

Natural Hazard Research

HUMAN IMPACT OF THE
MANAGUA EARTHQUAKE DISASTER

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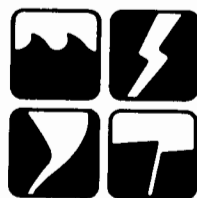
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PREFACE

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 is now being supported from funds granted by the U.S. National Science Foundation to the University of Colorado and Clark University. Authorship of papers is not necessarily confined to those working at these institutions.

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...the framers of the existing constitution of the State, in view of the rivalry and jealousy which exist between the cities of Granada and León, and in order to relieve the Legislative Assembly from the overawing political influence of the latter, designated the city of Managua as the place of its meeting. The choice was in many respects a good one; Managua is not only central as regards position, but its inhabitants are distinguished for their attachment to "law and order," and their deference to constituted government (1).

When the men of Granada and the men of León made a compromise decision in 1855 to locate the capital of Nicaragua on the shores of Lake Xolotlán they made a political accommodation and a geo-physical blunder. For no other city of similar size has had a more recurrent record of destruction than Managua. It has experienced severe shaking in 1885, destruction in 1931, severe but localized damage in 1968, and again enormous destruction in 1972. Thus it is not surprising that in the days and weeks following the December 23, 1972 disaster at least 39 groups of geologists, seismologists, and engineers from seven different countries converged on Managua to examine in detail this latest experience, for each such major geologic event provides the field data for earthquake science and engineering.

Less common was the mission undertaken by the authors: geographers, sociologists, and political scientists specializing in natural hazard and disaster preparation, prevention and research. Out of some forty major earthquakes in the last twenty-five years for which major scientific and engineering reports are available, only four have been seriously studied and reported upon by social scientists. Reasons for this discrepancy lie partly in the organization of science -- earthquake study is a well-organized component of the disciplinary

structure of the physical sciences and of engineering, but a comparable organizational focus is only beginning to emerge among social scientists. Underlying such organization is the latent view that the measurement and observation of earthquake events and their physical impacts is the proper activity of the physical sciences and engineering; the measurement and observation of human impact and response, is in the purview of journalists, relief organizations and governments.

But the extraordinary quality of the December 23-24 earthquake in Managua cannot lie in the uniqueness of its magnitude, its physical mechanisms, impact on the crustal structure or fortunate assemblage of seismic observations. An estimated 100 shocks of equal or greater magnitude occur yearly, the fault traces and mechanisms are unexceptional, the seismic record sparse. What brought at least 114 geophysicists, seismologists, and engineers to Managua in the month following the earthquake was the extraordinary destruction wrought by this earthquake, the potential for future recurrence and the hoped-for opportunity to gain from the Managuan experience insights helpful for earthquake loss reduction elsewhere in the world. In the interest of this concern which we share with our geophysical colleagues, we offer this report on human impact and response to the earthquake as complementary to the extensive geophysical, scientific and engineering documentation that will surely appear. But we also place our brief and hurried observation of human response in the context of the major questions of natural hazard and disaster research: How do men persist, survive and even prosper in environmental settings of high risk and recurrent loss? What is the nature of human response to catastrophe?

Human Adjustment to Natural Hazards

In a world without men there is no human hazard, only the ongoing geophysical process, exchanges and adjustments. Society, groups and individuals experience risk from natural hazards in the search for that which is useful in the natural world. There is a duality to resources and hazards -- the precipitation that waters the fields poses in maxima and minima the threats of floods and drought. Particularly attractive for human settlement have been the boundary zones of contrasting environments, those between land and water, mountain and plain, hill slope and valley. Such areas pose opportunities for the dual exploitation or integration of differing resources and climates and give special locational advantages for settlement and travel. The circum-Pacific seismic risk area is one such attractive zone -- a band of intense settlement -- where mountains meet the sea. If men are to reap the climatic, locational, and topographic advantages of a Japan, California, or Nicaragua, an encounter with seismic risk is inevitable.

In all societies men manage to survive and even to prosper in such areas by accepting the occasional, even catastrophic loss, by undertaking adjustments to modify the impact of natural events or to reduce human vulnerability and, more rarely, by making fundamental adaptive shifts in their modes of livelihood, habitation. Empirical findings from studies of fifteen natural hazards in varied settings within twenty countries now enable us to specify more carefully this process and to identify trends (2). On a global basis, we can speak

of folk, developing, industrial, and post-industrial societies, each having apparently distinctive patterns of losses and adjustments.

In brief, adjustments in the folk society are attuned more to modifying human behavior than to controlling nature, are often mystical and arational, are flexible and easily abandoned, are low in capital requirements, require action only by individuals or small groups, and can vary dramatically within a small area. The natural events that cause damage to be frequent, but the average loss for each event is low. But when events occur that exceed the capability of the society to minimize such losses, the ratio of deaths to damage is extremely high.

Adjustments in modern industrial societies involve a more limited range of technological actions that emphasize the control of nature, are uniform, inflexible, and difficult to change, have high capital requirements, require interlocking and interdependent social organization, but tend to be individually more efficacious than those in a folk society. With such adjustments, damage-causing natural events become less frequent, death rates diminish drastically, but the average damage loss for the remaining damage-causing events may be extremely high.

Comprehensive or post-industrial adjustments combine features of both the folk and the industrial society so as to involve a broader range of adjustments, greater flexibility and variety of capital and organizational requirements. In the few places, for the few hazards, that such comprehensive arrangements are now being practiced, damage-causing natural events increase slightly, death rates further diminish,

and average damage losses per event decrease by up to half of the maximum potential damage. Nevertheless absolute levels of damage and deaths may remain high as a function of increases in population and wealth over time.

The developing society normally contains substantial elements of an industrial society but such elements are often concentrated in a capital or primate city and surrounded by a rural society still characterized by folk culture. Evidence suggests that such societies are peculiarly vulnerable to natural disaster. In such societies much of the folk wisdom has disappeared or atrophied, and minimal applications of technology may actually increase the catastrophic potential. The expectations for support and relief may have shifted from family and clan to government or other large-scale organizations before the actual capacity to provide such aid has been realized. Thus, in one such developing country, Sri Lanka (Ceylon), where flooding is the most prominent natural hazard, per capita losses (in terms of relative income) from floods may be ten times that of the U.S., and amount to between one to two percent of GNP.

On another dimension, human adjustment is strongly affected by the character of the natural events. Earthquakes are at one extreme of a continuum of pervasive-intensive events characterized by such qualities as the frequency of recurrence, the extensiveness of affected area, the suddenness of onset and the magnitude of energy released per unit of affected area per unit of time. Earthquakes of high human impact are rare events (in a given unit area), affect relatively concentrated areas, are characterized by high energy release potential and extreme suddenness of onset. Such a hazard

does not favor extensive human adjustment because of the rarity of the event and suddenness of onset, and what adjustment does take place is literally built-in -- strongly oriented to resistant-building technology, controlling the secondary effects, and minimizing pain and loss of life.

In this perspective of the general characteristics of seismic risk and of hazard adjustment in developing countries, we can consider the unique qualities of pre-earthquake Managua: its urban history, geological setting, seismic record, and current social organization.

Urban History of Managua

Managua, Nicaragua, on the south shore of Lake Xolotlán, is no stranger to massive human tragedy. In the past four hundred years this site witnessed repeated bloody war, uneasy truce and natural catastrophe of great magnitude. At the time of the Spanish Conquest, this place, which would be called Santiago de Managua, was the location of an extensive settlement of Dirianes whose condition at the time of conquest and whose fate thereafter are concisely summarized by the Spaniard Oviedo.

"It (Managua) was inhabited by Chorotegans, and, to tell the truth, it was a beautiful and populous village, but so far from forming a city, was composed of isolated houses, at considerable distance from each other. Before it had been destroyed by war, it covered a great space, and resembled the villages to be seen in the valley of Alva, in Biscay, in Galicia, among the mountains and valleys of Ibarra, where all the houses are in view of each other and occupy considerable room. This village of Managua extends in a line along the lake; but so far from having three leagues of extent, it scarcely has one.

However, at the time of its prosperity, it was the finest place of the province, and contained 40,000 inhabitants, of which 10,000 were archers, or slingers. But when I visited it, six years after the Conquest, it was the most completely abandoned and desolate place of the government. It now contains 10,000 souls, of which 600 are archers (3).

In the 1840's when E. G. Squier traveled extensively in Nicaragua in the service of the Department of State and the proposed inter-oceanic canal the population of Managua had hardly changed in numbers. Except for the fact that the town had de facto become the compromise capital (in 1855 it would become officially so) of a nation torn by internecine conflict between the Liberales of León and the Conservadores of Granada, Squier's description leads one to believe that it had also changed little in ethnic make-up and daily custom (4).

The total number of inhabitants of Managua probably did not pass 20,000 until the early years of the twentieth century and did not again reach its pre-Columbian estimate of 40,000 until the late 1920's a period of growth in the commodities export economy and of civil war replete with U.S. intervention in the form of the ubiquitous Marine Corps. At the time of the great earthquake of 1931 the guerrilla leader Augusto Cesar Sandino issued a cease-fire order, nonetheless extra U.S. gunboats and other military reinforcements arrived at the same time as disaster relief personnel and supplies (5). The political order which is now Managua's did not arrive until two years later with Sandino's death by gunshot.

The history of the modern city of Managua dates, in fact, from this period of great political and economic change -- the late 1920's and 1930's. Recovery (in terms of population size) from the Conquest

took 400 years; recovery from the 1931 earthquake took considerably less than a decade. By 1940 the city's population had passed 50,000; by 1963 it had passed the quarter-million mark and the best estimates on the eve of the December 1972 earthquake are somewhat greater than 400,000 (see Figure 1).

The changes which Managua has undergone in this century are graphically indicated by its absolute population growth and its population growth rate since 1920. From a town of predominantly Indian tradition and culture, Managua, under the impetus of commodities export and a growing commercial industrial sector, had by the mid-1960's become a city typical of its kind in the developing world. The city's streets were filled with cars, trucks and buses during the working day and nearly empty after six p.m. and on weekends. North American and European foodstuffs might be purchased in a modern, shiny supermarket, and Iguana and Pithaya might be bought from wicker baskets in the Mercado Central. American, Japanese and German businessmen vied for the attentions of local entrepreneurs during business hours and during siesta sipped mixed drinks or beer (sometimes Lowenbrau) under the big fan in the Gran Hotel, elbow to elbow with Texas cattlemen and rough and ready cropdusters. Twenty thousand men, their families representing one-quarter of the total urban population, worked in the modern industrial sector, mostly along the North Highway, but the now dead heart of Managua was a place where the striking, stereo-typical contrasts, so familiar in the developing world, reigned.

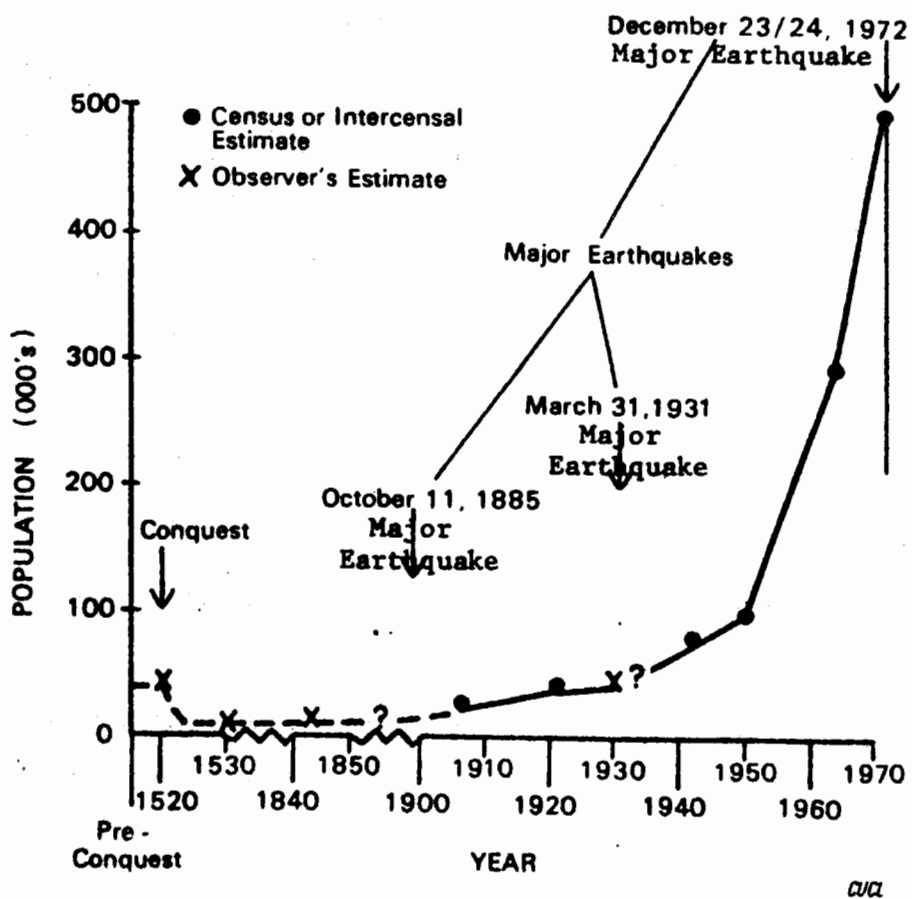


Figure 1. (6)

Population of Managua Over the Last 400 Years Compiled From Varied Sources and Illustrating the Recency of Growth

Seismic History

The plains of Managua constitute with Lake Managua, Lake Nicaragua, two major chains of volcanic mountains, and a scattering of other important geologic features, the Nicaraguan Graben, a long lagoon-dotted depression lying 30 km to 40 km inland from the Pacific and cut by innumerable fault lines generally running parallel to the coast (see Figure 2). The plains themselves are made up of aluvial and volcanic sediment dating from the late Tertiary and Quarternary periods. This broad, low fan which has been the site of the human settlement now known as Managua for at least 500 years is bounded on the north by 1040 km² of a seriously polluted Lake Managua, on the west and south by the Sierra de Managua, a northwest-southeast tending chain of volcanic material, and on the east and south by the major northwest-southeast tending chain of volcanoes which seem to lie along an extension of the fault line which is occupied to the northwest of Managua from León to Chinandega by the Cordillera de Marrabios (7).

In the century prior to the occurrence of the recent earthquake, Managua was damaged in 1885, 1931, and 1968. Comparative data are presented in Table 1 and brief descriptions follow:

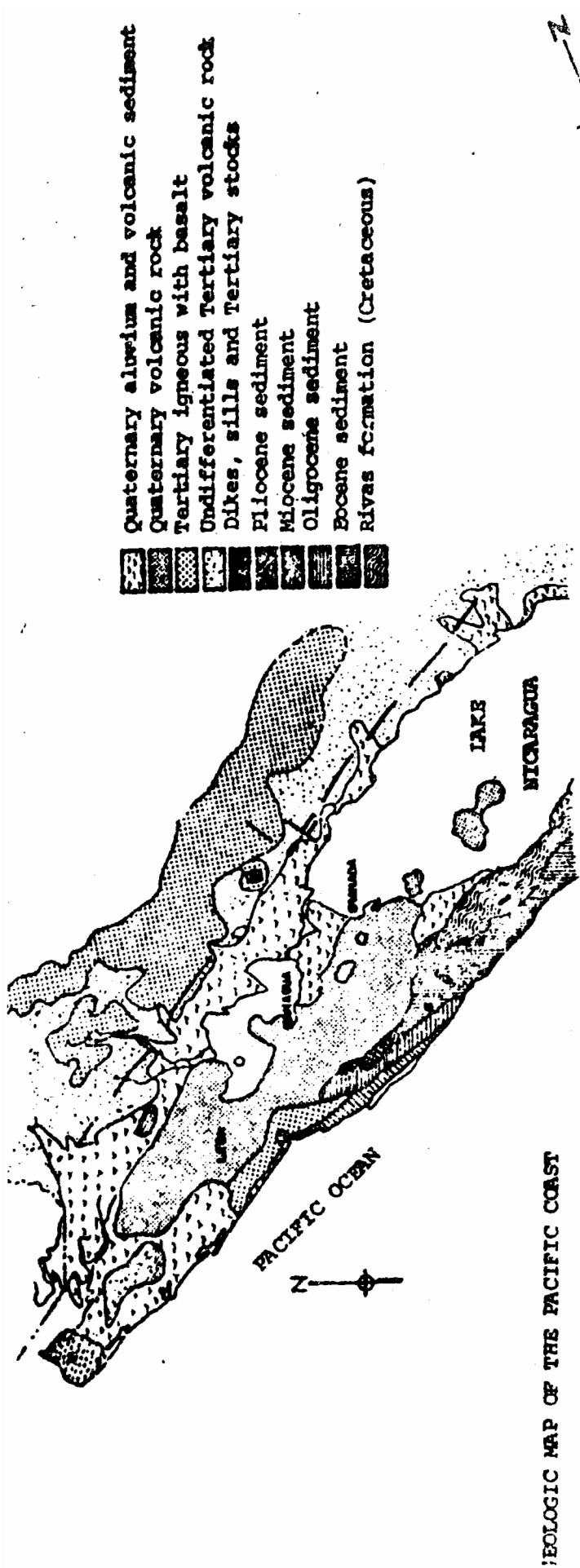
1885: As might be expected very little information exists about this earthquake other than that a very damaging earthquake struck Managua on October 11, in 1885. There were no estimates of casualties or damage except as implied by statements that the earthquake produced enormous material damage.

1931: This devastating earthquake has been well documented (8). It occurred at 10:10 a.m., March 31, 1931. In addition to the 1-2,000 deaths, there were several thousand injured. About 35,000 were made homeless. Property losses were estimated at \$14-\$30 million (1931 values). Surface faulting was discovered, and its approximate location is shown on the map (Figure 3). Serious damage covered an area of about 10 km², and minor damage was noted over about 23 km². Reinforced concrete buildings were reported to have fared well, even those poorly constructed, but the dominant wood frame with mud and rubble-filled walls survived poorly and fire contributed to the overall damages.

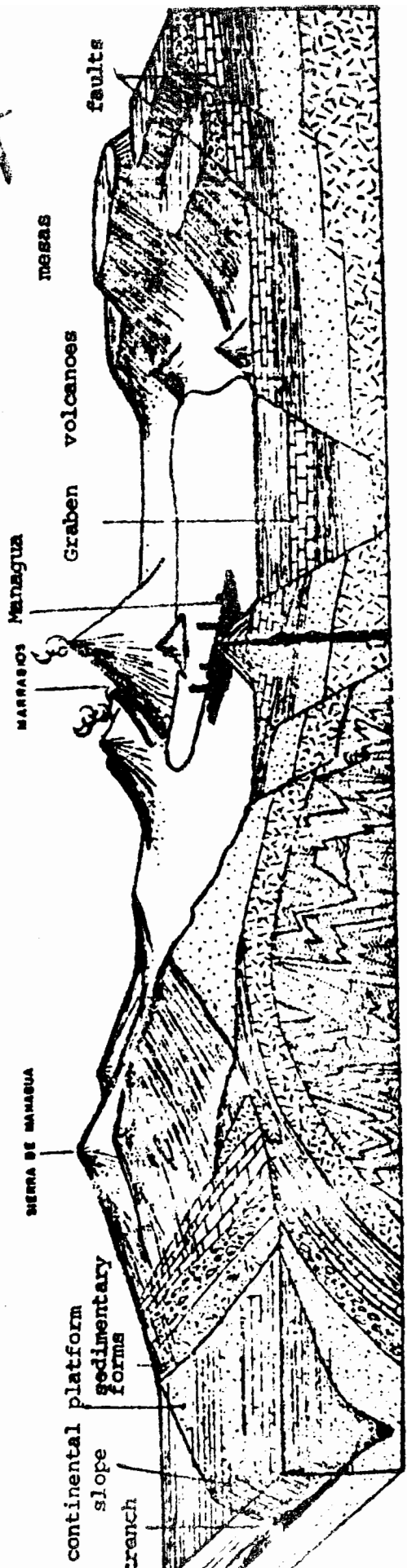
1968: Unlike the 1931, and 1885 earthquakes, this earthquake strongly affected a highly localized area on the outskirts of Managua (southeast). It occurred at 4:04 a.m., January 4. Except for two housing developments the area was lightly populated. These two developments and nearby schools, a dormitory and orphans' home were damaged. There were no reports of deaths or serious injuries, and we could not locate any figures for property damage.

Social Organization

A useful way to think about a city is to see it as a social system having many of the abstract characteristics of a very large, complex organization. A city has a wider range of system activities than in organizations, and the coordination and type of centralized



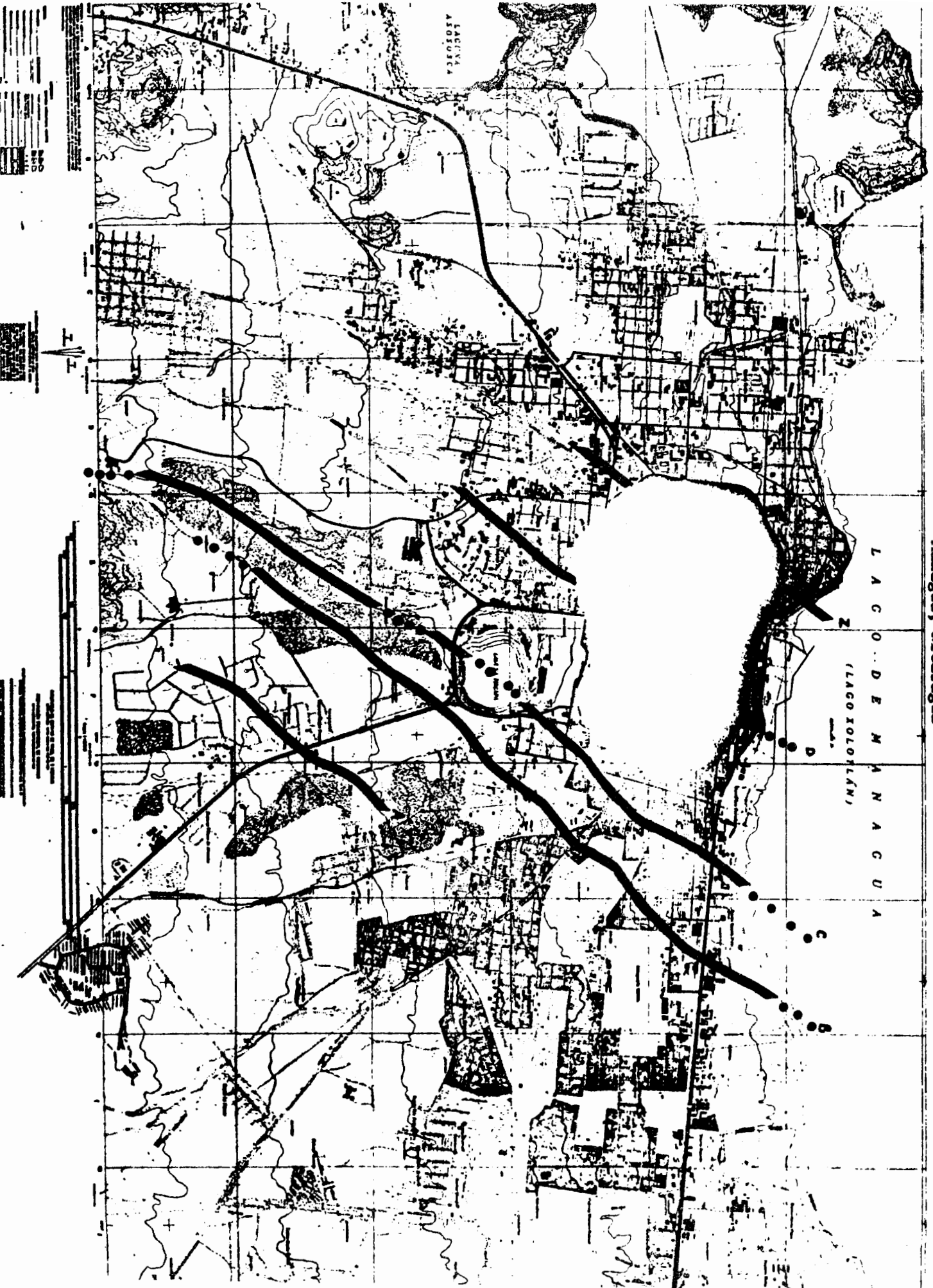
GEOLOGIC MAP OF THE PACIFIC COAST



BLOCK DIAGRAM OF THE PACIFIC COAST

Figure 2 -- A Block Diagram (Adapted from J. Incer) Showing the Setting of Managua, City and Lake, in the Graben that is Parallel to the Coast and Offshore Trench.

Estimated Area of Greatest Damage and Fault Ruptures of
December, 1972 Earthquake and 1931 Earthquake Fault Rupture,
Managua, Nicaragua



control is generally less pervasive. However, general social processes, such as maintenance, decision making, communication, conflict and adaptation to the external environment, are operative in both organizations and cities.

In our analysis we will cut across the various systemic processes by focusing on the basic community-relevant activities as they exist before and after the earthquake. In so doing we draw on previous research of community response to sudden impact, no warning, disaster primarily in North America, Japan and Italy (9). Needless to say, direct comparison with urban conditions and behavior in low income countries such as Nicaragua, should be made cautiously, at best.

The community-relevant activities in any city are based on a variety of determining variables. The principal category among these is the community normative structure. It includes widely held values, which are rather general and abstract notions about what is right and important, and social norms which encompass fairly specific ideas about required, preferred, and forbidden behavior. Some social norms appear in the form of legal statutes but most are simply understood by most adults without ever existing in written form. The significant point is that during "normal" periods in the ongoing life of any city there is a comprehensive normative structure, widely known, which can act as a blueprint for almost any set of circumstances that may arise. We shall return later to a discussion of the significance of this normative structure for the people of Managua after the earthquake's impact.

A large city provides essentially the complete life support system for its inhabitants and its visitors. For that to occur, however, there must be extensive interchange with the city's external environment. Managua, as is the case with many cities in developing countries, was very dependent on both the rural countryside in Nicaragua and on foreign sources and markets. Within the city itself, however, the range of basic community-relevant activities was fairly typical. The list includes those activities which center around 1) preservation of life and health, 2) provision of food, clothing, and shelter, 3) economic functions (production, distribution, sales, etc.), 4) provision of basic community services (utilities, transportation, communication systems, etc.), 5) maintenance of public order, 6) leisure and recreation, and 7) socialization (education, provision of information).

There were not many unusual features in the conduct of these basic community-relevant activities immediately prior to the earthquake. Schools were out for the Christmas holiday season and the stores had the usual upsurge in buying. But there were some patterns of activity in three areas which would not be considered typical in a U.S. city of comparable size and are particularly related to evaluating the earthquake experience.

Provision of food, clothing, and shelter. Nicaragua, as other Latin American countries, has a pervasive extended family system (10). Any given individual may reasonably anticipate assistance and social and psychological support when needed not only from members of the immediate household but to a significant extent also from uncles, aunts,

cousins and members of their households. While this pattern shows up in a variety of ways it is perhaps most noticeable in the provision of food, clothing, and shelter. The nuclear family in Managua is not a little island unto itself as is often the case in U.S. cities, although each family did have its own dwelling unit, however small.

The pattern of residence also differed. The central city contained many small commercial establishments within which the owner/operator family also lived. Thus there was more residential occupancy in the commercial district than is typical for the U.S.

Nicaragua was undergoing a year-long drought when the earthquake struck. During the preceding months some voluntary relief organizations such as CARITAS had operated a food distribution program for the most needy. However, Managua had no "welfare clientele" in any way comparable to most U.S. cities. The poor, no matter how desperate their plight, knew that no agency whether government or private would care for them on a continuing basis.

Provision of basic community services. Citizens of Managua could move around the city with relative ease due to the large number of bus lines and the frequent schedules. Only the moderately well-to-do could afford autos and so the busses were heavily used and except for the city center, traffic jams were quite rare. Many of the poor were accustomed to walking. Managua was not a city dominated by private autos and thus differs significantly from the prevailing patterns in the high-risk seismic areas of North America.

Maintenance of public order. Managua did not have a city police force for this purpose. No Nicaraguan city does. The National Guard was the only organization involved in law enforcement activity. It

was reported that in recent years some small movement had been made toward dividing the city into something like "police precincts" with a designated military officer responsible for law enforcement in each area. Reportedly there were only 5,000 personnel in the entire National Guard in all parts of the country prior to the earthquake. It is not known what proportion of the Guard personnel was in and around Managua on December 23, 1972. There were certainly no "competing" law enforcement agencies as is sometimes the case in the U.S.

A related pattern was the watching and guarding of property. Yard space around upper-class dwellings is almost always surrounded by a fence with sharp pickets or a wall with glass shards imbedded in the top edge. A private home is seldom left unattended. Either a family member remains home or a hired watchman/guard is present. The underlying assumption seems to be that anything of value that is left unguarded is fair prey.

Earthquake preparedness. Thus the special quality of the Managua situation prior to the quake was the unusually high occurrence of damaging earthquakes in a relatively new and rapidly growing city that contained twenty percent of the population and the major industrial, commercial and governmental capacity of this small nation. Yet despite its seismic history and special centralized vulnerability, pre-earthquake disaster prevention or preparedness measures were almost non-existent.

A number of major structures, at least six, had been designed and constructed in accordance with U.S. practice. A law providing

for seismic-resistance of major structures had been recently passed but not implemented. Insurance was in force on upper-income housing (with a coverage, perhaps fifty percent, exceeding that for comparable housing in California, about four percent (11)), by virtue of being required by the local mortgage lenders. And a radio frequency had been set aside for emergency broadcasts as part of a Central American network. To the best of our knowledge this was the entire state of significant pre-earthquake disaster prevention, planning and preparedness.

Premiums for insurance provide a clue to the perception of risk held by Managuans at least those with actuarial connections. The rates of \$2 to \$8 per \$1,000 coverage (with 1% deductible) imply an expectation of earthquake recurrence substantially less than that actually recorded in the seismic history.

The Earthquake of December 23, 1972

Three shocks produced most of the damage to Managua. They occurred at 12:29, 1:17 and 1:19 a.m. local time on December 23, 1972. A magnitude of 6.2 on the Richter scale has been computed for the first and largest of the three shocks. There were foreshocks beginning about 10:00 p.m., December 23 which resulted in some persons sleeping outdoors that night. Aftershocks (over 100) were continuing at this writing.

Surface faulting was located in four zones (A-D on Figure 3). This has been mapped extensively by the U.S. Geological Survey. The

greatest zone of damage was in the older downtown area (shaded on map). Moderate to extensive damage, including collapses, extended virtually everywhere in the vicinity of Managua. Damage was due to shaking, faulting, and fire in the downtown area. It is probable that these earthquakes had a shallow focus (epicenter close to the surface), which often intensifies damage. The epicenter of the main shock has been tentatively located northeast of the city under Lake Managua. Additional information is presented in Table 1.

When the sun rose over the city of Managua, Saturday, December 23 out of an estimated population of 420,000, at least one percent were dead, four percent injured, fifty percent (of the employed) jobless, sixty percent were fleeing the city and seventy percent were homeless. In this nation of two million people at least ten percent of its industrial capacity, fifty percent of its commercial property and seventy percent of its governmental facilities were inoperative. To restore the city would require an expenditure of a magnitude equivalent to the entire annual value of Nicaraguan goods and services. In a country where the per capita GNP is about \$350 per year, the seventy-five percent of Managua's population affected by the earthquake had on the average a loss of property and income equivalent to three times that amount, \$1,050.

There is a unique epistemology of disaster reporting. No one will ever really know the precise human magnitude of the disaster. Estimates of death ranged from 2,000 to 20,000; estimates of damage are almost certainly overstated. The methodology of loss estimation

Table 1

SELECTED CHARACTERISTICS OF DAMAGING EARTHQUAKES,
MANAGUA, NICARAGUA, 1885-1972

Date	Population	Magnitude ¹ (Richter)	Est. Duration of Strong Shaking	Lives Lost	Property Damage
Oct. 11, 1885	20,000 (1906)	Unknown	30 seconds (?)	Unknown	Enormous Material Damage
Mar. 31, 1931	45,000 (Est.)	5.3-5.9 (Est.)	6 seconds	1-2,000	\$15-\$30 million (U.S.)
Jan. 4, 1968	317,600 (1963)	4.6	5 seconds	0	Unknown
Dec. 23- 24, 1972	420,000	6.2(M _s); 5.6 (M _b) ²	5-10 seconds	4-6,000	\$400-\$600 million

NOTES:

¹For the earlier earthquakes (1885-1931) there were either no or poor quality instrumental records.

²M_s = Magnitude of the surface waves; M_b = Magnitude of the body waves.

itself is not clear. Damages differ whether they are considered as replacement value, restoration value, or the depreciated value of assets or property. In the aftermath of disaster the actual costs and expenditures may become seriously inflated. Conversely much opportunity for repair and salvage is underestimated initially. Losses differ by accounting stance as well. Much money will change hands among Nicaraguans. There are winners as well as losers even in great times of tragedy.

Two weeks after the earthquake a National Committee for Economic Reconstruction with specialists from government, industry, and the Central American Institute of Business Administration prepared the damage estimates given in Table 2. The estimates are based on simple and crude measures of damaged area, of employment, of the distribution of rental and owned property, and assumptions as to the average amount of space required per worker for commercial, industrial and governmental purposes. They are not really damage losses, rather, in the main, they reflect replacement costs. They include many transfer payments, for example, emergency expenditures for locally grown food stocks may only reflect a shift from private individuals to the government of the cost of food. Nevertheless, the estimates and the documents accompanying them are impressive when compared with early estimates made in other disasters. (For example, in the 1964 Alaska Earthquake (12)). Based on our review of these estimates, we would bracket the losses of material wealth as between \$400 and \$600 million.

Table 2

ESTIMATE OF DAMAGES CAUSED BY THE
EARTHQUAKE OF DECEMBER 23, 1972¹
(MILLIONS OF DOLLARS)

	Buildings	Equipment and Furniture	Inventories	Emergency Costs Unre- couperable ²	Accounting Losses and Others	Sub-Total
Government	22.5	9.0	1.0	38.6	30.3	101.1
Industry	3.0	15.0	2.9	2.6	17.1	40.6
Commerce	60.0	12.0	31.5	3.0	21.3	127.8
Housing	312.3	50.0	2.1	---	---	364.4
Services	28.5	11.4	4.5	4.4	---	48.8
Infra- Structure	101.4	30.8	5.8	20.8	3.3	162.1
Sub-Total	527.7	128.2	47.8	69.4	71.7	844.8

¹Translated from Table 1 "Evaluacion Preliminar de Daños a Consecuencia del Terremoto de Managua -- 23 Diciembre, 1972."

²Note: This column includes cost of feeding, medicine, temporary facilities, wages, etc., which have been incurred as a result of the earthquake as well as government income which will be lost.

Where this enormous burden of loss falls can only at this stage (and perhaps forever) be impressionistic. We would expect the deaths to be heavily concentrated among the very old and the very young. A review of estimates of rents and value of housing loss suggests that forty percent of the homeless were among the poor, fifty percent were salaried or self-employed middle-class and the balance well-to-do (13) and the psychic distress, widely reported but inordinately difficult to assess, cut across the entire society.

The comparison of the Managua, Nicaraguan earthquake of December 23-24 with the San Fernando Valley earthquake of February 9, 1971 well illustrates the special vulnerability of the transitional society. For a seismic event of a roughly comparable intensity pattern, Managua's deaths were one-hundred times greater and injuries ten times greater. Property losses, however, were roughly comparable but the relative impact in terms of income, fifteen times greater. (See Table 3).

Another comparison that may be instructive is to compare the earthquake with a man-made hazard that captured the imagination of the world during roughly the same period as the earthquake and with which comparisons were widely made. We refer to the renewal of intensive bombing of Hanoi that took place during the periods of December 18 to 28, 1972. From news sources we would estimate that the total tonnage of bombs dropped on Hanoi was of the order of 40,000 tons. Using North Vietnamese official statements, the number of dead and injured was 1,318 and 1,261 respectively. In terms of energy, that released by a Richter 6.2 earthquake in Managua, was twenty times the total tonnage of bombs dropped on Hanoi during that period.

Table 3

COMPARATIVE DATA FOR HUMAN IMPACT OF DECEMBER 23-24, 1972
 MANAGUA, NICARAGUA EARTHQUAKE AND FEBRUARY 9, 1971
 SAN FERNANDO, CALIFORNIA EARTHQUAKE

	Managua, Nicaragua	San Fernando, California
Magnitude (Richter Scale)	6.2	6.6
Duration of Strong Shaking	5-10 seconds	10 seconds
Area of Mercalli Intensity:		
VIII-XI	---	500 km ²
VII-VIII	---	1500 km ²
Less Than VII	---	?
Estimates of:		
Population of Affected Area	420,000	7,000,000 (1500 km ²) 1,100,000 (500 km ²)
Dead	4-6,000	58
Injured	20,000	2,543
Evacuees	220-250,000	80,000 plus
Housing Units:		
Destroyed (Unsafe)	53,000)	915*
Damaged)	29,559**
Commercial-Industrial:		
Destroyed	n.a.	574
Damaged	n.a.	1,125
Hospitals	(1,650 beds) 4	21
Schools	(classrooms) 740	180***
Unemployment	51,200	?
Damage (Restoration Value)	\$400-\$600 million	\$504,950,000****
Per Capita Loss	\$1,050	\$72

San Fernando: * Includes 65 apartments; ** Includes 1707 mobile homes and 58 apartments; ***Of which 35 received major damage, and 18 were located as unsafe; ****Of which \$250-\$7 million was public property.

Managua: Author's evaluations of data contained in "Evaluación Preliminar de Daños a Consecuencia del Terremoto de Managua -- 23 Diciembre, 1972."

Source: Report of the Los Angeles County Earthquake Comm. 1971: San Fernando Earthquake, Feb. 9, 1971; and Special Subcommittee of the Joint Committee on Seismic Safety, California Legisl. 1972: The San Fernando Earthquake of February 9, 1971 and Public Policy.

The bombs that fell on Panoi fell on a city that was prepared in considerable measure for such attack. The earthquake that struck in Managua struck a city that should have been better prepared but was not. Nevertheless, the comparison might be instructive in one particular sense. Both the energy pattern and human impact of what most observers would consider the most powerful of man-made hazards (war-time bombing short of a nuclear explosion) is still small in comparison to the enormous destructive potential of natural events.

Response to Disaster

When massive physical and human damage take place as a result of the sudden impact of "natural" forces and without significant prior warning, a reasonably well-known series of activities ensue. This account of typical immediate post-impact activities is based on what reportedly has occurred in modern times in North American, European and Japanese communities struck by a large earthquake or similar disaster agent (14). The sequence in which the activities are discussed is thought to be a rough approximation of the typical sequence following disaster impact, but the various activities overlap in time (15).

A typical response scenario (affected community).

1. Initial assessment of physical and human effects: through direct observation and contacting others, seeking to discover what has happened, who is hurt and who safe.

2. Efforts to secure self, family and organization: a quick initial attempt to shore up and to save those persons and property immediately around the individual.

3. Spontaneous search and rescue activity: cries for help and the sight of rubble are quickly followed by spontaneous, mostly individual, efforts at finding the injured, trapped and dead.

4. Attempts to insure or reestablish public order: responsible officials and other persons believing that public order has or is about to break down take first hurried action to keep the curious and most of the altruistic out of the damaged area, to direct vehicular traffic and to take steps thought to minimize the likelihood of looting.

5. Spontaneous, sporadic attempts to limit secondary effects: e.g., a blockade is quickly thrown up next to a fallen bridge, valves are shut off to stem the flow from obvious ruptures in the water system, attempts are made to stamp out small fires and to take quick corrective action against a few obvious fire hazards, etc.

6. Attempts are made to mobilize previously existing emergency-relevant organizations: calling in off-duty personnel, preparing directives for action, getting equipment and supplies assembled, all combined with a continuing effort to ascertain the needs and priorities.

7. Beginning actions of emergent groups and organizations: where certain needs are obvious and are not being met (e.g., search and rescue, traffic control, examination of buildings for safety), new groups form and carry out "needed" activities.

8. Systematic attempts to limit secondary effects including systematic evacuation: pre-existing local organizations, in some instances with assistance from non-local organizations, take immediate steps to reduce any further threat to life and property.

9. Systematic efforts to provide needed emergency services: careful search and rescue with records being kept, care for the injured no longer happenstance, identification of the dead, programs of inoculation, organized distribution of food and water as needed, organizing shelter for the homeless, provision of critical services to emergency organizations.

10. Organized debris removal and the beginning of emergency repairs: efforts to normalize the physical setting so that the full range of activities can be carried out with relative efficiency.

11. Efforts by public officials to boost the morale of the local citizens: through news releases and public appearances, citizens are told that the worst is over, that help is forthcoming, that the community will be rebuilt, that "we shall overcome."

When word of a disaster spreads it travels quickly. The result is that the affected area acts as a magnet attracting persons, food, medicines, clothing, and all manner of material. In the early hours and days much of the influx is not in response to specific requests or expressed need. This convergence appears to spring largely from a naive altruistic impulse to help those who have suffered unexpected loss for which they are not responsible.

In addition to the convergence of persons and material, there is a communications convergence. Every mode of communications is soon jammed with inquiries concerning the location and health of residents and of offers of help. News media representatives quickly arrive at the disaster scene and attempt to question already harried public officials. The convergence is a mixed blessing. It creates all manner of logistical and other problems but often in the cornucopia are some of the critically needed specialists, equipment and supplies.

The Managua Response

Community-relevant activities in and around Managua differed from the typical response scenario of industrialized societies previously studied in the following manner.

1, 2, 3. The early, spontaneous actions involving the assessment of effects and search and rescue were almost totally oriented to family, friends and neighbors in dire need. With large dispersed families for whom responsibility was felt, immediate assessment and survival efforts were lengthier and more laborious. Public and private organizations and institutions, some of crucial importance in the emergency period, were given little or no attention.

4. What would normally be the very early attempts to insure or reestablish public order simply did not develop. Indeed, some evidence suggests that those persons who might normally be expected, in the countries previously studied, to initiate such early actions either reported in later or abandoned their posts of public responsibility. Looting began almost immediately and was apparently widespread. Commandeering of private property (e.g., autos and trucks) took place to an unknown extent without effort at record-keeping or promise of compensation. The flow of traffic, though slow, did not become a major problem.

5. The early, usually sporadic efforts to limit secondary effects seem to have been absent with only a few exceptions.

6. Generally speaking, serious attempts to mobilize previously existing emergency-relevant organizations started late and proceeded slowly. It appears that for approximately 48 hours the city's population had no significant support or direction from public or private organizations in the country.

7. Emergent groups from the local populace consisted principally of neighbors assisting each other in rescue and less frequently in retrieving property from damaged homes. One emergent group conducted a survey of the families still in the Managua area.

8. Systematic attempts to limit secondary effects did not begin until the third and fourth day, later than is typical for North American and European cities.

9. Systematic provision of needed emergency services was mixed. Organized search and rescue with careful record-keeping never did take place. It was assumed that families would bring their dead and injured to a few centralized locations. Organized care for the injured started later than usual and was built around the presence of field hospitals that were sent in by other countries. Some injured were flown to other countries. Identification of the dead would have been a monumental task even in a well-prepared city. Here most of the dead were buried without any written record. Mass inoculation efforts were considered but on the advice of foreign medical experts were not initiated. No epidemics developed.

The distribution of potable water, though later than typical, was better organized, in the beginning, than the distribution of food. The latter was a source of friction between different parts of the government, and between the government and the voluntary agencies helping distribute food. Army officers in administrative positions in food distribution occasionally issued conflicting orders. For example, one officer would designate beans and potatoes as high priority food for a specific neighborhood and order them to be sent there, while another officer would order rice and meat. This was problematic because underlings would not know whose orders to follow. This situation also would become more problematic when the food needs of a specific neighborhood were different from those designated by either officer.

The relationship between the government and the voluntary agencies offering assistance was a strained one, even three weeks after the earthquake. The government declared itself the sole distributor of food and all others engaging in this enterprise either had to cease doing it or else they had to come under government supervision and experience problems such as the one discussed above. As a result of this situation it took much longer than usual for a modicum of organization in the food distribution process to develop.

Much of the usual need for planned emergency shelter for the homeless was obviated by the extended family system. An estimated seventy-five percent of the refugees went to live in or around the homes of relatives. An enormous, spontaneous, self-reliant evacuation and relocation to cities up to 80 km away took place in the immediate aftermath, only later to be organized and enforced by governmental services.

10. The provision of work space and utilities for emergency organizations was a very difficult task because most buildings were no longer usable. Tents and the homes of agency heads became temporary offices because they had some of the basic utilities available by the end of the first week. Only the electric power company came close to the usual timing in getting its service to emergency organizations, possibly because its headquarters and maintenance equipment survived well and a power surplus was available elsewhere in the grid.

11. Efforts by officials to boost the morale of citizens were unusually late and meager. Even the provision of simple information about what was taking place was very late and sporadic in presentation.

Interpreting the Social Response

There are three principal observations which help in understanding the social response in Managua. The first is that there was a highly centralized government, thin on human and material resources, and operating in a delicate political matrix. Secondly, the tradition of the extended family was still very strong in this urban setting. Finally, there was wide disparity in socio-economic status among the population combined with ready visibility of these class differences.

It is not at all unusual to have highly centralized governments, military and non-military, in developing and near-industrial societies. Their pervasiveness, however, should not be allowed to blind us to the significance of such centralization in times of disaster. These governments rarely have an established civil service force of adequate size and discipline to continue administrative and operational functions when the physical or political environments are undergoing upheaval. Nicaragua was no exception. And the more centralized the power structure of government, the less dependable and effective will be the civil service units that do exist. When communications break down and directives from the sole source of power are not being received as usual, the actions of usually subservient organizations become less predictable. They are not likely to conduct business as usual. And when, in addition, there is suspicion that the most recent government may no longer be in power at all, then organizational functioning becomes even more problematic.

It appears to us that the early, near total absence of concerted action, effective or otherwise, by governmental agencies must be

viewed in this context. It is true that these organizations had not considered and planned for such an emergency and that lack of preparedness did take its toll from the organizational response. But in disasters elsewhere other organizations have been caught without any semblance of preparation but with some innovation and inputs of heroic energy they have managed to get going again within twelve to twenty-four hours. In addition to the usual disbelief and shock, agency heads in Managua hesitated to take early actions because their attention was first turned to family. Also in the midst of the confusion, there was an unwillingness to act without new directives from top authorities.

In addition, at the time of the earthquake, the nation was governed by a three-man junta -- an uneasy alliance of the two major parties -- with former president Anastasio Somoza Debayle at the helm of the National Guard. Needless to say, the disaster left the nation in political conditions of extraordinary ambiguity. Effectively, the government began operating only when the Somoza family took charge of emergency operations and located them on the premises of their own estate. Dr. Fernando Aguero Rocha, the leader of the opposition party, resigned from the junta.

Immediately after disaster impact, the family, especially the extended family, is both a boon and a hindrance for societal functioning. Within the family unit all sorts of help, including social and psychological support, are available because the well-being of the family is usually given exceedingly high priority. Individuals survive and recover in large measure because of this strong tendency to seek out, help and protect members of ones own family first.

In Nicaragua this family priority provided an amazing resource. An estimated seventy-five percent of the homeless found shelter in and around the homes of relatives on the fringes of Managua or in more distant towns. The food stored in these host homes was in the aggregate a huge dispersed warehouse which supported an estimated 200,000 persons for several days.

But for persons who hold positions in organizations responsible for emergency operations to give top priority to their families at the expense of their organizations means that these activities in which the community as a whole functions will suffer unnecessarily. Only specialized organizations, not families, are good at fighting large fires, restoring electric, gas, water, phone and sewer facilities and treating the badly injured. And emergency organizations can't function effectively, if at all, without having most of their regular trained and disciplined members available for operations. For three to five days most of the emergency organizations in Managua were denuded of personnel. Much of the looting and perhaps many of the fires are attributable to the absence of law enforcement personnel. One can only guess how many of the injured need not have died and how many of the dead could have been identified before burial.

But the community normative structure of Nicaragua specifies that the family must come first, and organizational responsibility is, at best, a distant second.

Social class differences are also related to the social response in Managua. The differences in lifestyle between the small, very wealthy upper-class and the large lower-class families that exist

in poverty is obvious even to the casual observer. One gets the impression that they are almost two separate cultures. This becomes evident in the consideration of and the building of temporary housing for refugees. Those concerned with the planning of the one room wooden frame temporary houses talked as if the refugees would see the houses as being temporary in much the same way as the planners did. The reality of the situation was that the proposed temporary housing was better than the housing most poor people lived in before the earthquake. Therefore, it is very likely that the temporary housing will become permanent. As observers we often wondered if those doing the planning of "temporary" houses ever talked with or even knew the poor.

In Managua, as in other cities, the material products from industry are clearly visible in the small shops of the emergent middle-class and in the large stores. Everywhere the poor can see what they might have but can't afford.

When then in the middle of the night the walls came tumbling down and windows shattered and the affluent weren't there in the form of hired guards or the National Guard to protect these much desired possessions, the result was almost inevitable. The overwhelming evidence suggests that people took what they could get, from homes, shops, supermarkets, department stores and even warehouses. And persistent rumor has it that many of the fires were intentionally started out of resentment, as a mechanism for diverting attention from organized looting or to qualify for fire insurance benefits if earthquake coverage was not in effect.

Whatever. The community normative structure which operated during normal times provided a justification if not positive support for the taking of unguarded property. In the absence of some special norms for "disaster situations," it would be assumed that the usual community norms regarding property would apply after the earthquake. They did.

The Shape of the Future

If the seismic past is any guide to the future, Managua will experience further earthquake damage within the lives of most of the current earthquake victims. Why is that so? Does it have to happen?

In general, the record of human settlement provides ample evidence that human location in many areas of seismic risk is probably more than balanced by the locational advantages. Nevertheless, specific location patterns of human settlement and activity may pose burdens to a society not reflected in the pattern of advantage and gain. Locational advantage and resource exploitation change through time but long afterwards the organization of the city takes on an independent existence of its own. Its infrastructure, everyday activity, and its residents' attachment, create an enormous inertial mass that persists and often expands.

The record of major urban relocation provides no effective model to effectuate such change in modern time. New cities have indeed been started (Brasilia, Chandigarh, Canberra) but these have not resulted as a relocation of an older city. Very small places have been relocated (for example, the town of Valdez, population 1,200 was

relocated after the 1964 Alaska earthquake) but they are miniscule exceptions. Nor has the process of rebuilding on the same site shown much capacity for constructive change. Most cities rebuilt after World War II retain their essential structures even to the congested narrow streets and other urban inconveniences. With the need to restore facilities, encourage economic activity, and to reassert the security of familiar surroundings in the face of disaster, great pressure is generated to put back things exactly as before.

In Managua the public arguments for maintaining the existing location cite such factors as the survival of ninety percent of the heavy industry, 20,000 housing units, and the enormous investment in waterlines, sewers, connecting highways and the like. Also cited is a deep attachment of Managuans to their city, and the lack of alternative risk-free land nearby plus the potential to rebuild seismic-resistant structures: And privately, there is a widely held expectation that the city will remain where it is because of the value of land held therein by wealthy families associated with the government.

There has been no shortage of expert assessment: seismologists, cite the high seismicity of the entire area; geologists, the trending of the fault structures; engineers, the potential to build resistant structures capable of withstanding shock; planners, the possibilities of greenbelts and open space in the city's center. But at this writing, neither the organizational structure nor the will to develop one which will lead to substantial change in urban location or reconstruction is in evidence. Faced with both entrenched interests and conflicting

advice, one can safely predict intense pressure building up to rebuild -- larger structures with seismic resistance -- but smaller structures with conventional technology. The population, many who now say that they would prefer to remain away, would by necessity be drawn back, and sometime in their lifetime, the tragedy may well be repeated.

The Unplanned Experiment

For those interested in earthquake loss reduction a major earthquake becomes an unplanned experiment testing building materials, and construction techniques on the one hand and social organizations and human endurance on the other against the accumulated experience of past disasters in the same location and similar disasters in other parts of the world. What seem to be the significant lessons that can be learned even at this early writing?

Each decade, a cumulative toll of lives and property equivalent to a city of half-a-million disappears beneath mud or ash, is reduced to rubble and splinters, or shrivels in the parched ground. Managua underscores the global inequity of such loss. In comparison with the San Fernando earthquake -- losses in lives were one hundred times greater, in per capita losses of material, ten times greater. These accord with our scattered findings from other developing countries (16).

But if developing countries suffer more from natural disaster, they also do less to prepare for and to prevent them. Many features of the 1931 earthquake are faithfully reproduced in 1972, yet no

significant emergency planning, seismic-resistant construction, or redundancy and decentralization of emergency services was developed over the forty-year history between earthquakes. The low national priority given to seismic-loss reduction is not peculiarly Managua, but universal. It appears to be rooted in the predominance of pressing day-to-day needs, the focus on economic development and related urban growth over limited planning horizons, and the expectations for international altruism.

Natural disaster may be costly to developing countries, but so is disease, unemployment, and public disorder. Planning horizons are short, attention is centered on increasing economic wealth. The international community of nations is relied on to provide for the exceptional need; the small national surplus is needed daily. To the geophysically-oriented scientist attuned to geologic ages, a forty-year periodicity may seem highly recurrent; to a national planner whose universal foresight seldom exceeds five years, it can be millenium.

Thus substantial improvement in disaster preparedness and prevention in developing countries cannot be made a matter of exhortation to do better, but needs to become part of the international response to which most countries turn when in great need. This responsibility was accepted by the General Assembly last year when it authorized the establishment of the United Nations Disaster Relief Coordinator (17) and in subsequent action by the U.N. Conference on the Human Environment (18). In this context, the Managua experience is instructive.

Organized assistance in Managua was fragile, sporadic and unreliable during the immediate post-earthquake period (48 hours), but subsequently (when our observations began on January 7th) relief and emergency restoration was well advanced (in comparison, for example, with the Sicily earthquake of 1968). In part this was due to the earthquake setting, its capital city location amplified the damages but also enabled the government to draw on the largest skilled manpower pool in the nation. But in good part it was due to the growing sophistication of the international community in providing relief. Central American neighbors functioned as neighboring states or provinces; U.S. disaster stockpiles in the Canal Zone were providential; organized engineer units from the U.S. military, the Mexican highway department and the Southern Bell Telephone Company played strategic roles in restoring services. Symbolic of both the increased skill in providing and receiving aid, and coupled with the best humanitarian responses was both the offer and the acceptance of a Cuban relief team in spite of a decade of enmity. But while the social-scientist observer was impressed by the speed with which aid was marshalled and the skill with which it was used (in striking contrast to the Bangladesh Cyclone of 1970) such expertise was limited to the immediate post-emergency period.

The central weakness in our understanding of how to reduce the high cost of natural disaster for human kind lies less with the needs of the disaster moment and more with the critical post-emergency policy decisions for reconstruction. And the need is not limited

to developing countries. In Managua the housing under discussion was two room wood units, valued at \$200; in Wilkes-Barre (Hurricane Agnes), \$8,000 mobile homes. In both situations disaster relief planners were concerned with providing "temporary" housing, although the global experience is that except for tents that disintegrate, there is no such thing as "temporary" housing (19). And in both situations we can speculate as to the future social effects of instant communities of 15,000 housing units in Managua or 8,000 mobile homes in the Wyoming Valley of Pennsylvania. And in both cases we can suggest patterns of reconstruction that might minimize future damage but we do not know how to effectively overcome the strong trend to rebuild again as it was.

Finally, Managua reminds us in North America of our own vulnerability. While we can be encouraged in part by the comparative experience with the San Fernando earthquake, there is much in the Managua experience that is sobering. The Managua earthquake was a low-energy, short-duration earthquake and another perhaps 1,000 times greater can be expected to occur on the West Coast of the U.S. within the lifetimes of most readers of this paper. One set of scenarios for the San Francisco Bay area envisages deaths from between 10,360 and 100,000 and property damage of up to \$1,400,000,000 (20). The realism of such scenarios are underscored by three relevant aspects of the Managuan experience.

First, while the experience in Managua is reassuring as to the ability of construction built to current standards of seismic resistance to avoid structural failure, it is not reassuring with respect to

functional failure. A building may be safe; i.e., no one is killed or even injured by its collapse, but it may also be useless -- unable to effectively house the functional activity contained therein. Managua provides a grim lesson as to what occurs when all the major hospitals which do not collapse become non-functional. Recent legislation in California now calls for hospital buildings to be not only safe but functional. Literal enforcement of such an act should require drastic changes in design practice (21).

Second, a central city disaster of the type envisaged in the scenarios with a major fire will necessitate massive post-event evacuation of the surviving population. Three elements made the transport logistics in Managua possible: a simplified one-level road transport system, a large pool of public transport equipment and a minimum of private autos, and the fortuitous survival of the oil refinery and its initiative in distributing gasoline to suburban stations. None of these elements would necessarily occur in California, indeed the contrary could be expected. The freeway system can be fail-safe structurally but be rendered inoperative by unavoidable minor breaks and offsets. The everyday operation of private autos under normal circumstance approaches that of massive traffic jams, and gasoline while ample in the area, might be unattainable where and when needed.

Third, if a breakdown of public order takes place during such a major disaster and extended aid, while forthcoming, is unable to penetrate effectively into the stricken area, a large west coast

urban center might suffer much of the social dislocation and none of the compensatory supports of Managua. Already a norm similar to that of Managua prevails in many of our central cities -- what is not watched is likely to be stolen. But the compensating norm of broad familial responsibility is missing. Thus, while 200,000 Managuans moved in with their kin and are living there still, will four million Californians be able to double up with kin and strangers for an extended period?

These last questions are basically informed speculations, perhaps the most one can derive from transferring the results of an unplanned experiment. In any event the experiment of major earthquake disaster will be repeated somewhere else, possibly in similar fashion. If there is any conclusion to be reached, it is that it need not be so, but probably will.

Summary

Earthquakes, in contrast to other geophysical hazards, do not favor extensive human adjustment because of the rarity of the event and suddenness of onset. Transitional societies are especially vulnerable because much of the folk wisdom has disappeared or atrophied, and minimal applications of technology may actually increase the catastrophic potential. The expectations for support and relief have shifted from family and clan to government before the actual capacity to provide such aid has been realized.

The early response to the disaster in Managua can best be understood by recognizing (1) the existence of a highly centralized government, thin on human and material resources operating in a delicate political matrix, (2) the strong extended family system in this urban setting, and (3) the wide and highly visible disparity in socio-economic status among the population.

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