# CREATING HAZARD RESILIENT COMMUNITIES THROUGH LAND-USE PLANNING

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**ABSTRACT:** The Second National Assessment on Natural and Related Technological Hazards calls land-use planning the single most promising approach for bringing about sustainable hazard mitigation. This article describes the essential elements of land-use planning for hazard mitigation. It highlights important choices involved in formulating planning processes, undertaking hazard assessments, and crafting programs to manage urban development so that it is more resilient to natural hazards. Research conducted over the past two decades suggests that if local governments make the right choices in crafting land-use-planning programs, communities will be less likely to suffer severe losses of lives and property in natural disasters.

## INTRODUCTION

Local governments across the United States, as well as the state and federal governments, are slowly coming to realize that land-use planning is an important tool for reducing losses in natural disasters. This is a sharp reversal in policy. Throughout this century, governments at every level have emphasized programs that ease the development and use of land exposed to hazards with little attention to the long-term sustainability of that development. The measures familiar to everyone—beach nourishment, flood control works, disaster relief, emergency warning and evacuation, flood insurance, and others—have encouraged and sustained a phenomenal increase in exposure to loss in natural disasters. The consequences are immense, with natural hazards now estimated to cost the citizens of the United States an estimated $500,000,000/week (Mileti 1999).

Policymakers are now coming to realize that a different approach is needed if vulnerability to natural disasters is to be reduced. According to the National Research Council's Board on Natural Disasters (Board 1999) ''Communities can often achieve significant reductions in losses from natural disasters by adopting land-use plans.'' In fact, the Second National Assessment on Natural and Related Technological Hazards concluded, ''No single approach to bringing sustainable hazard mitigation into existence shows more promise at this time than increased use of sound and equitable land-use management'' (Mileti 1999). In this article, we review the key features of land-use planning to enable communities to actually realize this promise.

Land-use planning is the means for gathering and analyzing information about the suitability for development of land exposed to natural hazards, so that the limitations of hazard-prone areas are understood by citizens, potential investors, and government officials. In preparing plans, local governments engage in a consensus-building process, so that key questions and issues regarding the use of hazardous areas can be resolved. For example, should these areas be developed to realize economic and fiscal benefits, or should growth be channeled to other areas to preserve open space and protect sensitive environmental systems? Do the benefits of development warrant the public costs of disaster planning, response, and recovery; protection by levees; or the extra expense of building to higher, hazard-resilient construction standards? Which protection method is most cost-effective? Who should pay for protection or for preservation?

Planning also provides a basis for charting courses of action, so that vulnerability is reduced in ways that are optimal, given the unique circumstances, future prospects, and goals and aspirations of community residents. A variety of tools are available to manage development. Examples include zoning regulations that limit the intensity of development in hazard areas and subdivision regulations that require adequate storm drainage in new urban development. Development management, however, also includes building codes, acquisition of hazard areas with open space or environmental value, relocation of existing development at risk, infrastructure location and design standards, and public information programs that raise awareness of hazards. In combination, by preparing plans and adopting appropriate development management measures, local governments can substantially enhance prospects for a sustainable future—one in which citizens and elected officials make informed choices about using areas exposed to natural hazards in ways that will not jeopardize the long-term viability of the community.

The conceptual basis for land-use plans was codified

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long ago when the U.S. Department of Commerce (U.S. 1928) published model planning enabling legislation. Kaiser and Godschalk (1995) provide a history of the land-use plan. But the incorporation of natural hazards as a community problem addressed in plans is more recent. The noted geographer Gilbert White (White 1936) first proposed the idea in the *Planners Journal*, but his suggestion was not acted upon until 20 years later, when the Tennessee Valley Authority (TVA) prepared a floodplain management plan for Bristol, Tennessee/Virginia in 1956 (TVA 1983). Still few communities followed the TVA lead. Recognizing this, beginning with California in 1972, states began to require that local governments incorporate hazard-mitigation provisions in their land-use planning. At last count, half of the states mention natural hazards in their planning enabling statutes, and 11 states, like California, actually mandate local government planning for the mitigation of natural hazards (Schwab et al. 1998). This number is likely to increase as the federal government takes steps to encourage local planning for hazard mitigation. Two recent initiatives are noteworthy. The National Flood Insurance Program's Community Rating System provides insurance rate reductions for communities with floodplain management plans (Wetmore and Jamieson 1999) and FEMA's Disaster Resistant Community Initiative and Project Impact program provide financial assistance and other incentives to communities to undertake hazard-mitigation programs (Krimm 1998).

In the remainder of this article we describe and analyze the three lynchpins of an effective land-use-planning program for hazard mitigation: land-use plans, hazard assessments, and development management. The centerpiece is the plan itself. But plans will have little impact if they do not have a solid technical footing (Teter 1988). Of course, no matter how well crafted plans are, they also will have little effect if they do not result in a program of action that leads to a more hazard-resilient community.

## LAND-USE PLANNING

Land-use planning combines technical analysis and community participation to make wise choices among alternative strategies for managing changes in land use. Integrating natural hazards mitigation into land-use planning can help a community become more resilient through:

- *Intelligence* about long-term threats posed by natural hazards to the safety and viability of human development and environmental resources
- *Problem solving* to cope with imminent threats prior to, during, and after a disaster
- *Advance planning* to avoid or mitigate harm from a future disaster and to recover afterwards
- *Management strategies* to implement plans through policies, regulations, capital improvements, acquisition, and taxation

Land-use plans state community goals, principles, and actions. Kaiser et al. (1995) provide an in-depth look at the process of preparing land-use plans. Formulated through a participatory process, plans commit communities to action to achieve community goals, e.g., to reduce losses to private property or to reduce vulnerability of ''lifeline'' facilities. Making a plan serves several purposes.

First, the plan-making process is a practical way to facilitate consensus building. For example, hazard assessment informs the community about the type and location of hazards it faces, and then the review of alternative mitigation strategies helps resolve conflicts and build commitment to adopted policies (Godschalk et al. 1994).

Second, the plan coordinates community agendas. For example, hazard mitigation can be integrated with economic development, environmental quality, community development, housing, and infrastructure programming. This avoids uncoordinated and possibly conflicting policies and actions, strengthens the likelihood of effective mitigation, and overcomes the persistent problem of lack of political saliency for natural hazards first noted by Rossi et al. (1982).

Third, the plan establishes the rational nexus between public interest and implementation activities, necessary for both political and legal defensibility. For example, the plan can document the likelihood of property damage if development is permitted in high-hazard zones, thus defending against constitutional challenges based on claims of a ''taking'' (Platt 1999).

Finally, the plan articulates land-use policy, guiding public officials in deciding on development ordinances, capital improvement allocations, and permit review. It encourages private developers to follow the adopted hazard-mitigation policy to expedite their permit applications. It is a guide toward coordinating the community's actions along consistent lines.

There is no single model for a hazard-mitigation plan. Instead, the planner and the community must choose the stakeholder participation approach, plan type, and mitigation strategy that best serve their needs. Godschalk et al. (1998) provide additional details about these choices.

### Designing Stakeholder Participation Approach

Community agreement over a mitigation approach must be built on a foundation of public support. Local elected officials are unlikely to vote for mitigation measures that are highly controversial. A number of stakeholder participation process options are available (Godschalk et al. 1994; Schwab et al. 1998). They range from a central planning committee with several task groups or subcommittees, organized by geographic hazard area or by mitigation strategy, to a community mitigation planning conference followed by smaller task groups, to a planning committee or board, either set up just for mitigation or using an existing planning board, which invites public participation and comment through public hearings and

forums. The process may include dispute resolution, involving a facilitator or mediator. The exact form of participation is less important than ensuring that all affected stakeholder groups have an opportunity for genuine involvement in and are satisfied with the fairness of the process.

Building a base of public support starts with an *awareness effort* in which hazards analysis findings are disseminated. Choices of approaches for creating hazards awareness include media campaigns, public school information kits, homeowner and builder/developer seminars, community organization speaker series, and similar public information approaches aimed at informing and motivating the community to address natural hazards.

Next the community sets *mitigation goals and objectives*. This process combines technical planning activities such as preparing alternative goal statements, public participation activities such as taking part in community visioning or goal setting, and political activities such as building consensus among stakeholders and elected officials over adopted statements of goals and objectives.

Then the community *selects its implementation policies and programs*. This may be more contentious, as stakeholders debate policies that have a direct effect on their values. It may involve more direct attention from elected officials who must implement the plan. This step concludes with the official adoption of the final plan.

Over time the adopted plan needs to be *monitored and evaluated* to determine its effectiveness in meeting mitigation goals. The adopted plan is scrutinized and revised on a regular schedule (such as every 5 years in the case of a land-use plan) or on an as-needed schedule (such as following a major disaster). A new consensus-building effort may be required, particularly if the adopted plan contains clear weaknesses and the evaluation calls for more rigorous mitigation actions that affect important stakeholders.

## Choosing Type of Plan

The mitigation plan may be a *stand-alone* hazards plan or part of a *comprehensive community plan* (termed a *general plan* in California). Stand-alone plans are often prepared for specific hazard areas, such as floodplains, or following particular disasters. Incorporating mitigation into a comprehensive plan is usually preferable because that plan already has standing as a policy guide and because it allows integrating hazard-mitigation and land-use planning. In some states such as California and Florida, and in coastal regions of some other states such as North Carolina, city and county comprehensive plans *must* include a section on natural hazards (Burby et al. 1997).

Comprehensive development plans are particularly appropriate for several hazard-mitigation purposes: (1) identifying hazard areas, compatible land-use activities for those areas, and appropriate development and construction standards and policies for retrofitting existing development; (2) identifying areas less vulnerable to hazards, where development and redevelopment will be encouraged and supported; (3) suggesting lifeline strategies such as avoiding hazardous areas in siting community facilities, water systems, sewerage, and transportation infrastructure; and (4) imposing hazard-resistant development standards for lifeline facilities.

## Selecting Mitigation Strategies

A community's mitigation strategy is a creative combination of coordinated choices in several areas. The primary choices communities make in formulating a mitigation strategy are

- Taking a coercive or sanction-oriented approach versus a cooperative, incentive-based approach to influencing private sector behavior (May and Burby 1996; Burby et al. 1998)
- Addressing mitigation through various governmental powers, including planning, public information, regulation, spending on land acquisition and capital improvements, and taxation
- Shaping future development through regulations regarding land-use types and densities, engineering and site-design standards, building design standards, structural features, and protection of lifeline facilities versus addressing existing development at risk through retrofitting, acquisition, and relocation
- Controlling the hazard by constructing levees, flood-control dams, and seawalls, stabilizing slopes, or installing storm water retention and drainage infrastructure versus controlling human behavior by discouraging incompatible use of hazard areas
- Taking action before disaster events to anticipate and prevent disasters versus taking action after the event, during recovery to apply lessons learned from the disaster during redevelopment (Schwab et al. 1998)
- Going it alone within the local government's jurisdiction versus taking an intergovernmental and regional approach

Advice on making these choices is available in Burby (1998) and Godschalk et al. (1998).

## Principles for Hazard-Mitigation Plans

Principles and standards exist for a good land-use and hazard-mitigation plan. The primary standards for plan quality are

- Clarity of purpose and explicitness of procedural actions, understandable to both stakeholders and public officials
- Understandable definition of issues derived from a solid fact base
- Integration with other plans and policies and linkage of mitigation with community development

- Linkage of land-use and emergency management efforts
- Comprehensible organization and internal consistency
- Assigned responsibility for implementation and monitoring, along with regular revisions to keep the plan current

Land-use plans and planning programs that incorporate these principles help communities change their approach to hazard mitigation from a focus on postdisaster recovery and redevelopment to a focus on predisaster mitigation integrated with land-use planning. This is the critical transition necessary to demonstrate to citizens and decision makers how much sense it makes to deal with hazards *before* they become disasters.

## HAZARD ASSESSMENT: FACTUAL BASIS FOR PLANNING AND MITIGATION

Knowledge about the risks posed by extreme natural events, and an understanding of how such knowledge can influence human behavior, are central to achieving safer, more sustainable communities through land-use planning. When property owners, planners, and government officials make choices about how to use land exposed to natural hazards they make trade-offs between the risks and benefits of alternative land uses or land-use policies. To make fully informed choices, decision makers should know how many people may be injured, how many public and private structures can be damaged, and how likely such impacts are to occur. They also must understand how changes in land use can exacerbate or mitigate natural hazards.

Hazard assessment is used in land-use planning, redevelopment planning, and development management. When used to make decisions about the future use of land, it helps to identify and avoid potential problems associated with developing hazard areas. Where land has already been developed, hazard assessment may be used to justify the imposition of requirements for retrofitting existing development, to define areas where such controls are necessary, and to assess the benefits of other means of mitigating hazards.

Hazard assessment can provide the factual basis for decision making at three levels of sophistication (Cohrssen and Covello 1989):

1. *Hazard identification*, which defines the intensities and associated probabilities (likelihood) of a natural hazard that may pose threats to human interests in specific geographic areas
2. *Vulnerability assessment*, which characterizes the exposed populations and property and the extent of injury and damage that may result from an extreme natural event
3. *Risk analysis*, which incorporates estimates of the probability of various levels of injury and damage to provide a more complete description of the risk from the full range of possible hazard events in an area

Hazard identification is the essential foundation upon which all hazard assessment is based. Vulnerability assessment combines the information from hazard identification with an inventory of the existing (or planned) property and population at risk. It provides information on who and what are vulnerable to a natural hazard within the geographic areas defined by hazard identification and can estimate damages and casualties that will result from various intensities of the hazard. Risk analysis includes a full probability assessment of the various intensities of a hazard as well as probability assessment of impacts on structures and populations.

Typically presented as a hazard map, hazard identification is the most prevalent form of hazard assessment. It can be an effective means of defining where land-use policies and development management regulations should be applied. Hazard maps are used to define regulatory zones within which different development and construction standards apply, such as the floodplain ordinances adopted by communities that participate in the National Flood Insurance Program. Several states use hazard identification to define areas for which localities are required to prepare specific plans and policies. Examples include Florida's and North Carolina's statutes that mandate local planning for hazardous coastal areas. California uses maps of active earthquake fault zones to define areas within which detailed geologic analysis is required as a part of the development-permitting process. Hazards maps also can be used to identify property or structures to be acquired or relocated for hazard-mitigation purposes.

Hazard identification can help define where planning and management are needed, but it is not sufficient for deciding on the substance of land-use planning and policies concerned with natural hazards. Vulnerability assessments, which estimate the losses from natural events, have been the primary basis upon which hazard management policies and programs have been developed and justified. Damage-loss assessments have been used to estimate probable damages from hurricanes at a regional scale [e.g., U.S. Army Corps of Engineers (USACE 1990)] and earthquakes [e.g., Association of Bay Area Governments (Association 1995)] at one or several intensities under existing land-use conditions. More localized vulnerability assessments are typically conducted for wildfire and landslide hazards. There are few examples, however, of using vulnerability assessment to evaluate the relative benefits of alternative management strategies or policies. For example, vulnerability assessments are commonly used to assess structural alternatives for flood control, but studies that assess the impact of changes in land use on flood vulnerability are much less common.

Full-scale risk analysis addresses the magnitude of possible losses and the probabilities of losses across the full

spectrum of possible natural hazard events. Thus it provides the most complete assessment of the impacts of potential land-use planning and management strategies. There is, however, far less use of risk analysis, especially by local governments. Risk analysis has been used in several instances to estimate the annualized probable damage from hurricanes [Dzurik et al. 1990; Tampa Bay Regional Planning Council (Tampa 1993)] and earthquakes (Litan et al. 1992; Olshansky and Wu 1999). Risk analysis is also appropriate for making decisions about where to apply land and property acquisition strategies, critical and public facilities policies, and taxation initiatives. Deyle and Smith (1999) used probabilistic models of hurricane damage to private property and public facilities and infrastructure to devise a risk-based fee system for county emergency management services in Lee County, Florida.

Clearly, a comprehensive foundation of hazard identification data is needed for all hazards on a national basis if the full potential for hazard assessment to inform local planning and decision making is to be realized. While standardized hazard information on flood hazards and some aspects of hurricane hazards is available throughout most of the United States, there are many gaps in hazard identification information for earthquakes, landslides, and wildfires. Limited historic data, especially for more extreme natural events, and difficulty estimating the likelihood of such hazards as hurricanes and earthquakes at the community scale, constrain the use of vulnerability assessment and risk analysis in land-use planning. Significant advances have been made in understanding the vulnerability functions that define the effects of floods, hurricanes, and earthquakes on people and the built environment, but for other hazards, such as landslides and wildfire, there are no standard ways of describing the intensity of damage. Where data are unavailable from secondary sources or are inadequate for local planning and decision making, local officials must decide whether investment in better data is worthwhile. An important consideration in making such decisions is the level of precision needed to politically justify and legally defend decisions about where to draw boundaries that determine allowable land uses or impose different development regulations.

A more difficult decision concerns selecting the recurrence intervals that are the basis for defining acceptable levels of risk. Regardless of whether local officials follow state or federal mandates or incentives such as the National Flood Insurance Program, or choose recurrence intervals themselves, there is the risk that both public officials and citizens will treat the resulting boundaries, such as the 100-year flood zone, as absolute boundaries between hazardous and nonhazardous areas. Ideally, local officials should explicitly consider the trade-off of alternative specifications of acceptable risk.

With the development of better damage models, improved availability of hazard information, and the advent of new technologies such as geographic information systems (GIS) and expert systems, staff capacity is becoming a limiting factor to effective use of hazard assessment data and methods. As a result of staff limitations, local governments are making only modest use of vulnerability assessment and rarely use risk analysis in guiding land-use planning and policy-making for natural hazards (Deyle et al. 1998). The federal government and the states, however, are beginning to address this problem by providing hazard assessment tools and training to local governments. The National Institute of Building Sciences, with financial support from FEMA, has developed a national standardized methodology that local government staff can use for estimating potential losses from earthquakes. This methodology is implemented through PC-based GIS software called HAZUS. The National Institute of Building Sciences is developing similar damage estimation models for wind, flooding, and other hazards. In another recent development, the Florida Department of Community Affairs is providing each county in Florida with vulnerability assessment data and software for wind, flooding, and storm surge as a part of a state-funded initiative to promote preparation of local hazard-mitigation plans [Florida Department of Community Affairs (Florida 1998)]. The California Division of Mines and Geology also has been proactive in providing hazard assessment materials and training to local officials. Similar efforts by other states would undoubtedly lead to the use of more sophisticated hazard assessment tools in local land-use planning.

## MANAGING DEVELOPMENT TO BUILD RESILIENCE

Local governments use a number of techniques in guiding the location, type, intensity, design, quality, and timing of urban development. Many of these *development management tools* can be applied to hazard mitigation, and they can help to carry out hazard-mitigation plans.

- *Building standards* regulate the details of building construction. They include traditional building codes, flood-proofing requirements, seismic design standards, and retrofit requirements for existing buildings.
- *Development regulations* are the traditional site development tools of current planning. They govern the location, type, and intensity of new development. These can include: flood zone regulations; setbacks from faults, steep slopes, and coastal erosion areas; and zoning overlay zones for sensitive lands, such as wetlands, dunes, and hillsides. In some states, environmental impact assessment is used to assess site-specific hazards and recommend ways to mitigate their effects.
- *Critical and public facilities policies* affect public or quasi-public facilities. These policies include long-term capital improvement programs, location of schools and other public facilities at hazard-free sites, and location of streets and public utilities to minimize disruption from hazards. One obvious policy is to

avoid placing public facilities in hazardous locations. In addition, facilities should not be sited where they would facilitate growth into hazardous areas.
- *Land and property acquisition* is used to purchase hazardous properties with public funds and convert them to less hazardous uses. This can include acquisition of undeveloped land, acquisition of development rights, transfer of development rights to safer locations, relocation of buildings or uses, and acquisition of damaged buildings.
- *Taxation and fiscal policies* are used to more equitably shift public costs to owners of hazardous property. These policies can include impact taxes for hazardous area development, tax incentives for reducing land-use intensities in hazardous areas, and risk-based taxes to support emergency management services.
- *Information dissemination* seeks to influence the choices people and public officials make about the location and character of urban development. Programs include public information, education of construction professionals, hazard disclosure requirements in real estate transactions, and construction of signs that warn people of high hazard areas.

These tools allow planners to use a number of approaches to mitigate hazards. Some emphasize long-range strategies, while others react to current development proposals. Some try to reduce development in hazardous areas, while others accept such development but focus on site and building design to reduce vulnerability. Some redirect public investment, but most seek to regulate or influence private development. Some are regulatory, and others are voluntary. There is a logic to the order of the above list: the more specific, traditional, and short-term strategies are at the top, while longer-term, less site-specific policies are at the end.

### Principles for Development Management

Studies have examined successes and failures in regulating land use for hazard mitigation (Burby 1998). These provide a basis for the following development management principles:

- *Use clear and authoritative maps of the hazard*. Maps should be clear and unambiguous, so that planners and public officials can tell which zones apply to a particular property. A credible scientific body or expert, who is seen as being unbiased, should issue the maps.
- *Link clear and realistic design guidelines to the maps*. Public planners and private developers need to know what to do with a hazard map. The clearer the instructions, the more likely they will be to follow them.
- *Ensure that hazard-free land is available for development*. Cities need safety valves for growth pressures, and every jurisdiction with extremely hazardous areas should also have areas of lower hazard designated for development.
- *If trying to rearrange or restrict land uses in hazardous areas, do so before the land is subdivided*. Once land is subdivided, the individual parcels may be sold and owners are entitled to the use of their property. If some of the parcels are wholly within hazardous areas, frequently the only way to prevent their development is for the local government to purchase the parcels.
- *Offer incentives to encourage developers to locate projects outside of hazardous areas and to adopt hazard-mitigation measures that exceed those required by law*. Incentives for developers might include tax abatements, density bonuses, or waiver of off-street parking requirements.
- *If hazardous land is subdivided and built out, be prepared to purchase selected properties*. Property acquisition is always an option. If individual parcels are found to be in highly flood-prone areas, coastal erosion zones, or actively unstable slopes, public agencies should be prepared to purchase the properties. This is often more cost-effective than waiting for extensive property damage, injuries or loss of life to occur, all of which may also be accompanied by costly litigation.
- *Use project-specific design approaches*. In many cases, the most feasible approaches are those that can be implemented on a project-by-project basis, although well-designed comprehensive plans can establish the policy context. Such approaches are easy for local governments to administer because they integrate with normal development review processes, and they do not involve a large number of other institutions. Planning policies that call for clustering of development on the least hazardous parts of a property, design of subdivisions sensitive to natural processes, building setbacks, site-specific engineering studies, and building elevation or strengthening are the types of policies that are most likely to be implemented successfully by local governments.
- *Use the postdisaster window of opportunity to encourage individual owners to retrofit or relocate*. Individuals are most aware of the hazard in the immediate aftermath of disaster.

## CONCLUSIONS

Local governments in the United States are increasingly using their zoning and subdivision ordinances to mitigate hazards to new development, and many local governments have adopted and enforce hazard-resistant building standards. Communities with a coherent land-use plan and hazard-mitigation strategy are able to build settlements that will be resistant to natural disasters, able to recover quickly from a natural event, and able to last for many years with little cost in dollars or lives to their inhabitants. These are resilient, sustainable communities.

Local governments that plan, create public awareness of the hazards they face, and have adequate staff resources are most successful (Olshansky and Kartez 1998). In addition, mandates and assistance from higher levels of government are essential to create the local commitment to hazard mitigation and the capacity to prepare land-use plans for mitigation (Burby et al. 1997).

Governments must take care in carrying out hazard-mitigation planning, minding both the political and technical details. Some of the lessons from local experience show that communities must be both visionary and pragmatic. They need to be far-sighted in gathering credible data, preparing maps, building consensus through planning, and paying attention to development management well before pressures build to use hazard areas more intensively. They also must be practical in using site-specific approaches, integrating hazard mitigation into their normal development review procedures, taking advantage of postdisaster windows of opportunity, and being prepared to purchase properties if necessary.

Land-use planning for hazard mitigation is an essential ingredient in any recipe for building disaster resilient communities. In this article, we have pointed out a number of principles, based on research and practical experience, which will enable communities to craft planning programs to reduce existing and potential threats from natural hazards. The challenge for local governments and their citizens will be to take full advantage of what is already known to achieve community goals for long-term sustainability.

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