen or more years of active interests in the nature, distribution and frequency of a wide range of natural environmental stresses which occur at irregular and generally unpredictable intervals. A great

amount of material on the impact of these events has been assembled and this in turn has been analyzed so that it has become possible to identify some of the decisions needed to minimize their disruptive effects, be they psychological, social or economic. For the benefit of mankind it becomes a matter of major concern to examine whether or not the methodological approach, the analytical techniques and the resultant findings in the case of the United States can be utilized for similar planning purposes elsewhere in the world. Some research must be repeated in different areas because there are distinctive spatial characteristics which will determine the final research results. White makes the point that adjustments vary according to whether the society can be described as a folk society, an industrialized society or a post-industrial society (White, 1977). Community response is more commonly directed towards modifying the impact of a disaster or accepting the occasional loss if the event is infrequent than to seek to change the modes of life and habitation. In such circumstances previous inquiry provides a guide but not the complete answer to superficially similar problems already studied elsewhere. In other cases there are fundamental truths that can be discovered and which, once identified, can be applied to similar situations wherever they may occur. White and Haas in their Assessment of Research on Natural Hazards (1975) provide a valuable framework for research work elsewhere in addition to reviewing present achievements and future needs for hazard studies in the United States.

A number of basic questions must be resolved before the maximum benefit of very considerable natural hazard research in the United States can be realized:

a) Are the relevant characteristics of the natural event closely similar wherever and whenever it occurs?

b) Are the psychological make-up, the social system or the economic base of the affected community or communities dissimilar and do any differences, if they occur, influence the nature of the effects of the hazard?

c) Do any such community differences identified above also modify the response behavior so that similar hazards may give rise to a range of appropriate planning decisions according to different locations?

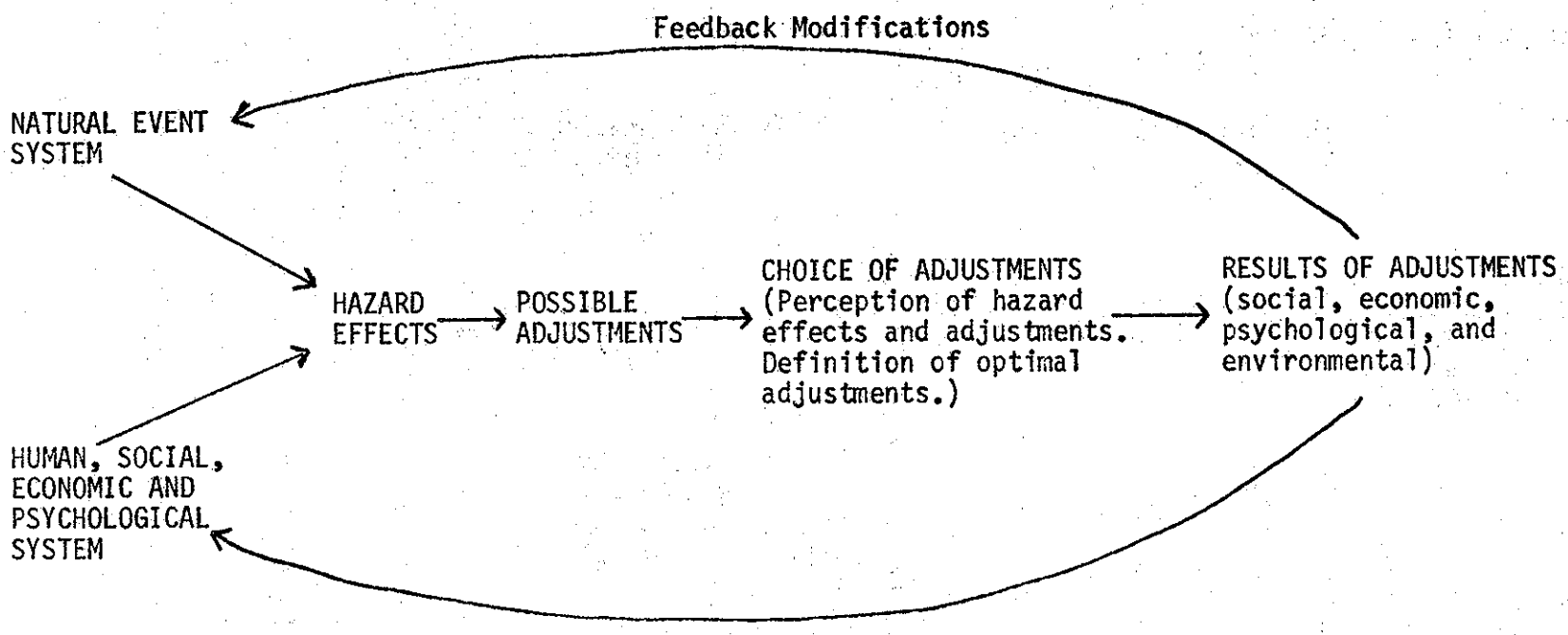
The discussion in this paper is directed towards an analysis of the hazard situation in tropical (north and central) Queensland, Australia, with a primary restriction to the complex of extreme conditions generated by tropical cyclones and human response to them. A simple model which has been evolved from the work of R. W. Kates (1970) has been adopted to serve as a framework for the discussion (see Figure 1). This paper makes no attempt to develop new concepts nor to establish alternative models. Its objective is to provide some pointers to the extent and the manner in which the Queensland area exemplifies basic ideas about natural hazard response planning, and to examine whether any specifically regional problems or solutions are observable within it.

NATURAL EVENT SYSTEM

The information required for this part of the model relates to definitions determined according to human aims and modes of adjustment. From these definitions relevant parameters can be established which describe the energy of the system, return period or frequency, duration,

FIGURE 1

HUMAN ADJUSTMENTS TO NATURAL HAZARD

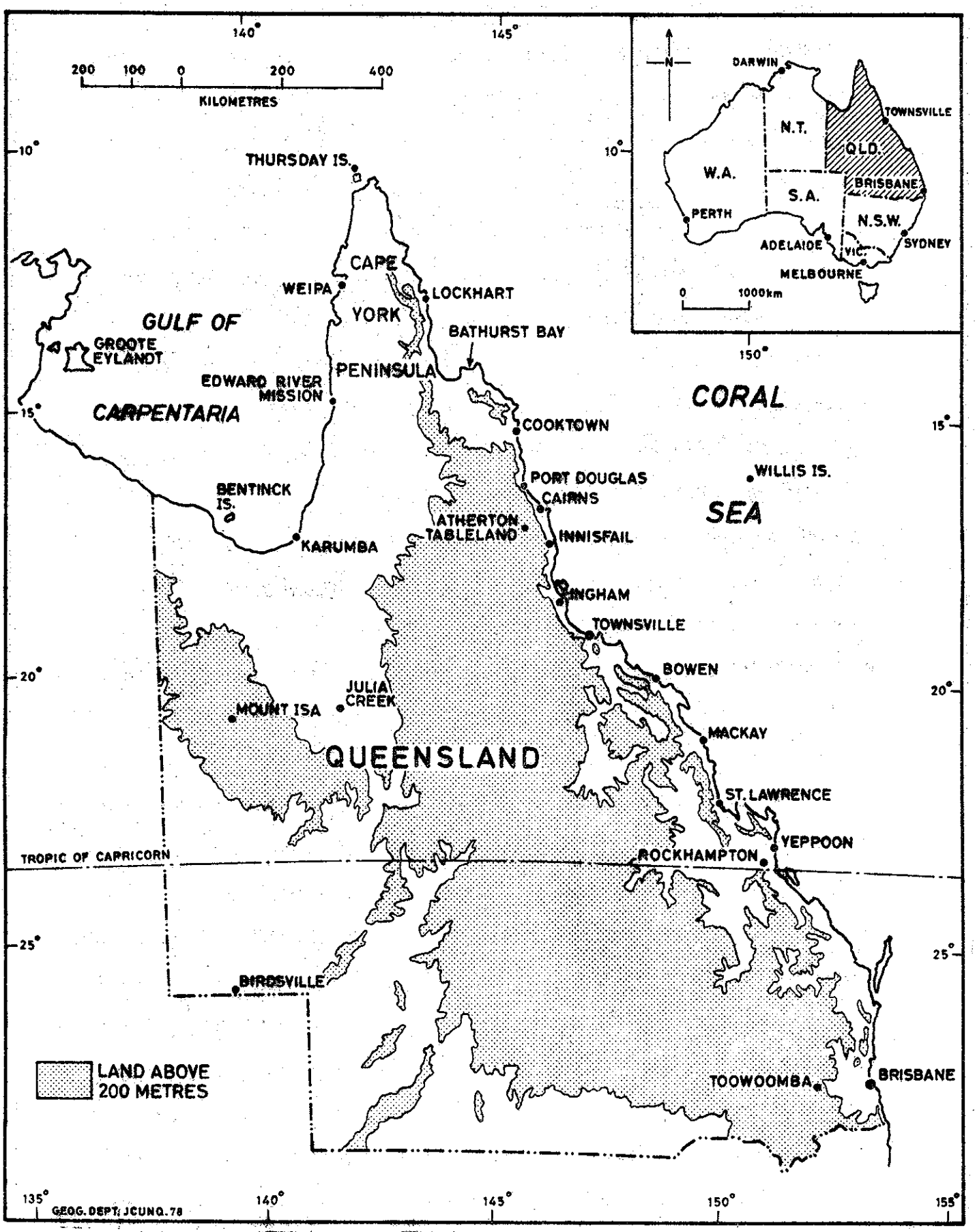


temporal spacing (regular, random, periodic or clustered), and areal extent. In addition, our ability to forecast its behavior and to estimate the possible warning time can be determined. This procedure varies in difficulty. Since tropical cyclones are, in effect, a complex of hazard events--strong winds, heavy rain and land and marine floods--the descriptive parameters may take on different values according to the relative strength and precise degree of concurrence of each individual stress. Many of the features of severe tropical storms are common to all areas. Some, and these are the ones focused on here, have local characteristics.

The tropical cyclones affecting tropical Queensland originate in the warm Coral Sea to the east or over the shallow waters of the Gulf of Carpentaria to the north. (See Figure 2.) The land areas most at risk are the Gulf coastal lowlands, the Cape York peninsula, and the east coastal lowlands and uplands which border them on the west. The risk frequency is not high. The annual number of storms (July 1909-June 1975) crossing the north coast east of 135^{o}E and the east coast south of Cape York to the Queensland border averages 2.4 (Lourensz, 1977), and about half of the storms crossing the coast are likely to reach severe, damaging proportions. The eastern coastline considered here extends some 2500 kilometers. In the tropical east coast section (Cape York to Tropic of Capricorn) storms crossing the coast, either land to sea or sea to land, total 88 (involving 73 individual cyclones) over the 66 year period mentioned above. Fifty-seven of these storms crossed the east coast from sea to land. In the section north of Cairns the return period is about 40 years, the southern section south of Mackay about 40 to 50 years and in the middle section 20

FIGURE 2

MAP OF QUEENSLAND



to 30 years. We could fairly describe the coast as a low probability--high risk area. At the present time, because of media coverage and the fairly wide dispersal of cyclone alerts or warnings, it would appear [evidence from a questionnaire survey conducted in Townsville (Stride, 1975)] that the public impression exaggerates the frequency expectation.

Coral Sea cyclones are usually of moderate diameter, and many that cross the coast may affect a zone no wider than 75 to 100 kilometers. Like most tropical storms they demonstrate great variability in behavior, speed of movement, intensity and structure. Some devastating storms have developed, crossed the coast and degenerated in the space of 36 to 48 hours. Other cyclones have had a life over the sea of several days and, if they have eventually crossed the coast, have presented a less difficult forecasting problem and more opportunity for a community to prepare itself. Though the general coastal direction is from north-north-west to south-south-east, the coastal trend in detail consists of a series of segments more north to south or west to east. This fact has an important bearing on the liability of different sections of the coast to be crossed by the cyclones as they move polewards. It also relates to the direction from which wind effects are most likely to be dangerous (Hopley, 1974). The coastal lowlands are usually no more than 10 to 50 kilometers wide. The high land to their immediate west slopes up steeply to plateau surfaces and rainfall declines sharply inland. These surface conditions contribute to the frequently rapid degeneration of a storm in a matter of a few hours from a hurricane to a rain depression which can dump 500 to 875 mm of rain on the upland crest in 24 hours and on rare occasions, if the depression becomes almost static, continue rainfall nearly at this intensity for as much as two or three days. A mature cyclone is more likely to generate rain at rates of 125 to 250 mm in 24 hours.

Queensland experiences other natural hazards. These will be listed only briefly here. Drought has, at periodic intervals, been a major challenge in the seasonally dry and inland areas in particular. Floods can be produced by tropical cyclones or by persistent convergence in a deep, moist monsoon circulation on a regional basis, whilst local convection can raise individual creek levels quickly. Whilst the coastal lowlands are most likely to suffer major flooding, heavy rain west of the main river divide on the headwaters of rivers flowing west or north-west can inundate extensive inland areas. Plentiful summer rain encourages the active growth of grass and other ground vegetation. If warm drying weather occurs at the end of the summer bush fires, possibly ignited by lightning, can then be a major threat. The bush fire threat decreases towards the humid parts of the coastal region or towards the more sparsely vegetated interior. Lightning itself is hazardous and can occur with a high frequency, especially inland. Landslides occur on the steep slopes of the coast facing ranges. Coastal erosion can be active under high wave energy conditions generated either by strong south-easterly gradient winds or tropical cyclones near to or crossing the coast. Thunderstorm squalls may produce considerable but very localized devastation. Tornadoes are relatively infrequent but must be included in the hazard list. Perhaps less to be expected, winter frosts can quite seriously damage pasture on the drier parts of the Atherton Tableland at about 750 to 900 meters altitude and at latitudes $15^{o}S$ to $16^{o}S$. Hail can also be a major though localized and infrequent hazard in the south-eastern, especially the higher altitude, parts of Queensland.

THE HUMAN SYSTEM

This system may be considered to incorporate both human use and human behavioral features. This discussion will focus upon the broad characteristics of the occupance of tropical Queensland. Some comments upon behavioral traits will be reserved until later.

Very approximately, an area with a population of about 300,000 is being considered. The distribution of this population is significant in several ways to the study of natural hazards. The coastal areas are the most populated and in general are experiencing the most rapid growth both in population and in economic activity. Apart from inland mining areas, Mt. Isa in particular, the small inland populations are static or declining. People are concentrated on the coastal lowlands in a number of widely separated small towns, located from 80 to 200 kilometers apart. Many towns have a population of only a few thousand and only one, Townsville, exceeds 50,000. The rest of the coastal lowland population tends to be widely dispersed, particularly in the sugar cane producing areas. A few coastal stretches are being developed for tourist and retirement purposes. A fringing ribbon of buildings is often located immediately on the landward side of the first sand ridge bordering the beach. Inland, where the economy is based upon cattle or sheep pastoralism, holdings are extensive (sometimes 20,000 to 40,000 hectares), settlement is widely scattered, and such towns as there are often have populations measured in hundreds.

The coastal regions are predominantly agricultural, based upon sugar cane and to a far smaller degree rice, sorghum, corn, or bananas. Crops are harvested outside the cyclone season and it is mainly sugar cane that is at risk from wind or flood damage, though the 1300 or so hectares of

bananas are also prone to cyclone damage. Sugar cane, however, is surprisingly resilient to rainy, windy weather and moderate flooding; though early, very wet conditions can impede the mechanical cutting of the cane. Some beef cattle rearing occurs in the coastal region but pastoral activities become more widespread inland. Outside the towns other economic activity is associated with forestry, mainly in the rain forest regions, and widely scattered mining operations.

The industrial structure is not highly developed. Townsville has the broadest economic base with a copper refinery, a nickel treatment plant, cement works, meatworks, phosphate drying plant, port installations and a range of tertiary activities involving regional administrative, legal and professional services and educational and scientific institutions. Neither at Townsville, nor in such other industries as occur in the smaller towns, is the individual labor force large, the industrial process particularly likely to suffer storm damage, or the industrial unit very adversely affected by supply disruptions, other than in the metal industry. A high proportion of the total work force works indoors.

Communications are very sensitive to flood effects. Communication and transport links are concentrated in the coastal lowlands. A narrow gauge railway and bitumen surfaced highway (single lane each way) connect the coastal towns. Both have to cross a number of creeks and rivers which frequently may rise and prevent travel along one section or another during the wet season, possibly marooning travelers between one flooded creek in front of them and another creek which has flooded behind them. Such occasions may occur perhaps 4 or 5 times in a very wet season, especially in the January to March period. The situation is even more difficult

inland. Although the bitumen surfacing of the main western highway has now been completed, other roads are dirt roads over clays which are virtually impassable after small amounts of rain and liable to be cut by flooded creeks. Wash outs can disrupt railway movements. There are relatively few alternative routes which climb the east facing scarps. Most of the larger coastal towns have good jet air services which are rarely storm interrupted, except when the cyclone is directly affecting the airports.

HAZARD EFFECTS

The adverse effects of tropical cyclones come under the three main headings of wind, rain and land flood, and storm surge, but a number of secondary effects follow from these (Oliver, 1975). The mapping of the hazardousness of an area should reflect the overall community sensitivity to the complex of disruptive effects associated with the natural event system. There is a great need to ascertain whether findings on the different attitudes related to age, social status, length of residence, and previous experience of a similar hazard apply in tropical Queensland. It is a common situation, in this area as elsewhere, that the adjustments adopted are more often concerned with influencing the natural phenomena themselves than with modifying the affected society or individual.

The major wind hazard in the tropics results from the passage of tropical cyclones, though locally damage can be caused by small scale tornadoes or thunderstorm squalls. The maximum recorded wind gust velocity is 200 kph (Willis Island, February 1957) but a number of storms have reached 150 kph gusts. The wind hazard is greatly accentuated when there

is flying debris or driving rain. Tropical building styles often utilize a fairly light-weight timber frame with considerable window areas for good ventilation, asbestos sheet or timber walls, and corrugated iron or aluminum sheet roofing. Once such buildings start to disintegrate, the air is filled with flying debris and the rate of building destruction downwind is accelerated. Where modern housing designs have introduced large picture windows and low pitch roofs additional dangers are caused. Unless the glass is exceptionally thick, the large windows increase the risk of damage. There is no tradition for the use of protective shutters which are difficult in any case to employ for large window spaces. Destructive eddies develop over a low pitch roof and tend to strip off the roof sheeting. Even if the wind does not cause direct breakage, strong winds driving sand and salt-spray have a destructive blasting effect on paint and other surfaces. Only one-third of those questioned in Townsville in 1975 listed ability to withstand cyclone effects as an attribute to consider in the choice of a house. The prevalent building styles have some advantages. Construction is rapid and repairs can be effected quickly so long as damage is not too severe. The traditional style house is usually quite easily shifted and transported. Houses can be relocated or house sites cleared quickly.

A serious hazard is presented to small ships during a storm, whether at sea or anchored in exposed locations. A cyclone crossing the coast frequently causes an expensive toll amongst small craft; the total of lives lost often includes several deaths at sea. Natural vegetation can suffer both short term physical damage (loss of leaves and breaking of branches) and more persistent effects such as cyclone "scrub" which is

caused by patches of rain forest destruction followed by vine growth which inhibits the recovery succession. Areas of cyclone "scrub" are identifiable on aerial photographs on the eastern slopes of the main range.

Tropical soils often have a high infiltration capacity, and where rain forest or eucalypt woodland have not been removed the vegetation reduces the rate of surface run-off. However, heavier cyclonic rainfalls produce large discharge volumes over extensive areas. The worst floods occur along the river or creek floodplains or at the river mouths especially when high discharges and tides coincide with landward blowing strong winds. Many of the early settlement sites were chosen at river crossings or as ports at the river mouths. Despite a history of development interrupted by flood episodes most, though not all, of these places have persisted without abandonment of the initially developed sites.

Large volumes of rapidly draining surface run-off deposit coarse sediments on cane fields, erode and gully the top soil and contaminate water supplies with sediment or leach fertilizers. In addition to direct flood obstruction, heavy rain raises the water table contributing to the deterioration of road foundations and rapid breakdown of the surface by increasing pothole development. Strong flood currents cause washouts on bridge approaches and undermine railway lines thus extending the period of flood disruption.

A particular problem of a humid tropical summer is the difficulty in drying out articles or buildings soaked by flood waters or rain ingress through damaged roofs, walls or windows. Even if the rain stops, cloudy conditions can persist, air humidity remains high and drying capacity is low. If the cyclone or flood has disrupted the electricity supply, the possibilities of artificial drying are ruled out. Materials deteriorate

or decompose rapidly in the hot, damp conditions. Mildew grows swiftly and is difficult to eradicate. Paint surfaces discolor quickly and cannot be easily cleaned. Hygiene is threatened in a short time in the humid tropics. This applies with obvious force to the removal of human or animal corpses and rotting vegetation or food which may remain scattered about after a severe cyclone. Blocking or flooding of sewers or breakdown of pumps may cause dispersal of sewage over the surface. Contamination of the domestic water supply is a further threat. Relief and rehabilitative steps must respond rapidly to such problems.

On the coastal margins the greatest threat to life and property is the storm surge flood. Saline flooding is serious enough, but more destructive still is the combined impact of abnormally high sea levels and the waves generated by the strong winds upon the protective coastal mangroves and the natural defenses of coastal sand dunes or sandbars. Building foundations not normally exposed to such forces are likely to be undermined.

A number of the early town sites, such as Mackay, Townsville or Cairns, were on the coast and were chosen because of the importance in the early days of coastal shipping. They have subsequently turned out to be seriously at risk from storm surges. Much of the initial urban growth took place in locations liable to storm surge before the risk was fully appreciated, but subsequent growth has still continued to take place in areas liable to surges. A major surge could inundate considerable parts of such places up to several meters depth in the lowest sectors. Apart from records of doubtful authenticity, the deeper surges recorded have tended to be of the order of 2 to 3.7 meters. Fortunately, to date, the only serious surge event in this century occurred in Mackay in 1918 when damage was severe

and 30 people lost their lives. In the case of Townsville, if the highest projected surges occurred at high tide level, tens of thousands of the inhabitants could be endangered and a major part of the present city area, including the airport, could be covered by water. The Queensland Department of Harbors and Marine, through the Beach Protection Authority, has prepared at the request of the State Emergency Service a booklet explaining the nature of surges and detailing the action to be taken at various stages of the cyclone surge threat.

The severity of a tropical cyclone hazard is increased by the convergence of a number of disruptions more or less concurrently. Physical damage caused by the storm produces additional consequential stresses. These situations are demonstrated by particular features of the tropical Queensland experience.

In this area electrical power is distributed from thermal power stations, with a supplementary hydro-electric component, by an extensive overhead high-voltage grid stretching over many hundreds of kilometers. Distribution of electricity to urban consumers is still largely by overhead connections. Such a system is particularly liable to wind damage. Live cables, brought down in a storm, may be a serious danger whilst power remains on. Repair becomes a major problem because of the potential scale of the damage, the distances involved and the difficulties of rapidly assembling men and materials for repair work from widely separated small depots. Transport disruptions will exacerbate this latter difficulty. It is not surprising that power may be cut off in some areas for several days after a severe storm. A further problem may affect the generation of electricity if debris in high flood waters blocks the intake ducts or damages the turbines of the hydro-electric plants. Hospitals, radio and

television stations, the State Emergency Services and military forces can fall back on the limited capacity of emergency generating sets, but these at best provide only point sources of limited power supply.

Apart from the obvious inconvenience of interruptions to lighting, cooking and heating, the most serious consequence of the loss of electricity is the inability to maintain the refrigeration of perishable foodstuffs. The losses are high because, in the hot months when the cyclones occur, deterioration of the freezer contents occurs in 24 to 48 hours and millions of dollars of rotten goods may have to be disposed of, not an easy task in itself. If refrigerators are not attented to they may be irrecoverably spoilt after the thawing and spoiling of the contents. Food processing dependent upon refrigeration, such as ice cream manufacture, will obviously suffer badly. It is fortunate that the major cyclone period of the year is not the main killing season for the meat works.

Disruption of power supplies for several days causes shortages in water supply where a pumped distribution is involved, whilst other causes of water shortage may arise from the blocking of intakes by debris or heavy sedimentation. Excessive flood discharges may cause damage both to filtration plants and distribution networks.

Underground cables are not easily maintained in the tropics. Whilst there has been increased underground ducting in the towns, telephone cables are still above ground in many urban areas and entirely so in the countryside. Wind damage will cause major communication breakdowns. The solution is to be found in improved radio links, but topographic conditions and siting problems for repeater stations on high, exposed sites present some difficulties in providing cheap radio substitutes for land lines. Improvements in the communication systems continue to be made,

but disruptions to long distance and local communications are still a major problem in severe cyclones. The Townsville cyclone (Althea) of 1971 severed teleprinter contact between the local airport weather office and the Bureau of Meteorology's Tropical Cyclone Warning Centre several hundred miles distant in Brisbane.

Compared with United States towns, systemic effects of tropical cyclones in north Queensland are probably somewhat less acute. Losses of inventories, interruptions to work and serious revenue decline, due to reduced activity or loss of earning capacity, are less likely than in highly industrialized or heavily capitalized economies. Indeed, in addition to the obvious stimulation to the construction industry and to the retail trade from the demand for replacement of damaged goods, there tend to be substantial injections of finance from outside sources whether from government, private relief funds, and insurance payments or from the repair and re-establishment, by regional or national organizations based elsewhere, of their local facilities. To the extent that this finance does not depend upon local sources, such as insurance premiums, it is a charge which is widely spread over more than the local storm devastated area. Such a subsidy to recovery from outside may carry with it disadvantages to the extent that to a greater degree decisions on recovery policies or priorities may be made outside the area, perhaps not on lines felt to be most desirable from the local community viewpoint.

The individual Queensland town does not have its own sales tax; urban rates are primarily related to the land values and are little influenced by whether or not there is a property in use upon this land. This means that the loss of local revenue may be less serious compared with affected towns that have a significant local revenue base. State or Federal

revenues will be of course adversely affected by reduced earnings or consumption, but the burden is more widely spread. The amount of loss will depend somewhat on whether there are moratoria on rate or mortgage payments.

FACTORS AFFECTING THE CHOICE OF ADJUSTMENT FROM POSSIBLE OPTIONS

Theoretical Range of Adjustments

The range of possible responses shows a general similarity in many hazard situations, but the particular adjustments and their mix will vary from area to area and between different hazards.

Five major headings cover the possible choices:

(1) modification of the nature of the hazard,

(2) avoidance of the hazard effects,

(3) improvements in and better understanding of the warning system,

(4) loss bearing and sharing, and

(5) relief and rehabilitation.

Choice of Adjustments and Local Perceptions

The possibilities will be viewed through the filter of the human part of the system. Once there is awareness of the nature of the threat and of the possibilities of adjustment, further action will be determined by the way the community and its various decision makers perceive the problems and their potential solutions and evaluate the relative merits of the actions they feel are open to them. The manner in which costs and benefits are assessed, the technological capabilities to act, and the social and psychological attitudes of the society, in particular the

general social goals of that society, will all be relevant to the response and planning processes. Local inclinations and characteristics will modify the general patterns of hazard adjustment. Different considerations are relevant, and different possibilities occur, according to whether the adjustments relate to the problems associated with the pre-disaster phase, the impact phase or the post-disaster phase.

Reliable data on how individuals, communities or official decision makers view natural hazard situations in the tropical Queensland context are deficient. A limited perception study has been undertaken in Townsville (Stride, 1975), some information is available from the analysis of the social work and welfare organization for the 1974 Brisbane and Ipswich floods, and some comparative material is available from studies (Haas et al., 1976; Western and Milne, 1976) of the 'Tracy' cyclone at Darwin in December 1974. Although dealing with an extra-tropical locality, an excellent survey of community response and counter-disaster planning, especially from the social welfare point of view, has been recently published on the Toowoomba (southeast Queensland) hail storm of January 10, 1977. (Leivesley, 1977.) Further ideas on community attitudes, which would probably be applicable to tropical Queensland situations, are presented by Southern (1973) in a series of short papers. This significant field of research still awaits comprehensive investigation, and in the meantime viewpoints must tend to be tentative and subjective.

Historical study (Bolton, 1970) has demonstrated that settlement and economic development in tropical Queensland took place in the face of recurrent natural, economic and social challenges. Distance and poor communications put a high premium on self-reliance and on the use of both natural and human local resources. Ability to withstand adversity was

fostered, and in its turn encouraged a state of mind which accepted difficulties as something to be endured. An element of fatalism was coupled with an optimistic faith that all would be well in the end. Or, in the earlier days of development, there was an alternative prospect that a fortune might be made and enable the settler to move out of the area before suffering a cyclone. Expenditure of effort on unnecessary planning, for what might never happen or might not be nearly as serious as predicted, was questioned. It is suggested, though it cannot be proved, that something of this state of mind persists. It also contributes perhaps to the widespread misinterpretation by the public of probability statistics and return periods. It may make more serious the danger of the "cry wolf" syndrome that overwarning can produce.

There may be other individual or community traits that cause regionally distinctive reactions and behavior. Haas et al. (1976) remark upon the fact that in the Darwin cyclone disaster of 1974 the adjustment of the people to the disruption of the normal daily living routine was facilitated by their relaxed, open-air life-style. This would, no doubt, be equally true in tropical Queensland. This and many other regional personality attributes need to be identified and tested.

Those who have lived in tropical Queensland for many years are fully aware of the cyclone threat, but on the whole their understanding of the real nature of the tropical cyclone is often deficient, and their perception of the most appropriate response demonstrates an imperfect appreciation of the hazard problems. The Townsville study (Stride, 1975) suggests that there is a surprising ignorance of the meteorological structure and behavior of a tropical cyclone. This must inevitably affect the way people react to the immediate hazard event, understand cyclone

warnings, and make plans on a long-term basis. Over the period of the region's historical growth, respect for the seriousness of a cyclone hazard has not commensurably been translated into the siting of settlements or individual dwellings, into building techniques nor in the planning of daily activities. Respondents with higher levels of education showed a better, though in some respects still unexpectedly poor, appreciation of the nature of the hazard.

The question of the importance of past experience was not so easily assessed. It would be anticipated that direct personal experience of the hazard would result in a more informed response to the problems, a better choice of adjustments and less socio-psychological stress after a severe disaster. It is undoubtedly the case that, immediately after a cyclone and for a few years thereafter, there is a heightened awareness of the reality of the cyclone hazard. So far as the Townsville sample can be considered representative, personal experience of a cyclone and number of experiences, or length of residence in the area either did not appear a significant factor or was less influential than was anticipated. The tourist or the recent arrival tends to be more sensitive to the threat of a cyclone than the longer established inhabitant. This apparent denial of the importance of experience may however be an expression of these recent arrivals' ignorance of the true nature of the hazard and their susceptibility to the influence of the news media. Human reaction to disaster tends to be highly individualistic and community response to such situations is irregular. Before arriving at firm conclusions on these problems much more rigorous and analytical inquiry is necessary in each of the coastal settlements of Queensland. So far the nature of psychological reaction in contrasting social environments and where background

experiences vary is inadequately investigated. An extensive sampling survey is necessary to determine the answers. The scale of such a survey is a rather daunting prospect and requires financial backing on a considerable scale.

As elsewhere, there are vested interests who fear for their investments or future prospects of profit. Inevitably zoning restrictions on the use of localities with high risks of marine or land floods are unlikely to receive their enthusiastic backing. Fears that an exodus of visitors and tourists will be encouraged by too much discussion of hazard conditions or too much public warning rouse opposition, in some quarters, to the needs of improved hazard awareness. Complaints against the Bureau of Meteorology have been loudly and quickly voiced when it has been felt, often without justification, that warnings have been given too early, covered too wide an area or exaggerated the severity of the threat. Official thinking is still influenced by the pressures of criticism, and both short-term and long-term planning for hazard preparedness may be impeded.

Official caution can stem from an anxiety of blame for actions that subsequently have turned out to be incorrect or unjustified. The coastal towns of tropical Queensland have been surveyed and cyclone surge maps, for selected different sea-levels above normal high tide or mean tide, have been produced. These have been displayed in public places, but the publicity has been relatively low key and many know little about their existence and less about their details. There is the inevitable concern about the legal liability of producing a map which shows a particular surge level contour dividing one part of a built-up area from another.

Real estate interests may well exert pressure to limit the dissemination of statements on,or the mapping of,precise potential surge details to the minimum. The strength of this lobby is increased in a situation where past experiences cannot be documented and where there is a considerable degree of uncertainty as to the precise meaning of a surveyed contour line. A series of critical contours relative to a datum level can be surveyed and mapped, but whether a surge of any of these depths will be destructive will depend on the local terrain, the direction and strength of wind, and surface water run-off. It is virtually impossible to present these qualifications so that they can be usefully evaluated by those who are at risk. Local influences can modify specific surge situations in a variety of ways.

Evacuation plans with designated escape routes and reception centers exist for the major towns, but tend to be treated almost as confidential documents, not only because of the uncertainties of how the surge would behave in reality in a surge-risk area, but more because of the fears that panic and uncontrollable public reaction might follow a cyclone surge warning. Seventy-four percent of the respondents in the Townsville survey did not know of the priority zone evacuation plan and 75% were not aware of an evacuation center. No one has a clear idea of what would constitute over-warning in a Queensland context. Those in responsible positions become more concerned with the risks of giving hurried, incomplete or uncertain information than with indicating the possible dangers.

ADJUSTMENT IMPLEMENTATION

The survey that follows reviews the adjustment possibilities in the tropical Queensland context. As anywhere, community needs and actions

taken to diminish the hazard should harmonize. The emphasis can shift from efforts which seek primarily to minimize the impact of the hazard on those sections of the community least able to withstand it to a concern for reducing the potential level of maximum economic loss. Present hazard planning tends towards the latter approach in Queensland.

Modification of the Hazard

Weather modification. So far as the Queensland area is concerned at the present time in cost-benefit terms this is an unlikely operational prospect. The resources available to Australian areas at risk preclude air surveillance on a sufficiently extensive and continuous scale. In the Queensland case, there is little or no thought given to dealing with hazard situations "at source" with the exception of the possibility of cloud seeding to break local droughts. At the present time even this is not considered an operational strategy.

Technological reduction of risk or damage. The historical record of the small towns of tropical Queensland over the last 110 years or so is punctuated with occasions when serious cyclone damage has temporarily halted growth and economic development. The economy has not developed, as a whole, a very capital intensive framework in terms of major constructional elements, and the need for expensive and advanced building and engineering techniques has not progressed to the level observed in some more highly developed, risk areas of the world.

There is, nevertheless, a widely held belief that the technological solution to the hazard problem is the one which is the most appropriate and upon which resources and funds should be concentrated. In the Townsville study already referred to, respondents placed a high priority

on damage reducing adjustments in their choice from the possible lines of action, even if they did not in fact translate this into positive action in their own responses.

For many years in domestic dwellings there has been the use of tie-bolts and strengthening brackets to retain roofs in storm conditions. Townsville's 1971 cyclone experience resulted in a stiffening of building codes and a greater awareness of the need for special building techniques. In its train this has raised the unavoidable counter-criticism that building costs have been unduly increased as a result of stiffer regulations. In the Townsville area there had been a lull in direct cyclone experience since 1956; and, in consequence, concern for special adaptations to strengthen buildings had declined, though the State Housing Commission construction had incorporated stricter control to meet potential cyclone stress than had some private builders. With the increased awareness of the danger and suffering caused by the break-up of houses in cyclones, some thought has been given to the incorporation of a strengthened room in a house to provide a refuge. The cost factor has had a strong control on the acceptance of this modification and in consequence it has not been widely adopted. Designs for separate cyclone shelters have been publicized locally but there has been no move to adopt them. It has been acknowledged that much of the progress in engineering buildings to withstand major stresses from winds has been related to large and expensive commercial, industrial or public buildings. In consequence, less attention has been devoted to the smaller residential structure, particularly with respect to the different techniques of building and different types of building materials (Walker and Stark, 1977).

Engineering solutions are already available for most of the types of hazard but are often ruled out because of cost. In the case of floods, elaborate urban drainage schemes and river training programs are technologically practicable, but their cost is such that, even if they could be supported, other alternative solutions need to be investigated also. The effect of floods on the roads or railways could be largely eliminated by higher embankments, stronger and higher bridges, improved foundations and subsurface drainage. The high ratio of mileage to population has made the cost of more expensive levels of highway engineering prohibitive. This conclusion is greatly accentuated if we attempt to resolve the surge problem by employing engineering approaches to protect areas already built-up in the surge prone localities. Whilst it would be true to some extent that complacency and lack of a full realization of the nature of a surge threat has discouraged a technological approach, the real deterrent has been the magnitude of such a project and its potential cost in relation to the damage potential.

In the Townsville area the construction of a dam on the Ross River, which flows through the city, was primarily planned for water-storage. It has also, in the belief of professionals and public alike, provided the complete answer to the city's flood problem, so that anything like the 1946 flood, the product of the combined effects of a high tide and heavy rain, was made a thing of the past. The immediate consequence has been a rapid suburban growth along the downstream part of the flood plain right up to the dam reflecting complete faith in the technological solution. Thus we have yet another instance of the sort of potentially risky flood-plain development to which White has drawn attention in the United States since 1945 (White, 1945).

In general, however, the adoption of technological solutions has been restricted by the limited capacity of a small population to meet the high costs. Cost-benefit analyses have not probed all the complex dis-benefits of community disruption, psychological stress, injury and death. It is likely that some of the technological (and other) solutions to the hazard threats might be shifted from the too costly to the feasible category if a fuller accounting procedure could be evolved.

Avoidance of the Hazard

Evacuation. The only solution for the prevention of loss of life in the settled areas subject to flood or surge is to take refuge in a safe locality. Since there are insufficient high rise buildings in tropical Queensland towns this means evacuation from the risk areas.

Although evacuation plans exist, it is difficult to see how, on a large scale, people could be moved quickly and without extreme hardship and danger. There are considerable problems in the accurate forecasting of the landfall of cyclones on the east Queensland coast (Oliver, 1974), and even greater uncertainties of assessing the potential magnitude of the surge and its likelihood of coincidence with a high tide. A considerable lead time is needed if large numbers of cars are to be got on to the roads without panic and in an orderly manner. This lead time has to be increased in holiday times (and several public holidays come in the cyclone season) and particularly if the surge development is anticipated to occur at night. It is probable that strong winds and heavy rain will be experienced prior to the time when it becomes sufficiently clear that a surge threat is likely to justify evacuation. It would be all too easy to set large numbers of people traveling into the storm, along roads where

creek floods would occur first in front of the refugees and then behind them. Such floods could isolate them from towns and expose them to the full force of the cyclone. Such a frightening prospect is particularly a danger for north or south travel along the Bruce Highway that serves the coastal towns of tropical Queensland. This highway, despite recent improvements in bridge crossings, is still notoriously prone to being cut by the creeks and rivers that drain the upland catchments located immediately to the west of the coastal lowlands. The coastal region can experience sharp changes in conditions of rainfall and flood run-off over relatively small distances. Even without these difficulties the capacity of the coastal towns to absorb large numbers of refugees would be severely strained--except perhaps in the case of Townsville and possibly Cairns. If the evacuation is designed to move the population at risk from the lower surge prone areas, the availability of sufficient, safe reception centers within the cities becomes the difficulty.

If evacuation inland is proposed as the alternative, the prospects seem even worse. Whilst the full impact of the cyclone might be less once one moves inland a hundred kilometers or so, there is still the prospect of heavy rain and flooded creeks. The roads inland are much poorer in width and surface, garages and gasoline supplies are very limited and where the roads cross the main coast ranges the gradients are steep and the roads winding. A few breakdowns and accidents would bring an evacuee column to a speedy halt. Perhaps even more serious is the lack of possible reception areas. There are no inland towns which could serve as reception areas for large numbers of evacuees. To reach any urban centers would involve journeys of 80 to 120 kilometers or so. The alternative of a tented camp seems to present almost insuperable problems of water

and food supply and sanitation together with attendant hardships of mosquitoes and other insects and even snakes. Shade which is essential in the hot daylight hours would be hard to find. Living in cars during daytime would be impossible for any length of time. Evacuation to these inland locations, if it involved more than a few hours stay, appears to be worse than staying put, except for the highest risk localities. It is perhaps not unexpected that though about 40% of the Townsville inquiry respondents felt that evacuation plans should be prepared, a mere handful even considered this a solution they would personally use.

The discussion so far has considered evacuation as a means of removing people from high risk areas prior to the arrival of a storm. The question of evacuation after a disaster raises a different set of problems. Australia has had the unique experience of a large scale, long distance evacuation in the case of cyclone Tracy (1974) at Darwin. Some of the psychological and social costs of such an operation have been identified at least qualitatively (Western and Milne, 1976). A final judgment can hardly be made objectively, but it is clear that the decision to undertake such an operation is a difficult one. The larger coastal towns of north Queensland all have aircraft landing facilities which would enable a significant scale of evacuation, but the road system is inadequate and quite likely to be out of action for a few days at least. Judgment before the event cannot be passed but one is inclined to consider other alternatives for dealing with a cyclone disaster than evacuation. Without the introduction of martial law, present legal systems do not permit compulsory evacuation and reliance has to be placed upon persuasion and advice (Stretton, 1976).

Land use management. This strategy is generally a long-term action requiring careful analysis of the costs versus benefits. The actuarial threat must be accepted as being of sufficiently high potential severity and frequency. In the Townsville survey only 8% of those who were asked what their action would be if their dwelling had been destroyed indicated any intention to relocate outside the city, whilst 13% indicated that they would change their location within the city. It is often considered that the time base of much present day planning is a few years, whilst the time interval, for a particular locality, between cyclone events in tropical Queensland is a much longer one. Acceptance of longer-term solutions requires a more constant perception of the fact that a severe cyclone will occur sooner or later. This is helped by a long memory of past events which usually exists in official records, but less often amongst the frequently changing officials. For eventual adoption of the land-use approach it must be acknowledged that the disruptions and financial penalties involved by restrictions on the free choice of land-use are less unattractive than the dangers of no controls. This concept must enjoy widespread acceptance not only by the engineer, planner and government official, but even more so by the affected public. Appreciation of the risks of particular sites and locations in a severe cyclone is poorly developed amongst the general public. No responsibility is placed upon the real estate agent, the solicitor nor the local government authorities to take the initiative of warning prospective purchasers. In the Townsville area planning permission for further residential development in surge areas is still being given. Suggestions have been voiced that a legal obligation should be established for the listing of the hazardous features of a building site.

Even this involves some potentially difficult matters of judgment and associated legal problems. The rock of short-term material profit has wrecked many an environmental planning ship.

Some moderate success has attended local regulations designed to deal with river flood risks, which have a higher probability than storm surges, and flood bylaws that have been established before land development could occur. This has not applied at all in terms of surge risks. If an area has not been developed, land-use zoning, if accepted as a policy, provides the effective solution. Unfortunately, in such cases as Townsville, Cairns, Mackay and other settlements on the north Queensland coast liable to surges, much of the risk area was built upon early, and it is inconceivable, before the event, that abandonment of all this capital development and its re-siting elsewhere would be envisaged.

Coastal lands are fragile environments in which misuse of the land can exacerbate the results of natural environmental stresses. In the tropical Queensland case pressures for development have weakened some of the natural coastal defenses thereby increasing the potential threat of the high-energy destructive effect of cyclonically generated waves. Mangroves play a significant role in tropical coastal ecosystems, providing a stabilizing and protective fringe. Their value has been appreciated to an increasing extent, but much of the earlier town growth has eliminated considerable sections of mangrove coast and the process has still not been entirely regulated. Property rights have taken precedence over the scientific appreciation of the role of the frontal sand dune or beach ridge as a natural defense, so that buildings, roads and other forms of misuse have been allowed to proceed in vulnerable positions and often with harmful effects to these features. In both these instances there

is a need for a clearly defined land-use program to ensure that the cyclone hazard is not made worse.

Improvement of the warning system. The best designed warning system is of little value unless it is thoroughly understood by all those who have to use its products. Educative programs of the Bureau of Meteorology in the last few years have done much to sharpen the awareness of the Queensland public of the need for immediate precautions when there is the threat of a cyclone. The do's and don't's are clearly summarized in the Bureau's pamphlet which is made widely available before each cyclone season. There are still problems of ensuring that all households receive a copy, but as a consequence of this policy there is more public response. Action to ensure that loose materials are not left about in the summer season is still not taken sufficiently thoroughly, even by local government levels. Public response still occurs at the last moment, at the time of the warning or, at best, a few hours before the arrival of the storm. The Townsville questionnaire revealed, for the households surveyed, that most action was taken when the first cyclone warning was received or at some subsequent time up to a few hours before the storm arrival. It is still not unusual after a cyclone warning has been received in a north Queensland town to hear the sound of hammering as people secure the roof cladding.

Some problems still exist in the transmission of the actual warning messages. Part of the difficulty relates to the imperfect understanding by the public of the real nature and behavior of cyclones which means that the full meaning of the warning is not appreciated. Many of the public find it difficult to interpret the present form of locational and directional information in the warnings, and despite a clear explanation

in the Bureau's pamphlet, there is much confusion over the meaning of the two forms of notification, Cyclone Watch and Cyclone Warning.

Controversy occurs about the warning system. Present policy is to concentrate all procedures at the Tropical Cyclone Warning Center at Brisbane where all data including satellite information are sent and the synoptic analysis is undertaken. In turn all the watches and warnings are issued from Brisbane. This enables the maximum of expert control and a means of ensuring uniformity and coherence of analysis and forecast. It does, at the same time, place a very high emphasis on an efficient system of message transmission. Critics argue that it tends to remove initiative and emergency action from the man on the spot and that it inevitably introduces the potential for delays and human error since even the best message transmission system is liable to failures. The goal is to find the best compromise between 1) the advantages of the expert analyst at the Center who is able to make the fullest use of the meteorological information from radar pictures or satellite cloud imagery and 2) the less expert person on the spot, who may still have information, especially in the final stages of the cyclone passage, which is not available from the more formal meteorological input. Experience shows, however, that well intentioned but poorly informed comments at times of stress can be made by radio or television announcers and may cause community confusion.

Some of the major difficulties in keeping messages flowing and heard by those for whom they are intended arise at night and on holidays or weekends, when offices are closed and officials are not on duty. Unless transistor radios or televisions are kept operating all night, people can be oblivious of the risk. Neither the local police nor State

Emergency Service branch is sufficiently staffed or equipped to provide a full public address system in the towns which, considering their population size, tend to cover large areas.

The Bureau of Meteorology is understandably cautious about the dangers of overwarning, premature warning or unjustified precision in the warning. However this conservative approach may cause uncertainty in the public mind. The public is commonly unaware of the subtler implications of the form of the warning and may fail to assess the full danger potential.

The problem of complacency resulting from infrequent exposure to a hazard is difficult to resolve. The infrequency of severe tropical cyclones at any one locality has already been noted. There would appear to be a natural desire to forget and thereby, once the immediate memories of a bad storm fade away, as they do in a few years, settle down to an attitude of mind which rationalizes the cyclone threat at a much lower level of severity. This tendency is reinforced by the mobility of the population and the recent rapid growth of the larger towns on the coast. A considerable proportion of the population has little or no understanding of what a cyclone involves; many have come from places where there is no cyclone experience.

Loss bearing and sharing. Precise information on the public attitude with regard to insurance is lacking, but it would appear that there is a considerable degree of under-insuring and some non-insuring. This view is based on limited information produced by the Townsville survey when, in 1975, it appeared that only 52% of the respondents who were home-owners had done anything to increase their coverage since the 1971 cyclone, despite inflation. This fits the general impression conveyed by Haas

(Haas et al, 1976) from his Darwin cyclone inquiry where 70% of the houses, but a much lower percentage of the contents, were covered.

At present, comprehensive coverage meets wind damage and, provided additional arrangements are made, land flood as well. Sea attack, and therefore presumably storm surge, is specifically excluded from the coverage. The public does not appear to think of insurance as a major solution. Responses to an open-ended question in the Townsville survey on what steps householders would take in preparation for future cyclones indicate the majority would not increase insurance coverage.

The insurance industry itself has not been fully sure of the potential risks. On the whole, the experience of the 1960s had been a reasonably pleasant one for insurers so far as tropical cyclone claims were concerned. The 1970 cyclone Ada in the Whitsunday Islands and the 1971 Townsville Althea transformed the situation. Insurance rates in the north Queensland area, which is identified as the highest of three risk areas in the State were raised in November 1971 and again in April 1973, so that premiums are 3.13 times greater than before November 1971. The insurance industry has still lost heavily in recent flood and cyclone experience with payments in recent years greatly exceeding premiums. It is in this context that consideration is being given to a government backed Natural Disaster Insurance Scheme (covering perhaps floods, tropical cyclones and earthquakes) on which a Working Party report was issued in December 1976 (Commonwealth of Australia, 1976).

The present insurance coverage has no deductibles which encourage observance of building designs particularly related to cyclone stresses. The main distinction at present in the rates for domestic dwellings is between higher rates for wooden buildings and lower rates for brick and

fibro. This mainly relates to fire risk. At the present time the incentive is not there, from the insurance point of view, to build or maintain buildings at a level which will minimize cyclone damage.

In recent flood and cyclone disasters State and Federal response has provided generous assistance in kind and in financial aid. There is the possibility, though it has not been confirmed by objective inquiry, that the more the expectation of government aid the less the community or the individual will consider insurance or other forms of provision for future losses or hardship.

Relief and rehabilitation. Recent disaster situations in various parts of Australia from 1970 onwards have stimulated a major improvement and expansion of the relief and immediate recovery services that are needed directly after the crisis has occurred. The local civil defense organization initially proved inadequate in the face of a severe natural event but a subsequent reorganization has been undertaken. In the larger towns the State Emergency Service organizations have been developed. Their concern is limited to the pre-disaster and the emergency phases, and it has been the policy to date for them to withdraw as soon as possible thereafter and to hand over responsibilities to established agencies and government departments. At the national level, from November 1974, the Natural Disaster Organization has provided a focus for greater awareness of the disaster challenge and a liaison with the State organizations. The civil police in Queensland play an important part in the local emergency organization which is under their direction. Each of 27 Disaster Districts into which Queensland is divided has a Disaster District Controller (the local police inspector) assisted by a Disaster District Control Group. Generally technical and specialized training has

been made available to an increasing number of personnel in key positions, particularly through the wide range of courses both in management and technical skills at the National Emergency Services College, Macedon, Victoria.

Other organizations have contributed significantly in actual disaster situations. In tropical Queensland, major help has been available from the army base and from the Royal Australian Airforce and helicopter squadron at Townsville. Church organizations such as the Salvation Army, Seventh Day Adventists, St. Vincent de Paul, and others and the Red Cross provide, in total, a major voluntary effort which is further supplemented by several service clubs.

The problems that have arisen,given this variety of relief bodies, are those which, in one form or another, have surfaced in disaster situations in other parts of the world. The co-ordination of the various efforts poses a major challenge. Even in the early stages of post-disaster action, interagency jealousies and suspicions arise. Different officials see the overall problems from a variety of angles. Bureaucrats tend to dislike the voluntary organizations, whilst the latter are irked by what they see as official inflexibility and obstructionism. The weaknesses in cooperation can be traced in some cases to a lack of awareness of the need for coordinated effort. Local voluntary bodies feel that in their own minds they have a well conceived plan of action and do not perceive the problems that a variety of isolated actions will generate. The towns of tropical Queensland, as a consequence of their historical development, have a strong feeling of jealous independence of each other which tends to militate against combined or cooperative action. There is

also the practical problem of mobilizing aid from places some distance away when roads are impassable.

Recent experiences have shown the rescue type of operation to be better developed than the welfare and social work facilities which are only now receiving adequate attention. This deficiency is even more marked from the point of view of the continuation of social and psychological rehabilitation on a long-term basis. Indeed, in a number of situations, after the first major input of relief help from official and government services outside the area, the policy has been to rapidly hand responsibilities back to the local government and other organizations (often too rapidly and with insufficient arrangements for the transition). Reflecting this gap in the services is a major lack of knowledge at the local level about the occurrence or nature of psychological trauma produced by natural hazard stresses in a community. In Townsville's cyclone Althea, the impressions of relief workers and social workers seemed to confirm the lower capacity of older people to withstand the effects of stress, but no reliable statistics were assembled.

Subjective opinions of those involved in social welfare work in the community after Althea in Townsville noted the immediate post-disaster syndromes of mental lethargy and inability to grapple with personal problems of rehabilitation. It was further observed that those reactions did not necessarily require an individual's experience of direct loss or evident major disruption. In the Townsville case, workers in the social work field did not consider there was evidence of long-term psychological after effects, but it must be observed that no investigation of this problem was undertaken. The concern for the individual who has social or psychiatric problems may run counter to the aim of others who are

responsible for providing protection for the community during disaster situations.

A particularly difficult problem results from the relatively low frequency of hazard events and the distance between towns. For instance, since its founding in 1864, Townsville has experienced about nine damaging storms, in this century in 1903, 1940, 1956 and 1971. The relief organizations frequently depend upon a very small nucleus of trained permanent staff and a larger body of part-time volunteers. After considerable periods of inaction they may be called upon to respond to a high pitch of activity at very short notice. It is obviously difficult to maintain training and dedication to duty at the necessary high level in this pattern of operation.

Local rescue and relief inventories can be maintained only at a limited level, but it is generally possible with the help of service aircraft for emergency supplies, tarpaulins, even building materials to be flown in quickly after a cyclone. Federal and/or State action has been prompt in this respect, but inevitably there have been cases where hurried decisions or lack of precise information on needs have resulted in waste of materials, duplication of effort, or incorrect action. Small isolated communities present special relief problems, and in this respect service helicopters based in Townsville or elsewhere have played a valuable role. This was strongly emphasized by the part they played in the floods of March 1977 at Ingham (a small sugar processing town about 110 km north from Townsville).

Emergency situations require rapid and immediate decisions. Such decisions may be in conflict with the law and not have legislative sanction. This problem was highlighted in the evacuation following the

Darwin cyclone. Fortunately there are not too many cases where the potential delay in decisions or actions has occurred for legal reasons, but the problem is potentially serious. Perhaps it could be argued that distance, and the time needed to refer decisions back to central offices for confirmation, has given those on the spot greater freedom of action when it has been vital. When insurance claims, pensions, social welfare payments, and housing repair grants have to be referred for decision to a distant capital city, delays have certainly added to the immediate stresses. Deficiencies of local staff, such as building inspectors or insurance assessors, may in an emergency situation compound the administrative delays produced by remote decision making centers. Distance from the place of decision making is an aspect of natural hazard response in tropical Australia which may not only need more study, but potentially may become more of a planning problem in the future.

Recovery from disaster can be considered under four sequential headings: 1) the emergency period of initial search and rescue, 2) the phase of restoration of immediately required basic services lasting over a few days, 3) the first stage of reconstruction which takes place over a matter of several weeks or months, and 4) the second stage of reconstruction which improves on the achievements of the first stage and undertakes work on a more permanent basis which may extend over the equivalent or longer period than the first stage. No generally accepted ideas for target durations for these four stages exist. They will clearly relate to the particular problems of specific regions, and will be especially susceptible to the legal and governmental structures and their flexibility in the face of pressures for rapid but orderly action. The flow charting

of anticipated recovery situations on a critical path basis for hazardous areas would be a profitable line of analysis.

SUMMARY

The tropical Queensland pattern of natural hazard response shows a number of parallels with the findings of White and Haas in their Assessment of Research on Natural Hazards (1975) which surveyed the present position in the United States. The Queensland analysis underlines the fact that mistakes or inadequacies, such as those identified by White and Haas, are being repeated elsewhere in the world where local experience has not been sufficiently analyzed or utilized. Comparative analysis of U.S. and Australian experience lead to the not unexpected conclusion that the broad framework and the methodologies of natural hazard research are basically alike. It is clearly apparent, however, that in detail there are qualities which are uniquely local. These cannot be ignored in considering planning policies.

The situation in tropical Queensland is not static, however, and recent years have seen a sharpening of the awareness of the tropical cyclone hazard. The news media carries a much fuller coverage of such events, and consequently the public is more aware of the risk. From this awareness has followed a much more positive approach to cyclone planning though this has been slanted particularly towards resolving the most immediate consequences of a cyclone. It has been observed in general by Taipa (1973) that "Experts in the field of disaster relief are of the consensus that planning for disaster should shift from post-disaster response to pre-disaster preparedness." It is usually better to prevent a disaster than to have to cure the ills that result. This

viewpoint is surely applicable to the emphasis required in the Queensland case.

Long-term planning has received little attention. Most attention has been given to the strengthening of new buildings, with active research being promoted by the establishment of a Cyclone Structural Testing Center and the installation of a wind tunnel at James Cook University in Townsville, with financial support from the State and local engineers, architects and builders. Valuable though this is, and although there are some specifically local building problems, such developments are more of general than purely regional scientific and engineering application. Long-term growth planning has not shown itself particularly sensitive to the cycone hazard, and there are many who wish to see mention of such problems relegated to a minor position in any assessment of plans and prospects for future urban expansion.

It is impossible to gauge in objective terms the extent to which changes have occurred in natural hazard response over time. Has knowledge increased and have new adjustments been adopted? Has there been effective socio-economic feedback in the natural hazard system? Have perceptions of the hazard or response behavior changed significantly? Basically the impression is that the public at large has changed little in its outlook, though the professional and the public official, whose duties relate in some way to hazard situations, have become more perceptive.

Progress in disaster planning and research in Queensland so far has been uneven. The tropical cyclone warning system has been improved considerably by a screen of cyclone radar stations along the whole coast from Cairns to Brisbane and by automatic weather stations on coral cays or reefs off the coast. These improvements have been aided by improved

technology in data collection and synoptic analysis. The launching by Japan of a geosynchronous satellite in 1977, which will bring Queensland and the Coral Sea under continuous surveillance in 1978, will result in a further significant improvement.

The amount of research into the natural hazard situation is small and poorly integrated. It is not supported or directed on any coordinated basis. To this extent United States experience and past and proposed pattern of research inquiry provides a useful guide for future attention to the problems in Australia.

There are many areas in which further research is needed. This is particularly true with respect to the social problems and rehabilitation of disaster affected communities. Much of the existing information on the psychological and sociological aspects of the disaster situation in the Queensland context lacks the authoritative basis of a rigorous statistical social survey.

University based projects should be financed on a major scale with sufficient manpower for intensive research investigation. In addition, the State could support further hazard research and planning efforts through the resources of the Coordinator General of Public Works, possibly supplementing this work by encouraging the participation of local authorities.

In general terms, an integrative approach to hazard management must be adopted. This demands a searching and coordinated assessment of the range of possible adjustments and an examination of the effects of different mixes of those adjustments. In addition this broad approach requires the evaluation of the relative hazardousness of different areas of tropical Queensland and a better understanding of the physical pro-

cesses--including the consideration of the unresolved question as to whether or not any periodic, cyclical or trend pattern of tropical cyclones exists.

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APPENDIX A

AN ASSESSMENT OF RESEARCH NEEDS

Some areas of investigation on natural hazard impact and response with specific reference to tropical cyclones in Queensland in which more detailed, especially quantitative, data are required are outlined here.

1. The nature of the hazard

   a) An improved and more comprehensive chronological record of tropical cyclones, their magnitude, duration, area affected (locality, land or sea) and types of major disruption (excessive rain, floods, violent winds, storm surges) and loss; the mapping of hazard areas.

   b) Research into the meteorology of tropical cyclones in the Coral Sea region to assess whether specifically local atmospheric conditions exist which would influence the genesis and subsequent behavior of tropical cyclones in that locality and which would consequently introduce regional aspects in forecasting procedures and local needs in the extent and nature of data collection.

   c) A more reliable probability statement of the risk and an analysis of the validity of climatic fluctuations or trends; study of associated damage and mortality or injury trends.

   d) An analysis of the public understanding of the character and behavior of tropical cyclones as a preliminary to improved public education on cyclone risks and the development of a more effective and better understood warning system.

e) A consideration of the relevance, if any, of age, sex, education, social class to tropical cyclone perception.

2. The technological aspects of tropical cyclone impact and response

a) Translation of basic knowledge on wind and flood effects on buildings and other structures into the prevailing building and engineering practices employed in Queensland; the compromise in a local context in building design between roof overhang, large windows, open plan, ventilation openings and light building frameworks and the stresses caused by high wind gusts; more effective separation of design studies for domestic buildings and for engineered public buildings and greater attention to the practical limits of cost and construction time in the case of the former.

b) The reduction of the hazard of flying debris.

c) Assessment of the relative cost merits of construction designed to meet all foreseeable stresses and of less resistant and durable buildings which can, however, be easily repaired or rebuilt.

d) Evaluation of the engineering stresses on dams, flood levees, sea walls or embankments or groins which can be envisaged from the severest levels of catchment flooding or storm surge.

e) Better understanding of tropical cyclones as high energy causes of coastline changes; the mechanics and their consequences.

f) Assessment of the agricultural and forestry impacts--crop damage, cyclone scrub, damage to tree plantations, soil erosion, river bank destruction.

g) Assessment of damage to paintwork or metal by driven sand or salt spray.

h) Impacts on shipping, including small craft and port facilities.

i) Effects of air traffic disruption.

j) Effects on road foundations and surfacing in circumstances where major water table oscillations or surface flooding occur.

3. Zoning and land-use regulations, building codes

a) Analysis of the perceived criteria upon which decisions to avoid (or prevent) use of areas at risk from tropical cyclone damage are based. This analysis should be related to the understanding and attitudes of the general public, the investor or developer, the local authority and the professional engineer and economist, i.e. different decision-making groups.

b) Analysis, on similar lines, of the appropriate policy for the future use of hazardous areas that are already developed or occupied.

c) The problems of establishing building codes and ensuring their adoption; control over caravan parks and the possible adoption of tie down regulations for mobile homes.

d) Investigation of the legal aspects of disaster recovery.

4. Evacuation problems

a) Survey of community attitudes to hazard dangers and evacuation problems.

b) Investigation into problems of overwarning and community complacency; dissemination of evacuation plans; determination of legal powers for compulsory evacuation.

c) Examination for different communities and for the hazard risks to which they are exposed of evacuation procedures, routes and reception arrangements; assessment of the scale of operation required and the nature and cost of the disturbance caused; capacity of ambulance services to deal with sick, injured and aged.

d) Local evacuation and health problems in the tropics.

e) Social consequences of longer period evacuation disturbance on family and marital life.

f) Identification of risk groups in evacuation situations--aged, young.

g) Communication and record maintenance problems in evacuations.

h) Establish acceptable and unacceptable damage thresholds for the abandonment of high risk disaster localities.

5. Warning systems

a) The problems of warning frequency, amount and type of information desirable, and methods of dissemination.

b) Determine what is a desirable and what is a minimum acceptable lead time.

c) Safeguards to ensure speedy, accurate and unfailing transmission of warnings.

d) Centralization of meteorological cyclone warning centers versus local meteorological out-stations.

e) Problems of night hours and holiday times.

f) Control of media, radio, television to ensure standardized and accurate warnings and subsequent information without delaying

message transmission, or reducing flexibility in the face of special circumstances.

g) Should public authorities feel responsible for presenting a full assessment of the hazardous nature of their area; should this be on permanent display; should there be a requirement for the inclusion of hazard risks on the sale notice for a property or on the title deeds?

6. Insurance and loss sharing

a) Community attitudes with regard to insurance; the problems of complacency or ignorance.

b) Private versus government cover; the social responsibility of community protection in a hazardous area--a local responsibility or a state regional responsibility? The spread of insurance cover; the problems of differentiating risk areas and of relating premiums to degree of local risks.

c) Need for long-term actuarial information.

d) Guidance on ways of reducing damage potential; incentive of deductibles in premium assessment.

e) Comprehensive cover or selective coverage of the range of potential cyclone damage?

f) Desirability of insurance as an answer to the hazard danger.

g) Tax relief approach as an incentive to insurance and an aid to disaster recovery.

7. Relief and rehabilitation

a) Response during a hazard; problems of individual or community panic, disorientation, confusion; identification of vulnerable groups; education for action during a disaster experience.

b) The immediate post-disaster needs of a community--emergency food, water, fuel and power, sewage, hospital and medical facilities, immediate social welfare grants; community perception of its greatest needs; psychological and social problems--mental health; the sociology of disaster.

c) Plans for rapid re-establishment of transport and communication links.

d) State Emergency Service; its organization, financing and preparedness for long separated emergencies; difficulties of mobilizing large scale relief where towns are small and distant from each other.

e) The analysis of disaster situations in general and assessment of the need to identify different types of hazard; are the risks of war and enemy action distinct from natural hazard risks?

f) Examination of the differences, if any, between environmental problems that are persistent and those that are irregular and relatively infrequent.

g) Longer term recovery problems--social welfare planning, family, social and financial disruption; the responsibility for re-housing, refurnishing and re-employment; re-establishment of the social structure of disrupted communities; psychological lag effects.

h) Liaison between and co-ordination of different bodies concerned with hazard rehabilitation; conflict between official bodies and the voluntary organization; recovery timetable and its phases; pre-planning needs.

8. The overall balance sheet of a natural disaster

   a) Overall costs of a disaster and how the community bears the losses; proportions of loss covered by the local community and by funds from government sources, relief appeals, insurance payments which are only partly or not at all derived from local sources.

   b) The psychological challenge as an incentive to action and initiative; does disaster stimulate or accelerate on-going change?

   c) Tropical cyclones as beneficial events--water supply, control of pests, as a stimulus to urban renewal or to a flagging economy.

9. Future research requirements

   a) Establishment of a co-ordinating and supporting body for natural hazard studies, e.g., a Natural Hazard Research Council.

   b) Integration of individual post-event studies of major cyclonic storms; multiple solution instead of single solution approaches to hazards.

   c) Need for longitudinal studies of hazard situations.

   d) Need to distinguish and analyze single and complex hazard situations.

   e) Monitoring of social and economic changes and their link with assessments of natural hazard problems, attraction of labor to new mining or industrial developments in hazard prone areas.

   f) Need to train personnel in the construction and application of data collection methods including interview and questionnaire techniques.

g) The problems of incorporating costs arising in a particular disaster situation with respect to social and psychological disturbance, injury, death or health problems, additional administrative load, disruptions to activities not covered by normal damage estimates.

APPENDIX B

TROPICAL CYCLONE CROSSINGS

Crossings of the coast by tropical cyclones over the period July 1909 to June 1975. Sections are over 100 km stretches of the coast from Cape York southwards.

Section	Place with section	Crossing sea to land	Crossing land to sea	Total crossings
1	Cape York	1	2	3
2		0	1	1
3		1	1	2
4	Lockhart	2	4	6
5		2	0	2
6		1	0	1
7		3	0	3
8	Cooktown	1	3	4
9		12	3	15
10	Cairns	4	2	6
11		5	1	6
12		3	4	7
13	Townsville	5	1	6
14	Bowen	1	0	1
15		4	2	6
16	Mackay	3	2	5
17	St. Lawrence	4	1	5
18		5	0	5
19	Yeppoon	0	4	4
			Total	88

(Lourensz, 1977)

Note: A tropical cyclone is here defined as a synoptic low pressure system with which mean wind speeds sustained over a 10 minute period attain at least 63 km/h are associated. Not all such storms will be equally destructive.

APPENDIX C

MAJOR CYCLONIC STORM SURGES IN NORTH-EAST AUSTRALIA

Date	Location	Surge (meters)	Lives lost
1884 Jan 30	Bowen	3.05	
1896 Jan 26	Townsville	1.80	18
1899 Mar 5	Bathurst Bay	12.2*	307
1918 Jan 21	Mackay	3.66	30
1918 Mar 9	Innisfail	3.01	1
1920 Feb 2	Cairns	1.21	
1923 Mar 28	Groote Eylandt	7.01	
1934 Mar 11	Port Douglas	1.85	75
1948 Feb	Bentinck Island	3.66	
1949 Mar 2	Gladstone	1.52	4
1956 Mar 6	Mackay	1.40	4
1958 Apr 1	Bowen	1.51	2
1964 Jan 13	Karumba	1.52	
1964 Feb 4	Edward River Mission	5.48	
1971 Feb 19	Edward River Mission	4.57	
1971 Dec 24	Townsville (Toolakea)	3.66	2
1976 Jan 20	Yeppoon	1.00	

(Harvey, 1974)

* Evidence does not permit this to be confirmed with complete confidence. The death toll was caused by loss of the pearling luggers at sea.

APPENDIX D

INVENTORY OF CYCLONES

Inventory of cyclones crossing the coast (sea to land or land to sea) July 1909 to June 1975 indicating date of crossing, lowest central pressure recorded during the life of the storm (where known), direction of forward movement.

Gulf of Carpentaria Groote Eylandt to Cape York			East coast Cape York to Cape Capricorn		
Date	Central pressure mb	Direction of movement Degrees from north	Date	Central pressure mb	Direction of movement Degrees from north
5.1.1911	996	195	27.1.1910	--	210
18.3.1911	--	310	29.1.1910	--	115
21.1.1913	--	095	10.2.1911	--	110
1.2.1913	--	275	12.2.1911	--	190
2.2.1913	--	275	17.3.1911	--	215
9.1.1921	--	255	8.1.1913	--	070
2.4.1921	--	225	22.1.1913	--	100
4.4.1921	--	180	30.1.1913	985	270
28.3.1923	--	255	27.12.1916	994	245
31.3.1923	--	235	15.12.1917	--	210
27.2.1925	--	275	15.12.1917	--	105
12.2.1927	--	340	20.1.1918	940	235
26.2.1929	--	280	10.3.1918	988	245
27.2.1929	--	270	3.2.1920	988	245
19.3.1945	1000	275	1.4.1921	982	230
10.2.1946	--	290	6.4.1921	--	120
12.2.1946	1000	270	28.3.1923	994	255
6.1.1948	--	110	26.2.1925	--	255
12.1.1948	--	130	19.6.1925	999	215
21.2.1948	--	125	10.2.1927	--	250
23.2.1948	996	200	26.2.1929	--	235
12.2.1949	--	260	27.2.1929	--	105
13.2.1949	--	180	31.1.1945	--	230
15.1.1950	--	165	1.2.1945	--	110
21.1.1951	995	180	6.3.1945	997	110
20.1.1952	--	130	18.3.1945	1000	275
13.1.1953	--	200	19.1.1946	--	210
15.4.1953	1003	240	9.2.1946	996	235
16.1.1956	994	185	2.3.1946	982	240
21.12.1956	982	120	3.3.1946	--	145
1.2.1957	1003	115	4.2.1947	--	220

APPENDIX D (Continued)

Gulf of Carpentaria Groote Eylandt to Cape York			East coast Cape York to Cape Carpricorn		
Date	Central pressure mb	Direction of movement Degrees from north	Date	Central pressure mb	Direction of movement Degrees from north
15.4.1958	990	235	5.2.1947	--	065
15.1.1959	992	035	11.2.1947	--	205
19.1.1959	995	070	6.1.1948	--	110
25.12.1959	988	095	13.1.1948	--	080
26.12.1959	986	130	10.1.1949	996	115
20.3.1960	1002	270	11.2.1949	995	230
22.3.1960	1003	270	16.2.1949	--	125
3.3.1961	988	110	6.3.1950	--	270
19.2.1962	999	090	8.3.1950	--	085
7.1.1964 (Audrey)	999	180	10.3.1950	--	285
11.1.1964 (Audrey)	983	225	3.1.1954	--	115
4.12.1964 (Flora)	996	120	7.2.1954	990	180
5.12.1964 (Flora)	992	110	7.3.1955	965	240
14.1.1965	998	105	20.1.1956	1000	360
27.1.1965 (Judy)	1002	105	6.3.1956	961	275
29.1.1965 (Judy)	996	130	2.2.1957	1001	110
15.3.1967 (Cynthia)	994	335	1.4.1958	968	250
19.3.1967 (Cynthia)	1002	235	20.1.1959	985	125
28.1.1968 (Dixie)	986	225	16.2.1959	948	175
21.2.1968 (Bonnie)	1004	265	28.12.1959	997	095
11.2.1970 (Dawn)	994	070	20.3.1960	1002	270
18.3.1970 (Cindy)	995	255	3.3.1961	--	115
19.3.1970 (Cindy)	1000	035	6.12.1964 (Flora)	996	110
3.2.1971 (Aggie)	986	275	14.1.1965	1000	105
19.2.1971 (Fiona)	960	140	30.1.1965 (Judy)	997	075
7.1.1972 (Bronwyn)	996	125	18.1.1970 (Ada)	962	205
13.4.1972 (Faith)	997	115	11.2.1970 (Dawn)	994	075
29.1.1973 (Adeline)	970	205	16.2.1971 (Gertie)	988	295
1.3.1973 (Leah)	996	260	21.2.1971 (Fiona)	995	110
5.3.1973 (Madge)	996	270	24.12.1971 (Althea)	952	230
6.3.1973 (Madge)	--	290	14.4.1972 (Faith)	1002	095
25.3.1973 (Bella)	1002	190	4.3.1973 (Madge)	997	265
11.2.1974 (Yvonne)	1000	285	19.12.1973 (Una)	988	175
14.2.1974 (Yvonne)	995	225	10.2.1974 (Yvonne)	995	280

(Lourensz, 1977)

Note: The above list does not represent individual cyclones. In a number of cases cyclones moved out to sea and crossed the coast again elsewhere. Some cyclones moved from one region to another. Where they stayed within a region and crossed the coast more than once the name is repeated.

APPENDIX E

Organization of the Queensland Counter Disaster Organization (1975)

1. December 1975 an Act of the Queensland Parliament established the State Counter Disaster Organization (SCDO) and State Emergency Service (SES).

2. i) The Director of the State Emergency Service administers the SCDO and SES under the overall control and direction of the Minister for Police.

   ii) The Director SES is the Executive Officer of the Central Control Group of which the Chairman is the Coordinator General. This Group provides the link between the disaster area and the Government.

   iii) Queensland is divided into 27 Disaster Districts. Each such Disaster District consists of one or more local authority areas and the operational counter-disaster control is under the direction of the Disaster District Controller. The Controller is responsible for organizing the resources of his District for the counter-disaster operations and, where he considers it necessary, for requesting outside assistance. Under the Act, Police Inspectors have been appointed Disaster District Controllers. A Disaster District Control Group, chaired by the Controller and including representatives from the local authority, medical authorities, the court, ambulance, fire brigade, the Regional Operations Officer SES, and the Local Controllers, SES and others, is set up to assist each Disaster District Controller. It meets at monthly intervals during the cyclone season and six-week intervals during the rest of the year.

3. The State Emergency Service provides for the education and training of the members of the public for counter-disaster purposes and for the coordination, direction and control of volunteers, material and resources in counter-disaster operations.

   Under threat or occurrence of a disaster the SES is activated at State level by the Director SES or at local level by the Local Controller SES.

4. In the event that the effects of a disaster or threatened disaster are likely to exceed the capacity of the statutory services to deal with the situation a State of Disaster may be declared by the Disaster District Controller for a period of three days (with the approval of the Minister for Police or Chairman SCDO) or for fourteen days by the Governor in Council (on the advice of the Minister for Police).

5. A State of Disaster confers extensive powers upon

   a) Chairman SCDO and Disaster District Controllers

      i) Owners of resources can be required to surrender them to authorized persons for counter-disaster use

      ii) Evacuation or exclusion of persons from particular areas can be directed

      iii) Powers similar to those conferred upon the group listed under b.

   b) Local Controllers, Police Officers and other Authorized Persons

      i) Power to enter places where necessary to prevent loss of life or injury or to relieve suffering or distress

      ii) Power to close roads, etc. to traffic

      iii) Power to remove vehicles impeding counter-disaster operations

      iv) Power to evacuate or exclude persons from particular areas (with the concurrence of a).

FIGURE E

QUEENSLAND COUNTER DISASTER ORGANIZATION