Natural
Hazard
Research

TOWARD AN EVALUATION OF POLICY ALTERNATIVES GOVERNING HAZARD-ZONE LAND USES

by

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January, 1976

Working Paper #28

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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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CONSIDERATIONS NECESSARY TO AN EVALUATION OF ALTERNATIVES

The concept of natural hazard is somewhat paradoxical; the elements of a natural geophysical event (e.g., wind and storm surge of a hurricane) are hazardous only when they prove detrimental to human activity systems. That is, they are natural in that they are generated by a system of nature, but they are hazardous only when they conflict with societal goals. It follows, then, that one manner of coping with natural hazards is to restrict--voluntarily or by legal action--the use of land subject to recurrent natural hazard. By limiting uses of the hazard zone to activities and structures which are least loss-prone in the case of the occurrence of a hazardous event, the effective hazardousness of the elements is diminished. The restricted uses are still achieving societal goals, but geophysical elements do not conflict with achievement of the goals as greatly as they might if more loss-prone uses were employed. For the sake of convenience, policies discouraging activities of high loss propensity will be referred to as "land use management", with the realization that other policies could also be included under that title logically.

Four investigations and developments concerning floods outline the development of land use management as a viable alternative to natural hazard adjustment. The first was White's Human Adjustment to Floods in 1942 which discussed the concept of land use management as an alternative or supplement to structural adjustments such as dams and levees and to an array of other adjustments. The next significant publication was in 1958 when Murphy surveyed the issues concerning the regulation of flood plain development and the extent to which various approaches to regulation had been implemented. Also in 1958 a team of researchers reported the results of their study of urban flood plain development, and one of the most significant suggestions of their data was that structural adjustments to floods may actually aggravate the hazardous situation by promoting growth in the flood plain (White et al., 1958). If the structural devices were overtopped or failed, losses could be catastrophic. Thus, one of White's hypotheses was lent credence, and land use management became viewed with increasing favor. Then in 1966 the Task Force on Federal Flood Control Policy issued its report and recommendations on the national management of flood losses, and land use management was given considerable attention (U. S. House of Representatives, 1966).

Today land use regulation is a widely practiced adjustment, not only for floods, but for other hazards as well, and much of the credit for the evolution and acceptance of the concept must be given to the four studies cited above. The single most important national policy decision regarding flood plain regulation occurred in 1968. Enactment of the National Flood Insurance Act made Federally subsidized flood insurance available in communities which agreed to adopt controls over the use of their flood hazard areas. At the present time, over 3,000 communities have agreed to terms of the Act, and passage of the Flood Disaster Protection Act of 1973 as well as the Flood Disaster Relief Act of 1973, both of which put additional pressure on communities to join the insurance program, give all nonparticipating communities facing flood hazard cause to reconsider their policy regarding hazard zone regulation.

Effective July 1, 1975, the Disaster Protection Act will prohibit the use of Federal funds for construction in flood plains and will prohibit lending institutions which are insured by the Federal Savings and Loan Insurance Corporation or the Federal Depositors Insurance Corporation from making loans to finance construction in flood plains, unless the community of the location is participating in the flood insurance program. The Disaster Relief Act makes communities which are not participating in the flood insurance program ineligible for some kinds of Federal relief in the event of a flood disaster.

To the planners and policy makers of local government, the management of hazardous areas within their jurisdiction poses a difficult decision problem. They must choose whether to adopt an alternative or combination of alternatives which have the effect of restricting use of the hazard zone to activities which are low in their propensity to losses. For example, a zoning ordinance may prohibit buildings in a flood plain unless they are "flood proofed" to resist damages from flooding. Given the charge of providing for the health, safety, and general welfare of the local populace, decision makers must consider whether habitation of hazardous areas provides positive net benefits to the community. It can be argued that secondary effects of hazard losses shift an undue burden onto the public sector and that occupants of hazard zones do not realize the full extent of their dangerous situation.

This investigation deals with the question, "What are effective ways for local planners to treat advantages and disadvantages of policy alternatives which would regulate the incidence of highly loss-prone activities in the hazard zone?" The balance of this chapter deals descriptively with concepts and considerations relevant to an evaluation of land use management alternatives. Chapter Two briefly surveys some of the literature which has attempted to view social benefit and cost considerations in economic terms. In Chapter Three a model is presented for hazard zone land use policy determination; the model is applied to an illustrative example in Chapter Four; and in Chapter Five the model is evaluated.

Benefits Versus Costs of Occupying Hazard Zones

Two general points are obvious: 1) there are benefits which accrue from occupance of hazardous areas, or otherwise the occupance would not likely recur, and 2) there are costs, generally in the form of losses from disasters, which result from occupance of the hazard zone, sometimes referred to as nature's tax (Renshaw, 1961). Still the best discussion of the advantages and disadvantages of hazard zone occupance is White's treatment of floods (1942).

First of all, among the benefits is the aesthetic, emotional, or habitual attractiveness of the site, primarily to residential usage. Areas such as seashores, hillsides, etc. often present considerable pleasantness to prospective residents, making these areas attractive places to settle. Sometimes there are other emotional involvements with a site, perhaps totally unrelated to the hazardous conditions, which make it a desirable place for some people. More often the involvement stems from habit or tradition, and this makes the site worthwhile to the resident. All these cases, of course, are above and beyond the minimum provision for habitation which are also provided by other sites. At any rate, the user requires some measure of benefits from the occupance of the area due to these values.

There are also conditions often present in hazardous areas which make them economically attractive beyond the attractiveness of alternative sites. One of the best examples is port activity, which, in most cases, can be operated most profitably if located at the water's edge, although it may be in a particularly hazardous situation. Industries often benefit from proximity to a large water supply, and tourist-related activities benefit from their nearness to recreational areas such as beaches.

In some cases there may also be physical or aesthetic advantages to locating in a hazardous area which have no direct payoff in economic terms. Businesses, too, may seek pleasing environmental surroundings for aesthetic rewards, for example.

The most dramatic cost of occupying a hazardous area results when hazardous events occur, and lives are lost, physical injuries are incurred, and psychological traumas are experienced. This category of costs varies considerably among hazards; it may be minimal for something like hail, but tremendous for hurricanes and tornadoes.

Another obvious type of cost is the pecuniary loss to property and goods subject to the hazardous elements. Buildings and their contents are damaged and destroyed; highways, airports, public facilities, automobiles, ships, etc. all are subject to loss, and their losses can be calculated in monetary terms.

But these two cost categories in turn affect other elements of the societal system and thereby generate secondary or systemic effects. Unemployment and decreased value added in production, due either to damaged facilities, inability of industries to acquire raw materials, or their inability to ship products, for instance, result in one class of secondary effects. There is a fairly interdependent relationship existing in many places, so that when one important link is incapacitated, others also suffer. Deaths, injuries, and general preoccupation with personal losses also burden the economic operations of a system. Many of these secondary costs result from diversion of resources and efforts from their primary goal by the disaster. Accounting for this category of losses has proved much more difficult than accounting for direct physical damages.

Another major cost of hazard zone occupance which should be acknowledged is that of environmental degradation. In the hurricane zone, for example, intensive use of the area aggravates coastal erosion, destroys dunes and beaches, and degrades ecologically sensitive areas such as mangroves. Ian McHarg (1969) argues that natural processes often work to man's advantage, and that the less those processes are disrupted the greater will be their benefits to society. Clear cutting of forests, for instance, interferes with the erosion prevention function of the tree cover.

Considerations in Evaluating Land Use Policy Alternatives

In estimating the effects a land use policy alternative will have, there are several basic points to consider: 1) loss aversion, 2) environmental effects, 3) other secondary effects, 4) administrative costs, 5) foregone benefits of hazard zone use, 6) legal costs, 7) capital outlay and maintenance, and 8) public acceptance.

Perhaps the most significant consideration in evaluating a hazard zone management alternative is the effect the strategy will have on losses from hazardous events. The primary benefits from a land use management scheme are reductions in 1) loss of life, physical and psychological injury; 2) pecuniary losses to property and goods; and 3) systemic losses to the economy.

By reducing elements exposed to risk, losses are abated. An important point should be made, however--land use measures have little effect on protection of entities currently at risk; rather, they control the amount of future risk-exposed development. Over a long time span, though, they can also affect the currently developed areas by requiring new construction and major repairs to conform to compatible use standards. (An exception to the former statement is structural modification of buildings which can be applied to existing facilities and is sometimes considered a land use management strategy when required by law.)

In judging the efficacy of a land use strategy with respect to its effects on losses, at least three loss management frameworks can be employed.

The most traditional approach is to emphasize average (mean) losses over time. One way to do this is to determine the probabilities of events of various magnitudes for any one year and the projected losses for each magnitude. Then for some specified time period, say fifty years, total expected losses are extrapolated, based on probabilities; this step can be made more dynamic by projecting increases in property and lives at risk. By dividing the total expected losses by the number of years in the time frame, an estimate of the average annual losses is obtained.

Another approach to losses is through the kurtosis and skewness of the loss probability distribution. Various adjustments alter the probability of losses of various magnitudes; some adjustments like structural measures decrease the likelihood of small and moderate losses which would occur if an event were to occur greater than the design capacity of the structure. A strategy which discourages loss-prone uses of the hazard zone, however, still may incur relatively frequent minor losses, but losses from the extreme event may actually be less than those with some other adjustment thereby decreasing the probability of catastrophic losses.

Concern with the catastrophic event is not new to natural hazard researchers; the 1958 study by White and his colleagues at the University of Chicago (cited earlier) produced evidence that some adjustments to floods may reduce average annual losses at the risk of increasing the magnitude of losses when extreme events occur. More recently the concept of "catastrophe potential" has been introduced to note an adjustment's effect on losses when the extreme event occurs (ARNH, 1974a).

The concern implicit in emphasis on catastrophe potential is that the societal system may have a threshold point for loss tolerance beyond which events may exact a disproportionate toll of debilitating effects, making recovery disproportionately more difficult. Whereas the average loss criterion may emphasize minimization of average annual losses, the kurtosis skewness/criterion may seek to minimize catastrophe while tolerating higher average annual losses. This sort of goal would call for a positively skewed, leptokurtic curve of loss distribution, like curve A in Figure 1, in preference to curves B and C. The vertical axis indicates probability of occurrence, and the horizontal axis indicates varying magnitudes of loss. Curve A, for example, suggests relatively high probabilities of small losses, but low probabilities of large losses.

A third approach to losses is the distribution of their effects within the affected system. One concern has to do with equity--should adjustments be sought which strive to give greater protection to groups who can least afford to suffer losses, or perhaps to those who are least able to protect themselves? Figure 2 represents three alternative loss distribution curves which vary the manner in which losses are distributed among income and age groups. Curve C, for example, represents a scheme by which the percent of one's worth (vertical axis) which is lost in a hazard occurrence is lower for both low and high age groups (horizontal axis) than for intermediate ages, the rationale being that the very young and the very old can least afford losses, and recovery for them may be more difficult. "Curve" B, on the other hand, represents a strategy by which percent of one's worth lost (vertical axis) is the same for all income groups (horizontal axis).

Another distributional approach relates to the importance of a particular activity or structure to the system. A major power generating facility or a plant employing large numbers of people, for instance, are relied on very heavily by the system, and if they were incapacitated, losses would be extremely great; therefore, an adjustment may seek to minimize losses to activities and structures on which the system is very reliant. Curve A represents that strategy, with magnitude of loss which might be tolerated indicated on the vertical axis and the degree to which the system relies on the activity indicated by the horizontal axis.

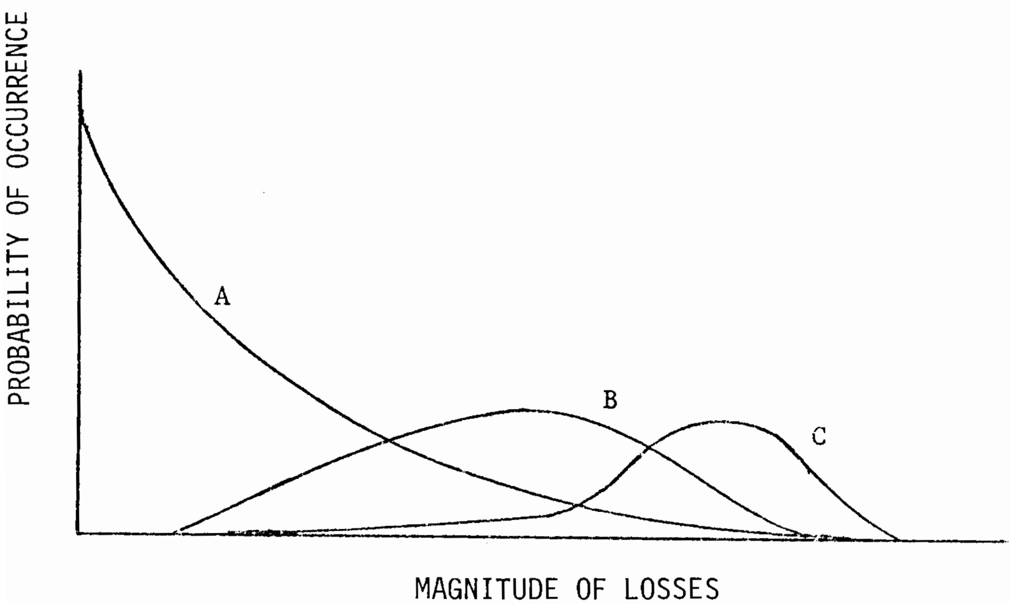

FIGURE 1

ALTERNATIVE LOSS DISTRIBUTIONS

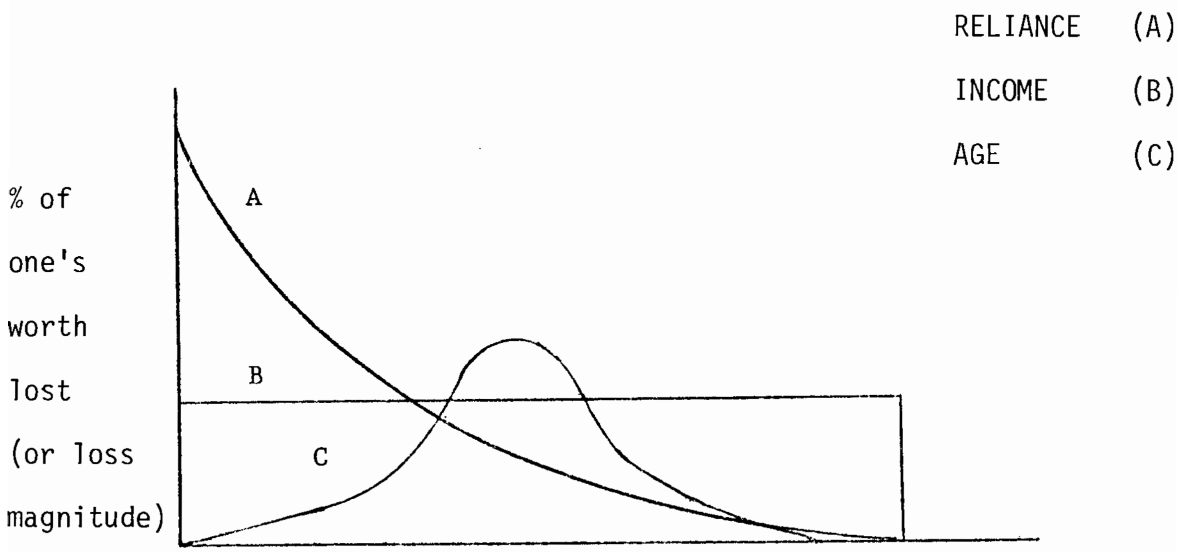

FIGURE 2

LOSS DISTRIBUTIONS WITHIN THE SYSTEM

In addition to averting losses, environmental degradation can be prevented or lessened by some types of land use schemes. Open space zoning, for example, which would prohibit dense development but permit uses such as parking lots, golf courses, agriculture, parks, and drive-in theaters, has many environmental pluses. Through these types of measures recreational, aesthetic, and ecological benefits increase, and some types of pollution are abated.

Although land use management usually provides environmental enhancement and abates environmental degradation, the latter can also occur with some land use schemes. Elevation of construction sites by filling with earth or other means, for example, is considered a low-loss propensity adjustment, but can result in appreciable damages to drainage, soil conditions, and vegetation.

Environmental effects constitute just one category of what may be referred to as secondary effects of the adjustment--that is, effects which are generated by the adjustment but were secondary to the motivation of hazard loss management. It is impossible to list all the possible effects, but a few examples are diversion of economic growth, income redistribution, and population redistribution. The environmental category was singled out because many land use management alternatives are of an open space nature.

Just as environmental degradation and some of the other effects of the adjustment may be considered undesirable, there are other costs inherent in restrictive land use strategies. One class of costs are direct monetary outlays for development and administration of the strategy. Some outlays may be slight (for developing zoning ordinances, for example, particularly if adequate maps, etc. are already available), but others may be substantial (for purchase of land, if public acquisition is the alternative, for instance).

For most land use alternatives, the largest cost is the opportunity cost of not using the land for its most productive use--that is, the use which maximizes economic rent (Barlowe, 1972). Some uses of land are more profitable, rendering a greater economic return, than others, and if the "higher" uses are precluded, then the benefits foregone can be considered opportunity costs of restricted development.

Legal concerns may also be an important consideration--what would be the legal consequences of a proposed alternative? The fourteenth amendment to the United States Constitution prohibits "taking" of private land and property by the government without payment of "just compensation". If an alternative such as making the hazard zone part of the public domain and maintaining it as open space is proposed, then payment to private owners is obviously required. But other schemes like zoning the hazardous area to prohibit certain uses may restrict an owner's use of his land to the extent that it is rendered practically useless; the courts, in that case, may rule that the land has in fact been "taken" from the owner, and that some compensation (perhaps the decrease in market value of the land) must be paid; therefore, the legal consequences of an alternative should be projected, and whatever costs are expected to result should be counted as a cost of the alternative.

Similarly, due to scientific or technological inadequacies in methodology used to delineate the hazard zone (assuming that the regulatory scheme relies on the delimitation), an alternative may be ruled invalid by the courts, and additional costs will be incurred in redefining the limits of the hazardous area. The display mode may also be declared invalid (e.g., too small a map scale for reliable decision making), and redrafting and preparation incurs additional costs. Thus, from a cost-effectiveness point-of-view, delimitation procedure and display mode should also be considerations.

Planners and administrators have come to realize that public endorsement and approval make the success of policy decisions much more likely than if they are unpopular. The result has been an increase in efforts to involve the public-at-large in planning and decision making (Sewell and Burton, 1971; Borton and Warner, 1971). Interest groups also exert considerable pressure on policy makers, and their influence in often profound (O'Riordan, 1971a). These factors should be considered to indicate expected success of the alternative being evaluated.

Evaluating a particular hazard zone management alternative in light of other community previously set and only indirectly related goals also presents a problem. For example, suppose a community has set a goal in its comprehensive plan, the acquisition of a given number of acres of parkland within the next five years. The community is therefore committeed to acquiring land, and by acquiring at least part of it in the hazard zone, two goals could be achieved with a single solution. Certainly the situation makes hazard zone land acquisition a more attractive alternative than it would be in absence of the commitment in the general plan. Actually, this is just a special case of the more general consideration of the role of community goals in the entire evaluation.

APPROACHES TO EVALUATION AND SOME EXISTING MODELS

The general goal of prescriptive land use models is the maximization of economic rent (Alonso, 1964; Barlowe, 1972), but in order for local policy makers to make decisions concerning hazard zone land uses, models more specific than those appearing in the general discussions of land use theory are necessary. Policy-oriented models need to specify particular variables for measurement and organize them into a practicable decision-making framework.

Before going directly to a discussion of models designed specifically for use in local hazard zone land use policies, it may be helpful to take a very brief look at the policy evaluation process in two other decision arenas--transportation planning and local zoning.

Transportation planning has been dominated by the goal of "maximization of economic well-being for society as a whole" (Weiner and Deak, 1972), which provides an interesting parallel with flood plain planning. The first application of a procedure attempting to measure all costs and benefits of a highway's impact was in Oregon (by the state) in the late 1930's, and the effort was viewed at the time as being highly scientific and useful. By 1952 the American Association of State Highway Officials (AASHO) had produced a handbook for transportation project evaluations, centered on three factors: 1) costs of construction and improvement of highways, 2) costs of maintenance and operation of highways and their appurtenances, 3) direct benefits to road users in time saved and reduced vehicle operating costs.

In 1956 the U. S. Bureau of Public roads began to seek information concerning benefits and costs broader in scope than those specified by the AASHO report, and a primary concern was the effects of a highway on non-users. A team of geographers under the direction of Garrison at the University of Washington (1959) made a significant contribution by investigating the effects which highways had on the distribution of activities. Using change in land values as their principal indicator, the team devised a manner of measuring the benefits to residential and commercial activities from the introduction of a highway into an area.

Today, transportation planners are concerned with even broader considerations such as the environmental effects of a new highway or the effect it will have on the "cohesiveness" of a community. While some planners have tackled the new challenges by attempting to measure in dollars the so-called intangibles, others have sought a more moderate quantitative solution. Weiner and Deak (1972) discuss several approaches such as input-output analysis, quantitative but nondollar measurements, and formal transportation-interaction models.

Most commonly mentioned as an alternative to strict pecuniary benefit-cost analysis are the matrix forms of evaluation, especially the goals-achievement matrix suggested by Hill (1968). The technique prescribes several operationally expressed objectives, and each is weighted relative to the others depending on the value placed on them by the community (influentials, officials, or the public may be surveyed to indicate the weights). Impacts of the proposed project on each goal are assigned a score ranging from, say, -5 to +5, and then a computation is performed to yield an index of desirability.

In summary, transportation planning is analagous to hazard zone planning in problems of evaluation, and the evolution of measurement and evaluation problems in the two areas parallel one another closely. The largest difference appears to be that the role of the states has been more pronounced in the transportation planning field, as a result of greater encouragement by Federal agencies involved in transportation.

The extent to which economic evaluations are practiced in local zoning decisions can be disposed of much more readily. The literature is replete with examples of political maneuvering, interest group pressures, and overriding concerns with producing a particular effect on the local economy or social structure (Siegan, 1972; Mandelker, 1971; Ukeles, 1964; Platt, 1972), but I have yet to find a case in which a conventional (residential/commercial/industrial) zoning decision was reached as a result of a formal analysis of benefits versus costs such as those used either in transportation planning or in river basin planning. Prest and Turvey (1965) make no mention of local zoning-type decisions being reached through benefit-cost analysis, although they note fourteen areas in which B/C analysis has been applied, ranging from defense to education. In fact, planners generally regard zoning (including flood plain zoning) as a zero-cost alternative.

This point is significant, if valid, because the decision situation facing local officials in evaluating alternative land use strategies for the hazard zone may often be more like the conventional zoning decision than like the transportation problem. While it is true that some Federal agencies are equipped to make hazard zone land use evaluations, they may not be consulted in the majority of the cases. Federal agencies involved in water resource development make recommendations to communities on flood policies (from a national economic efficiency perspective), but the procedures aren't oriented toward land use management alternatives. The Corps' most recent regulations do not even provide for measurement of environmental benefits of alternatives, for example. Furthermore, it would be interesting to know what proportion of the some 3,000 communities participating in the Federal Flood Insurance Program performed benefit versus cost analyses before agreeing to adopt land use regulations. Simkowski (1972) found no evidence of such a procedure having been applied in two case studies of flood plain zoning in Illinois and Indiana; nor did Emmer (1974) report any such incidences among the numerous sites he studied in Oregon.

Several procedures for evaluating riverine land use alternatives have been published, but the degree to which they are employed is probably negligible. Nevertheless, the existing procedures can provide a suggestive basis for formulation of a general hazard zone land use policy model. Four models have been chosen for discussion here: they were chosen because they conceptualize the relevant variables, organize the variables, measure the variables, and analyze trade-offs between benefits and costs at least as well as any other procedures I have seen (e.g., INTASA, 1972; Brown, Contini, and McGuire, 1972). Also they provide a fair amount of variety in their treatments of the problem.

Whipple

The first model to be examined here was proposed by William Whipple in 1969. His major complaint was that previous methodologies for evaluating flood adjustments was failure of the methodologies to recognize the increase in property and lives at risk which often resulted from the construction of structural protection projects. The projects, therefore, should be evaluated on the basis of project-induced growth in the flood plain as well as normal economic growth there. Zoning, he noted, resulted in no project-induced growth (zoning being defined as the prevention of all future construction, without interfering with existing installations).

Whipple began by denoting value of property subject to flood damages as p (existing facilities), p' (new facilities resulting from normal economic growth), and p'' (new facilities resulting from project-induced growth). The annual rate of flood losses (d) was expressed as a percentage of total property at risk which would be lost on an average annual basis. For example, in a given area, six percent of the exposed property may be lost per year on the average. "Associated indirect losses" were included in the loss estimates, but because there was no discussion of how to derive loss figures, it is impossible to say for certain how well the concept dealt with secondary (systemic) effects.

It may be fair, however, to assume that Whipple used a scheme which he published earlier (1968), an expansion of a categorization suggested by Eckstein (1958). The classification of tangible damages appears in Table I.

The benefits from zoning are given by

$$B_z = p'd;$$

that is, the portion of new property generated by normal economic growth which were it not for zoning would have been lost in the event of flooding.

To calculate the cost of zoning, the concept of "site income", (defined as the return from the property to the owner over and above

TABLE 1

Loss Classification

Primary	Secondary (1st round)	Secondary (2nd round)
Direct		
Damage to crops and industry by inundation.	Loss of profits to merchants due to reduced farm and industrial income of customers.	Loss of profits by suppliers of merchants.
	Loss of profits to those who normally process industrial output interrupted by flood.	Loss of profits by suppliers of processors.
Indirect		
Profits lost and productive labor prevented by flooded access routes or places of business.	Loss of profits by merchants due to flood losses of customers.	Loss of profits by suppliers of merchants.
	Loss of profits to those who normally process industrial output interrupted by flood.	Loss of profits by suppliers of processors.

the annual cost of the facilities built upon it) was employed. Site income due to existing and normal economic growth was denoted by s, and expressed as an annual fraction of the total value of the properties involved. The sacrifice of site income due to economic growth foregone was counted as the cost of zoning:

$$C_z = p's.$$

Whipple noted that p', d, and s necessarily vary from place to place within the flood plain, and that the area subject to flooding should be divided into several sectors which are homogeneous with respect to the annual rates of flood losses and site income. To evaluate zoning and compare it to other alternatives, Whipple simply summed the net benefits of zoning over the sectors:

$$Y_z = \ p'(d-s).$$

Whipple noted that p', d, and s necessarily vary from place to place within the flood plain, and that the area subject to flooding should be divided into several sectors which are homogeneous with respect to the annual rates of flood losses and site income. To evaluate zoning and compare it to other alternatives, Whipple simply summed the net benefits of zoning over the sectors:

$$Y_z = \Sigma p'(d-s).$$

Evaluation

Whipple's methodology is quite simplistic, but his primary goal was to illustrate that there are conceivable conditions under which neither zoning nore structural measures alone are an adeuqate solution--that a combination of the two may be preferable. Only three of the normative considerations discussed in Chapter One were actually employed by Whipple: opportunity costs of adjustment, direct pecuniary losses averted, and systemic losses to the economy. His notions of expressing losses as an annual percentage of property at risk and expressing site income as an annual percentage of property at risk are convenient concepts for discussing the problem.

TRW Systems Group

Also in 1969 an elaborate procedure for evaluating flood plain management alternatives was published by the Corps of Engineers Institute for Water Resources after preparation by the TRW Systems Group. Essentially it was a step-by-step procedure for decision makers, including two examples.

1. The first step is statement of goals, emphasizing the need to be explicit and accurate. The report leaves the statement of goals up to local decision makers but discusses

    a. economic efficiency
    b. regional economic prosperity
    c. environmental quality
    d. prevention of disasters
    e. equitable benefit distribution
    f. erosion control
    g. ground water recharge

   Determination of objectives is accomplished by polling key decision makers in the area.

2. Choosing an appropriate measure for each objective is the second step. For the above objectives, respectively, measures used were

a. maximization of net benefits

b. increase in regional employment; increase in acreage suitable for industrial development

c. open space (acres)

d. prevention of loss of life; reduction in risk

e. "windfall" profits as a percent of total benefits

f. acreage of soil erosion averted

g. acre-feet of water recharged.

3. Alternative plans were specified next: zoning, floodproofing, and site elevation were examples used.

4. The fourth step was to estimate benefits, costs, and effects on non-dollar objectives which each alternative would have. Detailed methodologies for estimating were not given. A table was constructed with objectives as column headings and alternatives as row headings, and with cross-classified cell entries being the quantitative measurement of the alternatives' effects on each objective.

5. If a single alternative proved most favorable with respect to every objective, then it clearly would be the best one. Similarly, if one alternative were least favorable in all categories, it could be eliminted. More likely, however, some plans will be stronger with respect to some objectives, while others will accomplish other objectives better. Alternatives are, therefore, paired for comparison to one another on each objective.

6. The most critical step in the entire evaluative procedure is how to value one objective against another--i.e., which

is more important and by how much? For the dollar value objectives, that is presumably known, because all are measured by the same units. Comparing the apples to oranges, however, is the problem, and TRW "solved" the dilema by interviewing local officials (planners, administrators, etc.) and inferring trade-off values from them.

7. Thus, through steps 5 and 6, all the plans except one will be eliminated.

Evaluation

Perhaps the weakest link in the TRW procedure is the placing of values on the various objectives; unfortunately, it is also the most critical step in the scheme. This point, of course, revolves on the confidence one places in local officials to make "informed judgments" concerning very specific value trade-offs held by the community. The "model" is helpful in organizing decision points and variables--especially in pointing out the importance of considering a wide range of objectives, but it doesn't seem to make the decision process any more accurate than informal methods. Detailed procedures were not given for obtaining effects of alternatives on objectives.

Day

One of the more elaborate and sophisticated methodologies is a recursive linear programming technique devised by Day (1970). The details of the programming procedure will not be discussed here, but the manner in which Day dealt with some of the considerations necessary to an evaluation of alternatives is relevant.

There were two types of variables in Day's nomenclature--efficiency variables and nonefficiency variables. The first category consisted of factors necessary to an "optimal" solution from a national economic standpoint. The two principal variables were a) present value of change in flood losses attributable to adjustment and b) economic rent as a measure of the value of land in alternative uses. Thus, as in the other models discussed, the benefits of adjustment appeared as losses averted and costs appeared as decrease in rent from a parcel due to the adjustment. It is not possible to infer from the articles whether calculating procedures differed among the models.

The nonefficiency variables were efforts to include community goals such as population growth, commercial and industrial expansion, and environmental quality in the evaluation process. Day included growth and population density criteria (as a measure of the goals) in the program as constraints to otherwise efficient solutions.

The Day model provides for determining the most desirable level of adjustment by identifying the point where marginal benefits of adjustment just equal marginal costs of adjustment.

Evaluation

The programming procedure may very well be the best for integrating the decision components necessary in evaluation because of its computerized nature, but Day's discussion appeared very limited in the considerations with which he dealt. Although the concept of treating community goals as linear programming constraints which a solution must satisfy is interesting and may work for some very general goals it may place too high a value on them. That is, although these goals may be desirable to the community, it is not clear that they are so desirable that adjustments which do not satisfy them should necessarily be rejected. Also, some community goals may be such that an adjustment which achieves the goal should be rewarded, but one which does not achieve it should not be penalized beyond the point of not receiving the reward. In that way, some adjustments which did not achieve the goal could still yield net benefits greater than those yielded by alternatives which did meet the goals. The marginal benefit-marginal cost criterion seems more useful in finding the magnitude of event for which adjustment should be oriented than in choosing one adjustment over the others.

James

The final model to be discussed here is proposed by James (1972), who has been a leader in efforts to have decision makers evaluate the costs as well as benefits of adjustments which restrict the use of hazard zones. Essentially the James model attempts to choose a scheme which maximizes net benefits by minimizing the sum of expected annual flood damages and the annual cost of the employed measures.

For zoning, economic rent is used as the key to determining cost of utilization. Basically, the cost is set equal to the market value of a parcel of land in use without zoning, less the projected value of it in use with zoning (projection techniques were not discussed). More significantly, built into the equation was a component to account for the benefits to the community of open space which would accrue from the zoning; such benefits were subtracted from the loss in economic rent. A "capital recovery factor" for a 5 percent annual interest rate and ten year time span was also incorporated in the computations.

Benefits of adjustment are simply losses averted as a result of development prevented by zoning. Varying the level of adjustment (magnitude of event planned for) and evaluating each one (for one persent, five percent, and ten percent event) indicated the extent to which zoning should be employed.

Evaluation

The James model's most interesting concept is the effort to include environmental benefits of open space. The examples of how such values could be determined were either very qualitative (asking for estimates by officials, etc.) or circular. The latter type consisted of determining how much the community had been willing to pay in the past for acquisition of open space. The problem with that type of determination is that it can lock decision makers into errors of the past or fail to recognize changes in willingness to pay. Open space value is one of the most difficult of the environmental benefits to determine. James was the only one of the four authors who explicitly discussed the use of a discount factor for a specified time span, although the idea was implicit in the other procedures.

Summary

It should be noted that three of the four procedures were presented in fairly brief journal articles, thereby excluding details which might otherwise have clarified their presentations. Also, the presentations of all four models were broader than those parts discussed above; that is, land use management was but one of several adjustments being evaluated.

It seems fair to say that the procedures have several apparent shortcomings in view of the considerations put forth in Chapter One.

1. First of all, the models all were oriented toward the riverine flood plain, to the exclusion of other hazard areas, Whereas most of the concepts and steps in the procedures are general enough to apply across hazards. There may be biases built into them which limit their utility to evaluating land use schemes in other hazard zones. This is not to suggest a failure on the part of the authors, but to suggest that a more general approach to hazard zone management may be more rewarding. Such an approach could then be tailored to specific hazards by altering the measuring devices for particular variables and giving differing weights to particular variables depending on the hazard.

2. None of the procedures computed fiscal, administrative, and legal costs associated with alternative schemes, and only the TRW and Day approaches touched on community goals. Criticisms of the manners in which they did so were included in their evaluations.

3. Only the Whipple model explicitly accounted for secondary or systemic losses averted by the adjustment. If the other models did not intend for these losses to be included in their computations this is an inadequacy in measurement of a particular variable rather than a shortcoming of the models themselves.

4. Only one approach--that of TRW--included loss of life. Pain and suffering and psychic distress averted by adjustment were discussed by none of the models.

5. All but the Whipple model dealt with environmental benefits, but all employed highly informal, qualitative techniques or were too

narrow in scope. Other secondary benefits were largely ignored.

6. Only the TRW procedure considered a loss management goal framework (disaster potential) other than average annual losses, and its treatment was very general.

7. Finally, all the models failed to deal adequately with local decision criteria. It was unclear whether they were attempting to achieve some "national economic efficiency" or what. The impression given is that they are models designed for local users, but without adequate attention to local concerns as opposed to national or even regional concerns. If the users are federal analysts, this may be desirable, but not if decisions are made for betterment of the locals exclusively.

The task remaining is to utilize the better concepts from the models while overcoming their weaknesses in design and measurement.

A GENERAL MODEL AND SOME EXAMPLES OF MEASUREMENT

A general goal of hazard zone management is to achieve some positive trade-off between benefits and costs of occupying the hazardous area. One way of pursuing the goal is by adjusting to the hazard so as to minimize the sum of losses from the hazard and costs of adjusting. The concept has been portrayed clearly by Russell (1970) as in Figure 3, with optimal adjustment being at the lowest point on the L + C curve (cost must be interpreted broadly in the diagram; any undesirable adjustment effect should be conceptualized as a cost). The first point to make is that there is at least one more dimension to the conceptualization: benefits from the adjustment other than losses averted. This could be incorporated without changing the above figure by setting C equal to costs of adjustment minus secondary benefits of adjustment.

With this conceptualization in mind, Figure 4 displays a general procedure by which to determine the type and level of land use management that should be applied as an adjustment to hazard. As discussed in Chapter Two, there are several approaches to evaluating alternatives, and the approach employed here is but one of them. In the model I attempt to take the type of methodology used in the four flood plain models and generalize it to hazards in general, to incorporate a broader range of considerations than usually noted, and to give some examples of how some of the more difficult concepts might be measured although measures cited are not necessarily endorsed. Issues and concepts not usually given a great deal of attention in the traditional literature are given disproportionate attention here.

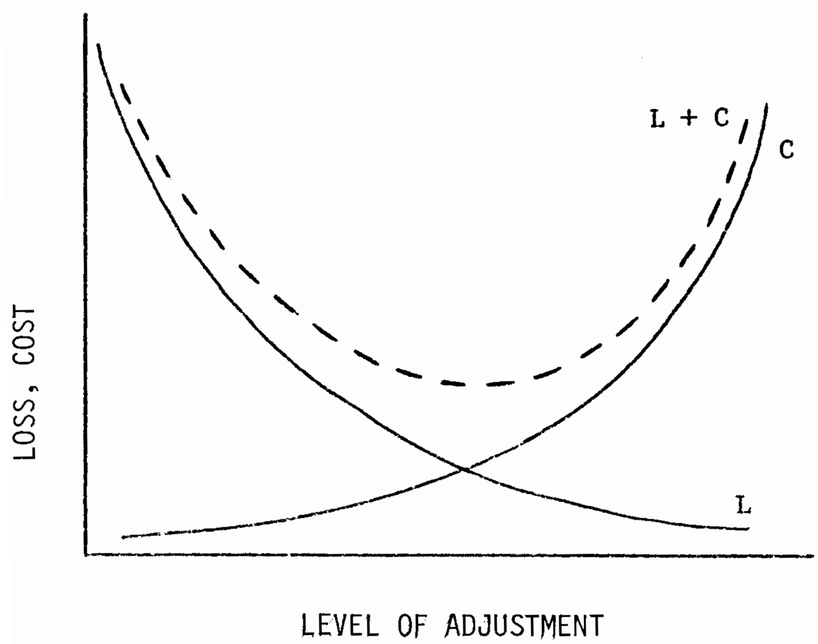

FIGURE 3

ADJUSTMENT LEVEL DETERMINATION

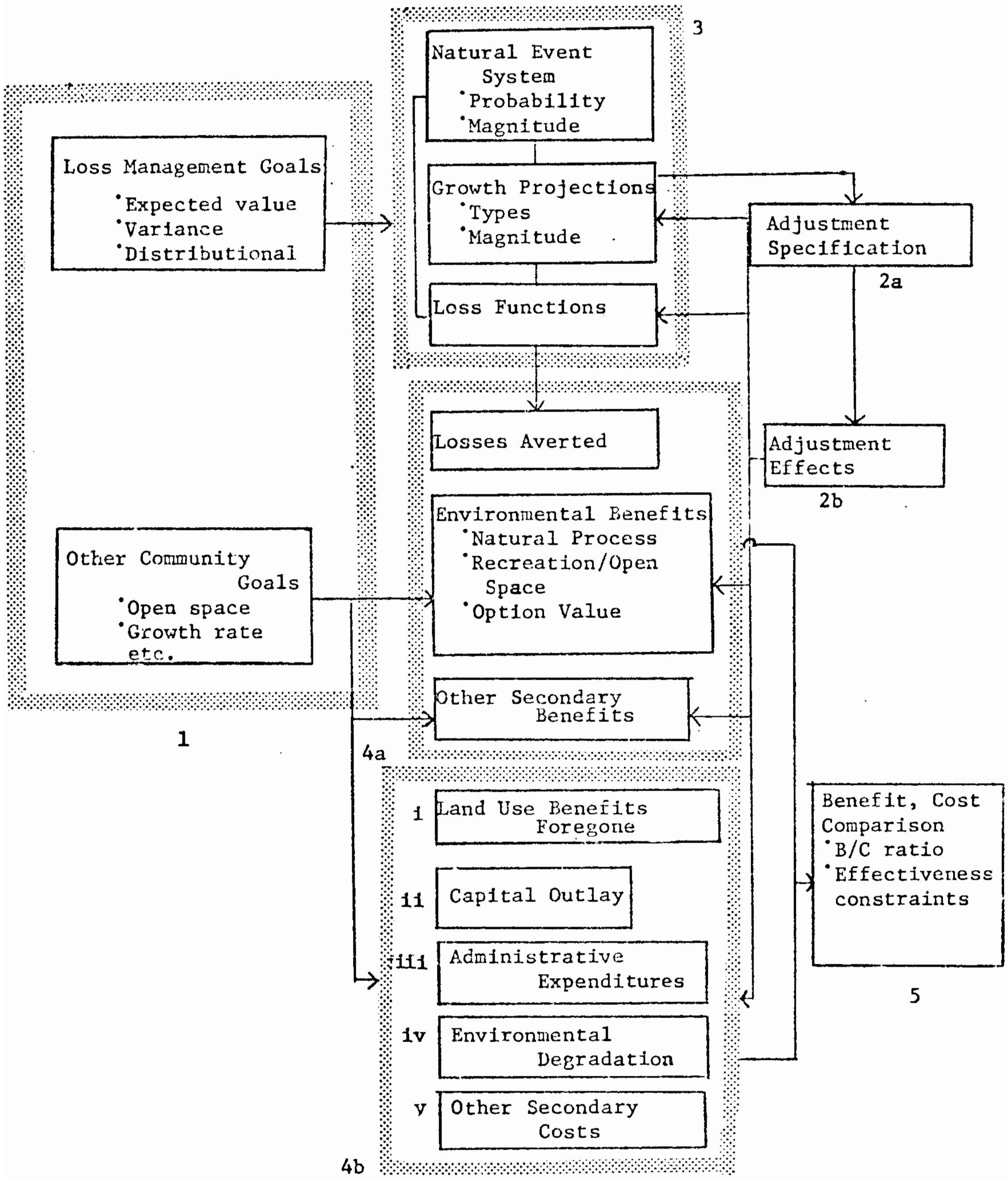

FIGURE 4

A GENERAL EVALUATIVE MODEL

1. The first step is to identify goals of the community; this step is depicted in the shaded box numbered "1" in the flow chart. There are two categories of goals to be identified. The first are general desires of the community such as open space, a given economic growth rate, a population ceiling, water quality standards, and so forth. The function of these goal specifications is to indicate whether various effects of the adjustment should be considered benefits, costs, or neutral consequences.

The second category of goals is the manner in which the community desires to manage losses from the hazard. As discussed earlier, the goal may be some level of average annual losses (mean value framework), or some distribution of losses within the system (equity, dependence framework), or some combination of the three.

This is the most qualitative point in the model, because measurement of value judgments is inevitable here. Two techniques are suggested, however. The first is to examine the "Comprehensive" or "General Plan" adopted by the community (city, county, etc.), because most local governments have some such device. This will be especially helpful in inventorying the general goals, and can provide insight into identification of the desired loss-managment framework.

Another technique is to poll local officials and "influential". This must be done with care, and a rigorous procedure such as that devised by Sheaffer et al. (1971) should be employed.

In any effort to measure goals of the community (which in turn reflect values and attitudes of the community), consideration must be given to the fact that values change over time, and that a long-term policy achieving present goals very effectively may be viewed unfavorably ten years hence. Likewise, values vary among places even at a given point in time. By specifying local goals, the latter point is accounted for, but there still may be a need to alter measuring devices from place to place when benefits and costs are being weighed. The first problem (accounting for changes in values over time) remains difficult; social prognosticators generally have done a poor job of predicting changes in values.

2. Next, the range of adjustments must be specified. A large number of techniques to regulate hazard zone land use are available: acquisition by purchase, tax policies, zoning, and siting of key facilities, to name but a few. A thorough listing and discussion of alternative measures appears in Land Use Management and Regulation in Hazardous Areas (ARNH, 1974b). Each alternative to be considered must then be evaluated on the basis of the effects it has on the community.

3. The first effect to consider is on the losses from the hazard. The natural event system must be specified with the probabilities of events of various magnitudes enumerated. Loss functions then must be determined to predict the effects that hazard events of various magnitudes would have on different types of structures, facilities, activities, and groups. Growth and development projections then must be made for the hazard zone, both in terms of type of development and magnitude of growth.

Combining these three elements--natural event system, growth projections, and loss functions--the projected effects of the hazard can be calculated. If the expected value criterion is being employed, then average annual losses can be computed for whatever time frame is being considered. If the variance criterion is being used, particular magnitudes of events can be specified and the effects of each can be caluculated. The distributional effects of events on various groups and activities can likewise be projected if that is the criterion.

In calculating the anticipated losses, methodologies are fairly well formulated for predicting direct pecuniary losses. A problem arises in computing two types of losses which are characteristically not dealt with in loss projections. The first of these is the accounting for secondary losses to the economy. One approach is the one proposed by Whipple (1968) and presented above, consisting primarily of profits lost down the line of merchants and suppliers tied to people and activities directly affected by the hazard. If lost profits are to be considered losses, however, increased profits must be considered benefits. If the decision making is being done for the local area the latter category (increased profits to contractors, etc.) may be relatively slight, especially for large scale disasters. The reason is that most profits accrue to firms outside the affected area, who come in to help. For small scale events, local firms may enjoy a larger share of the increased profits.

An alternative for assessing systemic effects on the economy which seems to deal adequately with both costs and benefits, is essentially an input-output model for the local economic system (Cochrane, 1974). It projects such things as unemployment and, eventually, net effect on value, added as an indicator of the well-being of the economy.

The concept of systemic (secondary) losses is not at all a new one; the Corps of Engineers has been attempting to identify losses of this type for at least forty years (White, 1942). At first the Corps dealt with what it called suspension of business, which included wages of employees. The principal problem has been one of including all legitimate losses without double counting. The sensitivity of loss estimates to varying assumptions was illustrated dramatically by a case cited by White (1942) in which the Corps placed losses from the 1937 Ohio River flood at $25,000,000 while the TVA estimated the same effects at $13,000,000. The Corps has recently revised their estimation procedure (one of many revisions since 1934) and now includes net losses of normal profits and return to capital, labor, and management.

Unfortunately, it is not known what relationship exists between the output of the three techniques mentioned here, and there is certainly no conspicuous agreement as to which is best. My own inclination is in favor of the input-output approach because of the availability to planners of the sort of data which goes into such a model and because of the familiarity of many planners with input-output analysis.

The other, more problematic loss to estimate is that of life, physical injury and suffering, and psychic distress. The first problem is to estimate the numbers of people who will experience death or particular intensities of injury and mental anguish. More data is available on deaths than on either of the other effects, but rough estimates can probably be made from past disaster experience for both. For example, the ratio of people killed to people experiencing injuries requiring treatment or hospitalization varies from hazard to hazard, but a good estimate could probably be made for a particular place and a particular hazard by looking at experiences of past situations which were similar. Recent data suggests proportions of the population which require short term psychiatric counseling after disasters (Haas, 1973), and one longitudinal study gives insight into the extent of long term psychological effects of disaster (Bates et al., 1963).

A much more troublesome problem, however, is how to measure such effects in order to weigh them alongside economic effects. The TRW model simply counted lives saved by adjustment, but eventually that set of benefits had to be evaluated for its worth relative to other benefits. And because at least one set of benefits was in terms of dollars, there was implicit in the TRW methodology at least an ordinal conversion factor of dollars to other measurements used. This is not meant to criticize the TRW model for that conversion; the criticism lies in the very qualitative manner in which the conversion rates were determined.

Any methodology which accepts the premise that there are pecuniary losses from hazards, and that there are also essentially nonpecuniary losses (at least nonmarket losses), must assign relative weights at some point. While it is distasteful to speak in terms of the dollar value of human life, and while there is an inclination to say that such things are "priceless", decisions are made every day which at least implicitly recognize a trade-off in values, one of which is valuation of life, pain and suffering, etc.

Economists speak of two basic ways in which to determine the social worth of commodities, services, and so forth. The first--often reflected in the market--is aggregate willingness-to-pay by society for the entity in question. Some consumers are willing to pay a great deal, while others are willing to pay very little for the same item; the sum of all the "willingnesses" supposedly reflects the value placed by society on the entity. Another measure used by economists is the "price compensation" indicator of worth. Instead of asking how much one is willing to pay in order to acquire an entity, it is asked how much one would have to be paid (compensated) if he had the entity and it were taken from him, in order for his state of well-being to be as satisfactory as it was before the entity was removed.

These premises have indirectly and perhaps informally found their way into attempts to place dollar values on "intangibles" such as life, but to illustrate the fact that some valuation is indeed appropraite and necessary, the following argument should be considered: there is some amount of money, beyond which society is unwilling to pay, to <u>prevent</u> the loss of life or the experiencing of physical and psychological pain. The reason is that society is faced with the fundamental economic dilema--unlimited wants and limited resources.

Several attempts have been made to quantify the value of a life using expected earnings (Rice and Cooper, 1967), jury awards to dependents of those killed in accidental death (Roberts, 1973), hazardous duty pay (Carlson, 1963), life saving costs of the Federal Aviation Administration (Carlson, 1963), and the monetary point in property damages at which the public seems to shift its attention and emphasis on disaster effects from lives lost to property destroyed (Otway, 1971). A study was conducted for the Corps of Engineers on the subject in 1972 (Buehler) which reviewed several of the methods and concluded that engineers should indeed utilize "dollar human values" to aid in making decisions. Most of the various techniques (their rationales will not be discussed here) suggest an average value of about $250,000 per life lost, although one may be able to defend going as high as $500,000 (both figures are in 1971 dollars).

Most of the efforts to value pain and suffering and psychic distress rely on awards made by courts. The difficulty in this case is that court awards vary for type and intensity of injury, and of course, effects of that specificity can not be predicted very accurately. Most reviews of court decisions, however, indicate that large awards generally are made only when the victim's earning potential is adversely affected (Franklin et al., 1961; Banzuly, 1961). Injuries requiring professional medical attention as a result of disaster experiences vary somewhat according to hazard, but could comfortably be assigned a liberal average value of $35,000 each, while the numerous incidences of short term mental anguish could be assessed at an average of $2,000 each, with the very few long term cases of psychic distress being valued at $50,000 each.

After spending the better part of three pages on this touchy and difficult subject, I must concede that losses to life, etc. may comprise an almost negligible component of total losses for some hazards even if double the valuations proposed here are valid measures. There may be many situations, however, in which this component may make a difference in evaluations involving an alternative which is marginal with respect to its desirability. Also, the relative importance of these effects are probably greater for some hazards than for others.

After losses have been projected for each of the three categories, it must be determined what effects the adjustment alternative would have on those losses. A regulation requiring flood proofing of structures in a particular area, for example, would alter the loss function, while an open space zoning ordinance would alter the growth and development of structures in the area. The reduction in projected losses, then, due to the adjustment, can be counted as a benefit of the adjustment.

4a. Although losses averted are likely to be the primary benefit from a land use adjustment, there may also be others, the main one of which relates to environmental quality. Natural areas provide several functions beneficial to society which we may not want to interfere with (e.g., recharge of aquifers, erosion control, wildlife habitat, fire suppression). Intensive development of the areas does conflict with the natural processes sometimes, however, such as dredging and filling of wetlands to provide homesites. In some cases quantification of the natural process values may be more practicable than most of us realize; a detailed example is given in the following chapter.

Recreational benefits may also accrue from many land use management alternatives and can be considered of an environmental nature. Some communities have purchased flood plain lands for use as park land, for example. Some types of recreational benefits can be quantified by techniques like the "travel cost" method, which assumes that the cost of traveling to the recreation site reflects at least a part of the user's willingness-to-pay to recreate. Many recreation planners feel uncomfortable with the technique although it is the most widely used one (Coomber and Biswas, 1973), and benefits from urban parks, particularly open space benefits, have been more elusive to researchers who have attempted to place a value on them. Thus, evaluations of this nature have often been more elusive to researchers who have attempted to place a value on them. Thus, evaluations of this nature have often employed a methodology like the goals-achievement matrix technique (Hill, 1968), discussed in Chapter Two.

An indirect, partial measure of benefits from an urban park or even a golf course or some other aesthetically pleasing open space area is the enhancement of property values of land surrounding and proximal to the area. The approach is discussed with an empirical example by a group at the Regional Science Research Institute in Philadelphia (Hammer et al., 1971; Coughlin and Hammer, 1971).

In 1966 Clawson and Knetch said that recreation economics was at the developmental stage which agricultural economics had been thirty years earlier; progress in some areas has been slow in coming during the past eight years. One of the more innovative concepts having emerged, however, is "option demand", proposed by (Weisbrod, 1964). Essentially there are two conceptual measures of the notions:
a) the price compensation measure--how much an individual is willing to pay in order to preserve his option of using a preserved or recreation area in the future, and b) the price equivalent measure--the amount an individual must be paid to give up voluntarily his option to use such an area (Weisbrod, 1964). The idea is that the effects of some decisions are more reversible than than those of others, and therefore, the less reversible ones are more risky than the others. For instance, if a decision is made to maintain open space in an area, it is physically and economically easy to reverse the decision and permit intensive development later. Conversely, if a decision is made initially to permit the development, it is relatively infeasible to remove the structures and revert the land back to open space. Thus, there is some value to preserving the option of future flexibility.

There have been problems in operationalizing the concept--that is, in actually determining the aggregate option demand for retaining non-intensively developed land in that state--although a very elaborate procedure was applied to the Hells Canyon of the Snake River (Fisher et al., 1972). A plausible alternative seems to be in modifying the rate at which benefits and costs of an alternative are discounted over time depending on the extent to which the alternative preserves the option of future flexibility. The rationale for and debate concerning discount rates is discussed at length elsewhere, and will be discussed only briefly and partially here (see Howe, 1971; Mishan, 1971; O'Riordan, 1971b).

If effect, a lower discount rate usually favors the feasibility of a project (adjustment alternative), especially one in which benefits increase with time, and risky projects are usually discounted at a higher rate. Thus, preserving the option of future flexibility can be rewarded by assigning a lower discount rate to alternatives which yield that benefit. Such a procedure can be justified by attributing a higher degree of risk to alternatives producing irreversible effects.

Environmental benefits like those discussed above can be considered secondary to the primary goal of loss reduction (which usually motivates the evaluation, at least in the situation with which this paper is concerned), and there may actually be other secondary benefits as well. By restrictive zoning of a particular area, for example, growth may be diverted from an already overly dense sector of the community into an area which perhaps is in need of the facilities and services which accompany development. Rather than enumerate early in the evaluation all the things we want to measure for inclusion as benefits or costs, a more cautious approach may be to attempt prediction of all effects of the alternative, and then determine whether they should be counted as benefits or costs after comparing them with the community goals. Those effects labeled "benefits" and not already considered as loss reduction or environmental benefits would be counted at this point.

i. Land use adjustments sometimes restrict the use of hazardous areas to activities which are not as profitable to the manager as those precluded by the regulation. All four of the models discussed recognized this point and considered it a cost of the adjustment. All of the models measured the cost in essentially the same way--assessing foregone profits, rent, or site income, as the nomenclature varied.

The argument goes that if an activity sought to locate in the hazard zone initially, it was because the site offered it something more than it could obtain outside that area. Thus, if the activity is forced to locate at the next best location (outside the hazard zone) due to land use regulation, then the difference in profits to the activity from its location outside the area and what they would have been within the area must be considered a cost of the regulation. There is general agreement on the point; slight differences of opinion arise in measuring that cost.

Again, growth projections are necessary, and it must be estimated what development would have occurred in the zone without restrictions, what development would occur in the area with restrictions, and where displaced activities would locate outside the zone. While these estimates are very difficult for individual facilities, aggregate projections can be made more easily. The Corps of Engineers has developed fairly detailed procedures for estimating land use changes.

Land prices under competitive conditions are presumed to equal the discounted expected value of the stream of rents from the parcel (Lind, 1967), and therefore can be used to reflect the sort of profits which activities expect at various locations. James (1972) argued that the cost is equal to the difference in price of a parcel of land before the restrictions were imposed minus the price of the same parcel after the imposition of regulations. Lind (1967), to use the same reasoning he employed to determine land enhancement benefits from flood protection projects, would calculate the cost as the difference in price of the parcel without regulation and the price of the next best parcel outside the hazard zone without restriction.

Both these approaches seem to ignore the fact that the adjustment (regulation) can also enhance the utility of land bordering the restricted (hazardous) area. An example will be given in the following chapter. Therefore, to recognize that possibility, the best measure of this "opportunity cost" of non-development for a given parcel of land appears to be

$$P_H - P_A,$$

where P_H is the price of the preferred site within the hazard zone without regulation, and P_A is the price of the best alternative site outside the hazard zone <u>with</u> regulation of the zone. Thus, if no enhancement of land utility outside the area accrues from the adjustment, the approach is equivalent to Lind's. If enhancement does occur, the methodology detects it. Also, land values have a drawback as indicators of the actual stream of rents, especially in hazardous areas, because managers characteristically underestimate the losses their use of the parcel will incur, thereby overestimating the rent from the land. The error lies in what is usually called "hazard perception", a concept initiated by White (1942) and refined by him and his students at Chicago in the 1960's. The effect is that the method I have suggested for computing the opportunity cost of restricted regulation may be a liberal one (i.e., overestimating the cost), because inaccurate expectations of hazard losses may inflate the cost of hazard zone land appreciably.

ii. The next type of cost of adjustment is direct capital outlay and operation expenses required by the adjustment. In some cases it may be a cost to the local government in the form of the cost of purchasing land, development rights, easements, etc. In this case it is especially important to consider funding supplements to the local government by state or Federal programs. If cost of buying an area is $600,000, for instance, but the local government can get two-thirds of the funds from a Federal funding program, the effective cost to the locals is only $200,000. Thus, that alternative may be preferable to another alternative with costs in excess of $200,000, but less than $600,000 if the locals must bear its full cost.

The above accounting stance suggests a bothersome dilema; the procedure seems valid enough in that it measures the real cost to the community, but should the reasoning be extended to loss projections? If so, losses to the local area may be computed as absolute losses in the community <u>minus</u> Federal relief benefits which could be anticipated. I am not convinced of that latter application of the stance and will not employ it here, but it is a concept deserving deliberation. That is, rejection of the latter application casts a shadow on acceptance of the former usage.

Sometimes regulations require flood proofing, site elevation, or structural modifications of facilities located in the hazard zone.

The direct capital expenditures necessary to satisfy those and similar requirements should be counted as a cost of the regulation.

iii. Some alternatives result in additional expenditures by the local government for administrative tasks, unless they can be absorbed into the existing administrative framework. Otherwise, they must be counted as costs of the adjustment. Examples are surveying and mapping costs, policing and enforcing building codes, and legal transactions, especially law suits.

iv. Although most land use management adjustments have positive environmental effects due to their open space nature, some can degrade the environment. For instance, a regulation requiring site elevation could destroy natural habitat, interfer with drainage patterns, and permit development of a relatively irreversible nature. Environmental benefits foregone as a result of the adjustment should be counted as costs.

v. A final cost category is a catch-all analogous to the "other secondary benefits" discussed under heading 4a. Just as an adjustment can provide benefits in reduced traffic congestion, etc. by redirecting development, so can it provide costs. Those effects generated by the alternative and valued as undesirable according to the community goals and not already counted earlier, are evaluated here as secondary costs. The range of effects can vary considerably depending on the alternative and where it is applied, of course.

v. Two general categories of benefits (B) and costs (C) have been identified:

$$B = L_a + E_b + S_b,$$

where L_a is losses averted, E_b is environmental benefits, and S_b is other secondary benefits;

$$C = R_1 + O + A \div E_c + S_c,$$

where R_1 is economic rent foregone, O is capital outlay and operation costs, A is cost of administration, E_c is cost of environmental degradation, and S_c is additional secondary costs.

The manner in which these costs and benefits are handled from this point depends on the loss management goals framework chosen. Mean losses are the easiest to deal with. A time frame for evaluation is specified first; it should be as far into the future as reliability of estimates and projection permits (also contingent on such things as expected "project" life), probably not exceeding fifty years and more often being shorter than that.

A benefit-cost ratio can then be computed by

$$B/C = \left[B_0 + \sum_{i=1}^{t} \frac{B_i}{(1+r)^i} \quad / \quad C_0 + \sum_{i=1}^{t} \frac{C_i}{(1+r)^i} \right],$$

where B and C represent benefits and costs per year, i is the number of years beyond the initial year of the adjustment, t is the time frame, and r is the discount rate. There are also other techniques for evaluating the trade-off between benefits and costs, the most commonly employed being subtraction of costs from benefits to yield a net benefit figure (Howe, 1971). Although all the procedures have their advantages, Sewell et al. (1962) generally recommends the ratio technique. Choice of discount rate will depend on the conventional criteria as enumerated by Howe (1971) and O'Riordan (1971b) and also according to the irreversibility of the land use decision's effect on future flexibility. The entire process can be followed for each of several alternatives and various levels of adjustment (magnitude of event planned for) of each, after which the B/C ratios can be compared. The hazard zone can be compared. The hazard zone can also be broken into sectors, with different alternatives and combinations of alternatives applied to each sector.

Catastrophe potential and distributional effect goal frameworks are considerably more difficult to evaluate. Perhaps a graphical analysis of plots like those in Figure 5 could be carried out to determine the behavior of loss functions for a given level of various adjustments, yielding a sort of aggregate "stage"-damage curve. In Figure 5, the lines represent loss behaviors when different adjustments, designed for a particular magnitude of event, are exceeded beyond their design capacity. Something like a critical skewness/kurtosis ratio could be inferred to suggest how sensitive a particular alternative is to an event of greater magnitude than the one for which it was designed. That is, it may be possible to identify some measure involving variance of the loss distributions for each adjustment which should be avoided, because it may lead to too high a catastrophe potential. To my knowledge, this procedure has not been followed, and my own dealings with it are more conceptual than operational.

If catastrophe potential were the only goal framework employed for loss management, then a cost effectiveness procedure could be used to identify the best alternative. That is, only alternatives which yielded a skewness/kurtosis ratio below the critical value would be considered viable, and among those which yielded that result, the

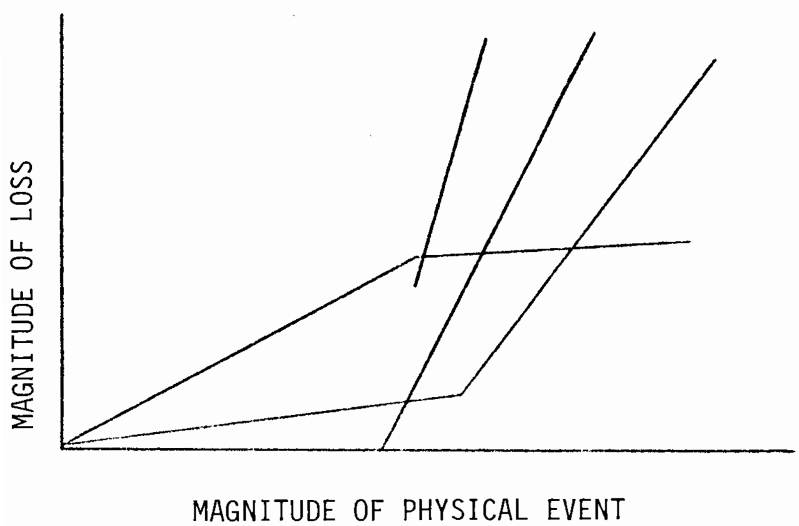

FIGURE 5

LOSS DISTRIBUTION BEHAVIORS
FOR VARIOUS ADJUSTMENTS

one which generated the least costs would be preferred. Secondary benefits could be subtracted from the costs.

A more likely situation, however, would be a combination of mean and variance goals. In that case, the average annual losses B/C procedure discussed above could be used, with an alternative which exceeded the critical catastrophe potential value being automatically eliminated. Thus, the mean value approach would be used, with alternatives being constrained by the catastrophe potential criterion.

Distributional effects could be handled similarly, with distributional goals being specified, and the goals operating as constraints to the solution yielded by the B/C or cost-effectiveness procedure. For example, if we want to assure that no one loses more than fifty percent of his worth in a disaster, only alternatives which would provide that result may be considered. Among those which do achieve that goal, the one with the lowest cost would be preferred.

AN ILLUSTRATIVE EXAMPLE

To illustrate the proposed model's use, an example will be worked through for what I will call a quasi-hypothetical situation. Some of the conditions of the example are accurate for an actual place--Panama City, Florida--but others are fabricated to provide flexibility in the illustration. I chose to base the example, in part, on a real place both for convenience and to maintain some contact with reality. Hereafter the place will be referred to as "The Site", because, strictly speaking, it is not Panama City. The hazard to be dealt with is hurricane storm surge.

The Site is located on the Gulf of Mexico and has a population of approximately 64,000, with the economy based on tourism (primarily in the summer), port activities, and commercial fishing, shrimping, and oystering.

1. Identification of Goals. The loss management framework will be average annual losses, and other community goals are extracted from the Comprehensive Plan (formulated by a consulting firm and approved by the City Council) for the area, with the assistance of three planners employed by The Site. The relevant goals will be mentioned during the illustration as they come into prominence.

2. Adjustment. The city is expected to grow to the west along the coastline, because a Federal military installation borders it to the east and extends several miles. To the west is about a mile of beach and dune topography and then another mile of marshy land (see Figure 6). Both areas are in the incorporated limits of the city. It is expected that within five years the beach area will be

commercially developed and within ten years, development pressures will be sufficient to lead to filling of the wetlands for residential development.

The proposed alternative for illustration here is a two-pronged solution to controlling future development in these two areas seaward of the 100-year hurricane storm-surge contour.

a. For the beach and dune area, a selective zoning ordinance is proposed, based on the model ordinance formulated by the U. S. Water Resources Council (1972). It is basically an open space provision which permits marinas, piers, parks, parking lots, golf courses, tennis courts, boardwalks, temporary structures for sale of food, refreshments, arts and crafts, etc. Uses of an intensive nature, such as residences and hotels are generally excluded.

b. For the marsh area, The Site proposes that the area be purchased by the city and managed in a manner that will not destroy the natural ecological balance fo the area.

3. Hazard Loss Projections. Both the Corps of Engineers and the National Oceanic and Atmospheric Administration have determined probabilities of events of various magnitudes for the reaches of shoreline being planned for by The Site (the NOAA figures being more recent and indicating lesser magnitudes). Also, the Corps, in an Interim Hurricane Survey, has specified stage-damage relationships for structures of various types and has computed aggregate loss figures for various events for the already developed hazard zone. These data combined with Planning Office projections to the year 2000 of development in the areas west of the urbanized city make it feasible to project what expected average annual losses in the two areas would

be over the next twenty-six years if no adjustments were employed. The aggregate would be approximately $4,000,000 over the twenty-six years, or $160,000 per year.

These, however, are only the direct damages to property. For this illustrative purpose, I will assume a ratio of 1:1 between direct and systemic losses. In an actual decision making situation, the input-output procedure mentioned earlier should probably be carried out, but the Cochrane's application (1974), the ratio proved to be 1:1, and he feels very comfortable with that as a rule of thumb. The Corps has rejected this technique because the ratio has been shown to vary significantly from place to place (see White, 1942). It is not likely to overestimate losses to the economy in this case because in coastal areas the economy is so dependent on activities in the hurricane flood zone.

Deaths, serious injuries, and distress are the most difficult to predict, but employing experiences from past hurricanes elsewhere and the evacuation plan for The Site, it seems reasonable to expect only about two deaths, ten serious injuries, 100 short term mental distress cases, and no long term incidences of mental disturbance. The aggregate value, then, would be $875,000 or $35,000 per year.

Total average annual losses, without adjustment, therefore, would equal $355,000, two-thirds of it being in the beach area.

With the prescribed adjustments, because most loss-prone activities would be excluded from the areas, losses would be reduced by approximately 85 percent, or $301/750 per year. That would be benefits from adjustment attributable to losses averted--$201,267/year in the beach area and $100,483/year in the marsh area.

4a. Preservation of the marshes permits them to continue their natural processes, and one of those processes is provision of detritus, food, and breeding habitat for shrimp and oyster crops offshore. Several different valuations have been placed on such processes, but one of the more recent is that by Gosselink, Odum, and Pope (1973) which places the value at $450/acre/year. There is no widespread agreement in the literature as to the validity of this valuation, but it is more conservative than some alternatives.

One of the community goals to which The Site is committed is implementation of a tertiary treatment system for its waste water, because of the need to maintain clean water at its beach areas (the effluent is emptied into the Gulf). Gosselink et al., have shown that waste water can be pumped into marshes, and the natural processes will purify the water through the tertiary stage before it returns to the Gulf or underground sources. The value of this process to the community is placed at $30,000/year for the entire marsh area it has proposed to buy.

Thus, the natural process value of the 160 acre marsh area is $102,000 per year.

There are no recreational benefits from the area, but it does reserve avenues for flexibility in the future, so a lower discount rate will be used for its evaluation than would be used for more irreversible alternatives.

The zoning of the beach area provides no significant recreational benefits that would not have occurred without the action, but it does enhance the value of property nearby. This calculation, though,

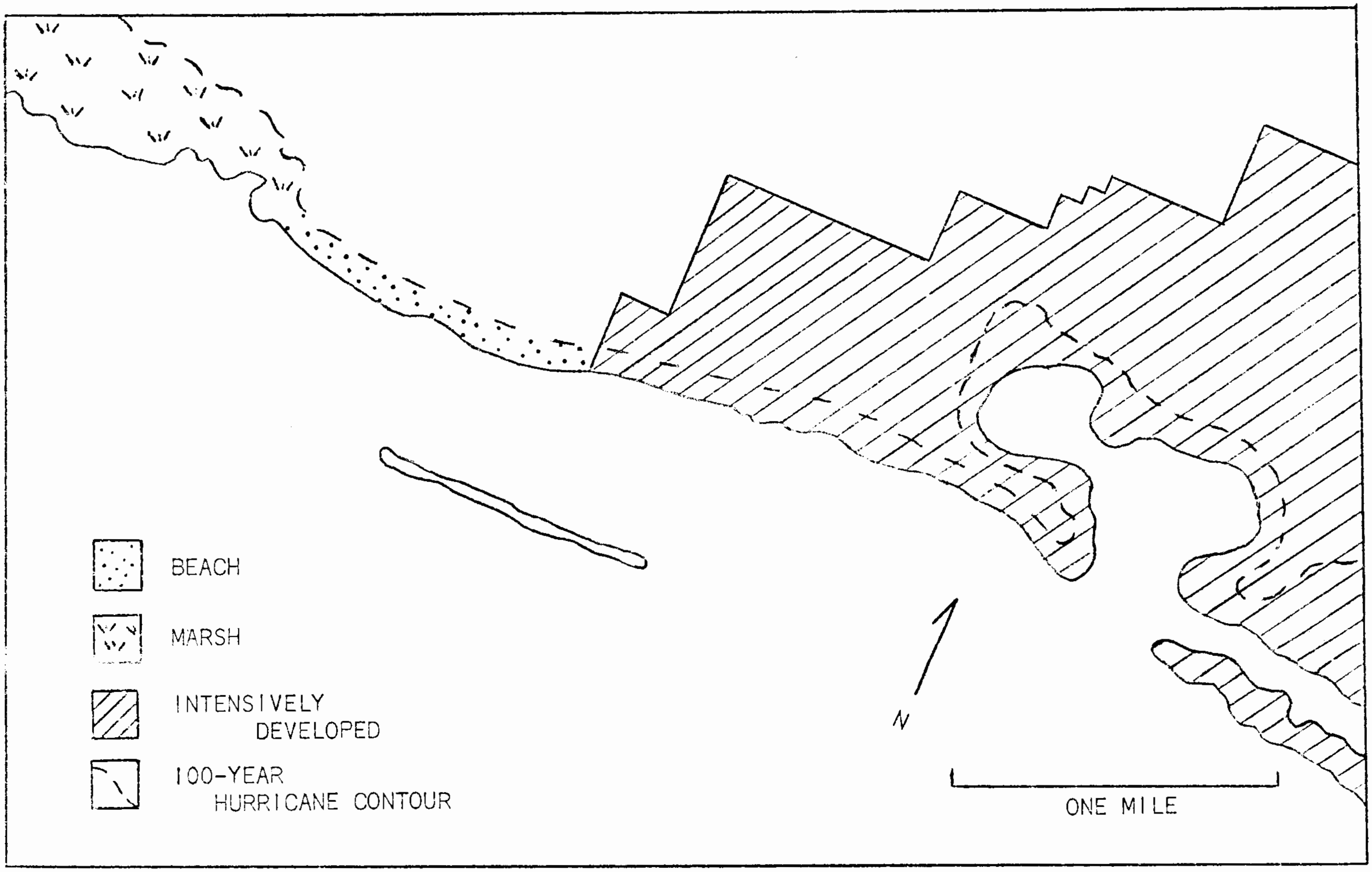

FIGURE 6

MAP OF THE SITE

is included in the net decrease in economic rent attributable to the zoning (computed below). The zoning will be evaluated at a slightly higher discount rate than the preservation, because the development it permits is slightly more intensive.

4b. Cost of Adjustment.

i. In the beach area, the zoning is not expected to preclude any activities which would not have located elsewhere at a lower profit. The primary displacements are expected to be to hotels, motels, condominiums, restaurants, and related activities. It should be noted, however, that the reason for locational advantages accruing to the beach area is not just proximity to water, but also relative proximity to water--that is, being closer to the water's edge than "the other guy". Thus, all such developments are excluded from the area and none has an advantage over the other. Also, the zoning permits only low intensity, open space uses, so the view of the sea is left open, just pushed inland a few hundred yards. There are other competitive activities of the same function located on the beach in the already developed area, though, and that gives them a locational advantage over new locators. The net effect is that profits to this functional category of activities will be lower on the fringe of the zoned area than they would have been within the area, left unzoned. However, profits on the fringe locations will be higher than profits would have been to any activity locating there if zoning had not been implemented.

Net difference in expected profits (rents) as reflected in projected property value changes indicates that the opportunity cost of zoning in the beach area will equal $1,245,000.

ii. There will be no such opportunity cost in the preservation area, because purchase price mirrors present value of expected rent. The market value of land in the marsh area is $2,525 per acre, on the average, with speculation about future development. Total purchase price, therefore, is $404,000. But The Site is confident of obtaining 50 percent of the funds through the state from the Federal Land and Water Conservation Act; thus, their net price is only $202,000.

There will also be construction costs in transferring the waste water to the area, estimated at $40,500, and maintenance thereafter averaging $1,200 per year.

There is no capital outlay in the zoning alternative.

iii, iv, and v. Administrative costs are absorbed into the existing governmental structure, no law suits are anticipated, and environmental costs and other secondary costs of the alternatives are negligible.

5. For the marsh area,

$$B = \underset{(L_a)}{\$100{,}483/\text{yr}} + \underset{(E_b)}{\$102{,}000/\text{yr}} = \$202{,}483/\text{yr}$$

and

$$C = \$242{,}500 + \underset{(O)}{\$1{,}200/\text{yr}}.$$

For the beach area,

$$B = \underset{(L_z)}{\$201{,}267/\text{yr}}$$

and

$$C = \underset{(R_1)}{\$1{,}245{,}000}.$$

Discount rate used for each of the components will depend on that used for other alternatives being evaluated because it will be reduced for those with future flexibility. For this example, assume 5 percent is being used to discount projects allowing intensive development (although this figure is unrealistically low, it is in line with other examples in the literature). Then 4 percent may be appropriate for the marsh area and 4.25 percent for the beach area. Thus, for the marsh area,

$$B = \$202{,}484 + \sum_{i=1}^{25} \frac{\$202{,}483}{(1.04)^i} = \$3{,}365{,}772$$

and

$$C = \$242{,}500 + \sum_{i=1}^{25} \frac{\$1{,}200}{(1.04)^i} = \$261{,}250.$$

For the beach area,

$$B = \$201{,}267 + \sum_{i=1}^{25} \frac{\$201{,}267}{(1.0425)^i} = \$3{,}260{,}589$$

and

$$C = \$1{,}845{,}000.$$

The overall benefit-cost ratio is, therefore,

$$B/C = \$6{,}626{,}361/\$2{,}106{,}250 = 3.15.$$

Summary

The preceding example in no way tests the proposed model; a normative procedure like this one, which state how something *should* be done, is not testable--at least not in the strict hypothesis-testing framework. Rather, it provides an illustration of the methodology to a situation, a set of data. The estimates, projections, and calculations made here were not done with the precision or detail that would be followed in an actual decision-making situation. Particulars of some of the computations were not presented, because the goal of the illustration was to present the more general steps of the procedure.

Attempts were made to keep the data realistic, basing them when practical on actual conditions known to exist. But whether the circumstances of the example are accurate or not is not crucial--the very same general steps would be followed, regardless, perhaps with different results. Applying the model to different alterantives having different effects would tell no more about the validity of the model, although measurement problems could be raised which are more difficult to deal with than those encounted in the exmaple, a point which I readily concede is likely. The model is not of the form that varying the assumptions of discount rate, time span, etc. would reveal more about the validity of the model in the manner that sensitivity analyses are usually performed. Changing the situation, of course, would have altered measurement problems and specification of alternatives (for example, evaluating a policy to include the already developed area).

It is also difficult to say how the performance of this model on the example would compare with that of the other four models discussed. It may be fair, however, to speculate that the proposed land use policy analyzed in Chapter Four would have been less favorably evaluated by the Whipple, Day, and James models, due to their lower accounting of losses averted and secondary benefits. The TRW model, because its valuations on various considerations are less explicit and highly subject to variation depending on the values of the evaluators, is more difficult to compare.

The objective has been to develop a refined version of the four models discussed in Chapter Two for application to local problems in the pursuit of local goals dealing with hazard zone land use strategies. The example has sought to illustrate that a more comprehensive treatment of relevant variables is possible than the treatments appearing in the four chosen models and that quantitative measurements are often available as alternatives to "informed judgments" of individuals. The following chapter provides a critique of the procedure.

Applying alternative methodologies to this same example would have added nothing to the goal of illustrating the proposed model, and comparing results of alternative analyses to a single case would have added nothing to evaluation of the proposed model's validity or reliability. The latter point reflects the intrinsic nature of evaluating normative models.

SUMMARY AND CONCLUSIONS

This paper prescribes an array of considerations useful in the evaluation of alternative hazard zone land use policies and presents examples of current methodologies to illustrate the state-of-the-art, pointing out shortcomings of present models. A framework is proposed for integrating the considerations to evaluate alternative land use policies.

The effort is more integrative and organizational than fundamentally original, although there are some original components in the model from the standpoint of measurement.

The major strengths of the model can be summarized in seven points.

1. The model comes closer to "touching all the bases" in terms of accounting for the benefits and costs of alternatives than any of the models reviewed had done. Secondary benefits and costs other than environmental effects, a more comprehensive treatment of losses averted, and administrative costs are all included in the procedure.

2. More than one loss-management framework is recognized and dealt with. None of the other four models discussed treated any framework other than average annual losses, whereas the proposed technique requires explication of the framework(s), and the evaluation is modified depending on which is employed.

3. Community goals are integrated into the analysis differently than previous methodologies. They are used to indicate whether particular effects from the adjustment should be counted as benefits, costs, or neutral consequences.

4. To a greater extent than in previous models, this procedure avoids qualitative judgments of valuations and trade-offs of criteria. Instead of polling officials or viewing past valuation decisions, efforts are made to find recent techniques for formal measurement of variables and employ those techniques.

5. A different way of accounting for option value pertaining to an area is suggested by expanding the use of the conventional criterion of risk on discount rate assignment.

6. A different way of using property values to measure the opportunity cost of nondevelopment is proposed which makes the valuation more dynamic.

Major misgivings and shortcomings of the model can be enumerated in four points.

1. To be made most useful to decision makers, the procedure should be computerized in order to facilitate rapid analysis of numerous alternatives. There should be no major problems, however, in converting the basic manual steps to a computer program.

2. Community goals are still not dealt with adequately. Although using them as a key to assignment of benefit or cost labels to adjustment effects is useful, some situations remain unaccounted for. When the community (or state, nation, etc.) is unalterably committed to a particular decision--say, the acquisition of open space, to use the same example cited in Chapter One--then an alternative involving acquisition of the hazard zone for maintenance of open space should somehow be favorably weighted beyond the point of simply stating that open space effects will be counted as benefits.

3. Although the model recognizes the need to operate in catastrophe potential and distributional effect loss-mangement frameworks, its methods of treating them are inadequate. First, the manner of specifying what framework or combination of frameworks will be employed is the most qualitative point in the model. Second, methods of determining evaluative criteria, especially for catastroph potential, are terribly vague and unproven. The kurtosis/skewness approach appears promising, but it is not at the point of being operational. Even if a critical value with respect to catastrophe potential could be identified and distributional goals specified, it is not clear how they should be weighted against one another and against net benefit calculations. The suggested procedure for dealing with combinations of framework goals) may place too high a value on the goals operating as "constraints".

4. While the notion of using a reduced discount rate for alternatives preserving the option value of a natural area seem conceptually sound, work is needed to determine the magnitude of reduction which should occur.

How much nearer does this bring us to the goal of providing an integrated and complete methodology for evaluating hazard zone land use policy alternatives in a manner which would fully utilize the current state-of-the-art in measuring relevant considerations? The suggested model appears to improve on existing similar methodologies without requiring impractical procedures. Hazard zone land use policies are not "zero-cost" alternatives and should be evaluated for their net worth to the community rather than simply adopted or rejected because of a very informal consideration of a narrow range of effects which the policies would have. The proposed procedure attempts to consider all effects of the policy and to measure them with formal techniques.

Although the thrust of this paper deals with hazard zones in general, principal reference has been made to entities concerning flood plains--the Corps of Engineers, the models discussed, etc. The reason is that evaluation of hazard adjustments receive much more attention for flood plains than for other hazard zones. To a considerable degree, local planners and decision makers draw upon the experiences and procedures of Federal agencies involved in flood plain decisions and can try to adapt them to more general hazard zone policy decisions.

There are at least two fundamental drawbacks to such a tactic, however. First of all, those procedures are designed principally to achieve national economic efficiency--not local. That trend may be changing, however, as the new guidelines for evaluation adopted by the Water Resources Council (1973) also include provisions for regional economic development, environmental quality, and social well-being. Second, Federal procedures in the new Water Resources Council standards are still primarily oriented towards evaluation of construction-based alternatives even though they are intended for broader use. They often do not deal adequately with some variables important to evaluation of land use policies, especially those involving provision of open space. Cicchetti et al. (1973) pointed out the inadequacy of an early version of the WRC standards in dealing with the environmental reversibility of a policy, for example, and the revised version of the standards still seems to neglect that variable.

Two other drawbacks (of a more practical nature) to use by locals of Federal procedures are lack of availability to local planners of many of the detailed techniques and lack of expertise and training by locals necessary for the use of those procedures. Although Federal procedures very effectively reach memebers of the agencies who will actually be using them, the rules are not circulated widely outside the sphere of the respective agencies. Furthermore, it seems unlikely that Federal agencies will be called on by locals whenever the locals are faced with a hazard zone policy decision. This is especially true in view of the fact that some open space decisions may be made with the recreational or open space considerations playing the motivating role in the decision, and hazard loss-abatement considerations being of secondary importance. Thus, agency workers, who know about the procedures, may not be involved in many of the decisions at all, and few people outside the agencies know the procedures well.

Even those local planners who are aware of disciplined procedures formulated by agencies such as the WRC may not possess the training or expertise necessary for the application of the procedures. It seems important that decision models be usable by decision makers from the standpoint of the users' capabilities. Similarly, a technique such as discount rate modification may be preferable to a mathematically involved method of accounting for option value like the one suggested by Fisher et al. (1972).

Federal water resource analysis procedures and Federal and state highway analysis procedures probably reach a greater number of local planners than do articles in most professional journals, not to mention academic theses and dissertations. The most pervasive medium of reaching locals is likely to be through the American Society of Planning Officials which publishes specialized topical reports intended to aid local planners in their work. It is through that channel that guidelines for hazard zone land use policy alternatives need to be directed. Also, such guidelines need to be described in greater detail than those in this paper.

The paradigm of the model proposed herein is actually quite traditional, in that it attempts to measure adjustment effects monetarily and then analyze the trade-offs between them. The bolder part of the model is that it attempts to apply the monetary measures to a broader range of effects than those usually assumed to be amenable to that method of measurement. This effort reflects the trend toward incorporation in decision models of additional monetary measures as techniques for estimating them are refiend. The new WRC standards, for example, place a dollar value on recreational benefits, which were once only included descriptively (qualitatively) in Federal studies. This paper seeks to illustrate that perhaps there has been more progress in placing dollar estimates on the value of "intangibles" than is generally believed.

Another trend in analytical models, however, has been to seek a middle ground between dollar valuation and verbal description of intangibles. The trend has already been noted in reference to transportation planning, but the concept is also receiving increasing attention in Federal water resource evaluation. A study involving a methodology similar to matrix evaluations was contracted by the Corps of Engineers (Crawford, 1972), and the Corps also contracted a study employing systems analysis (Anderson et al., 1972). The TRW systems model discussed in Chapter Two, also contracted by the Corps, employs such a "middle-ground" approach to evaluating intangibles. In view of the WRC's new procedures of accounting for "project" effects in four categories--national economic development, environmental quality, regional economic development, and social well being--only the first of which is measured in dollars. The newer modes of analysis may very well come into increasing prominence.

There is considerable need for alternative forms of analysis to be compared to see how their respective solutions to the same hazard zone policy decisions relate to one another. Perhaps the effort to place monetary measures on all effects results in gross measurement error. But on the other hand, resorting to ordinal valuations may sacrifice valid information, resulting in even greater errors in evaluation.

In confronting the problems of measurement in evaluating the effects of adjustment to floods, it has been argued for a long time that although numerous relevant variables are difficult to measure, some effort to that end is needed. Otherwise, those variables would be assigned an effective weight of zero. Those of us who are involved in research relating to planning and policy making have a responsibility to see to it that "intangibles" are not effectively assigned a weight of zero, but that they are measured as accurately as present methodologies allow.

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