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The Effectiveness of Land Use Planning in Hazard Mitigation : The Experience in the 1994 Northridge Earthquake

자연재난 완화에 있어서의 토지이용계획의 효과에 관한 연구 : 1994 미국 Northridge 지진 사례연구를 통해

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목 차

I. Introduction

The purpose of this paper is to examine the effectiveness of land use planning as a hazard mitigation tools. To do this, a case study is selected: the 1994 Northridge earthquake among natural hazards. To date, many hazards specialists and planners have introduced land use planning to hazard mitigation and argued the importance of the relationship between them(White. 1936; Burby & French. 1985; Godschalk et al. 1989; Berke & Beatley. 1992; Mileti. 1999). The summary of their contentions is that land use planning can be a powerful tool for reducing losses from natural disasters.

However, generally, it is difficult to evaluate the effectiveness of adopted land use planning tools in preventing damage or loss of life in hazards because it is easier to document planning failures than planning successes. Actually, Agenda 21 recommends studies on the effects of inadequate land use in hazard-prone areas, instead of good effects of land use planning for hazard mitigation(New Zealand Local Government Association. 1993. p14). Particularly, in earthquake, since the safety elements overlap other state seismic safety and environmental mandates and related local program, it is difficult to evaluate their effectiveness(California Seismic Safety Commission. 1994. pp63-70).

Despite this situation, however, the importance of land use planning in hazard mitigation should be stressed and must be enhanced in public awareness. There are several reasons for this: First, as urban growth in hazardous areas continues, the devastating potential of hazards is growing(Berke. 1998. pp76-77). So, there is the importance of having a pro-active land use planning designed to prevent or lessen loss. Second, land use planning as so-called nonstructural measures is less costly than structural approaches: structural protection against natural disasters such as dams, levee, dikes, pumps, sea wall, and groins(Burby. 1998a. pp1-26). Third, the concept of sustainability can be integrated into the practice of land use planning and hazard mitigation planning (Beatley. 1995; Burby. 1998).

II. Research Method

This article introduces planning techniques to earthquake hazard mitigation and reanalyzes the results of prior empirical researches in the context of land use mitigation for reducing seismic disaster damages. The prior empirical researches are about 1994 Northridge earthquake. Actually, while there was little study about real effects of land use planning in hazard mitigation fields, a few recent empirical researches in 1994 Northridge earthquake came out of

planning fields(Burby & French. 1985; Holway & Burby. 1993; Olshansky. 1998; Burby. French & Nelson. 1998; Nelson & French. 2002). While the empirical researches in planning deal with various issues relating to plan's adoption and disaster damages, their analysis have a common theme. The common thing is that land use planning is matter in reducing earthquake damages. The reanalysis in prior research provides a good opportunity to know whether land use mitigation for reducing seismic disaster damages is effective.

This paper, in particular, tries to evaluate some planning techniques to earthquake hazard mitigation and recommend some techniques for reducing damages by future events. However, this evaluation is limited to regulatory approaches in land use planning, such as plans, zoning and subdivision, because other approaches like incentive is very limited as a mitigation device in California (Olshansky. 2001).

The process on the study is deductive First, theoretically, the relation of land use planning and hazard mitigation is examined. The next is that land use planning in earthquake is noted. Finally, to know the real application effect to practice, a few empirical researches and reports(California Seismic Safety Commission. 1994; 1995) on the 1994 Northridge earthquake are used to find the effectiveness and lesson on land use planning in earthquake mitigation. Specifically, as the lesson from 1994 Northridge earthquake, this paper focuses on land use planning techniques.

III. Hazard Mitigation and Land Use Planning

Integrating hazard mitigation and land use planning has a long history in the United States. Geographer Gilbert White(1936) first proposed them in an article in the Planners Journal[1]. In there he thought the basic problem in human adjustment to hazard is one of land use planning. And hazard specialists have long argued that it makes sense to prevent development in hazardous area, to design structures to withstand stresses imposed by hazards, and to build public facilities, such as roads and bridges, to stand up under hazard forces while allowing for evacuation of threatened population(Kaiser et al. 1995. pp445-453; Berke. 1998; Burby. 1998a). So, the possibilities for planning solutions has long been advocated by hazardous researchers who see land use and development management as keys to mitigate risks posed by natural disasters. Land use planning can be a powerful tool for reducing losses from natural disasters. Planning programs reduce losses by affecting both the location and the design of urban development and by helping create a

1) This is a predecessor of the Journal of the American Planning Association.

knowledgeable constituency of citizens who support hazard mitigation program(Burby. 1999. p248).

Land use planning techniques generally seek to influence and manage the type and density /intensity of uses and development on the land, as well as its timing and design. And land use planning is an on-going process(Kaiser et al. 1995). Plans are usually prepared, implemented, and revised on a five-to ten-year cycle. A community planning board made up of citizens works with the professionals on the planning staff to prepare the draft plans, guide them through a public participation process, and craft their final recommendations to the elected officials who make the ultimate decisions about content, and then adopted the plans. Hazard mitigation may be one goal of a land use plan, along with other community goals such as coordinating future growth with infrastructure capacity or protecting fragile natural resources(Federal Emergency Management Agency. 1996).

Land use planning as a response to natural hazard has a number of potential advantages (Beatley. 1995. pp31-36). First, there is greater effectiveness in reducing long-term damages and loss of life. Second, there is the potential for substantial long-term cost savings over many other forms of societal response to natural hazards. Third, there is an ability to protect valuable features and elements of the natural environment. Fourth, human settlement patterns which are generally more sustainable environmentally and socially can be achieved(Beatley. 1995. p32).

Recent research points one more aspect about barrier in effective land use planning for hazard mitigation(Burby. 1999). This is that US federal policies have failed to offer suggestions for reforms that will encourage states and localities to use land use planning as a hazard mitigation tool. Following this research, US federal policies addressing natural hazards and disaster have two primary flaws. The first is the facilitation of intensive development in areas exposed to natural hazards. Second, federal policies undermine natural mitigation planning, making those who support it seem like they have wasted their efforts by crying wolf.

IV. Land Use Planning for Earthquake Hazard Mitigation

Drabek et al(1983. pp3-5) contend the earthquake hazard in U.S. has two aspects. One is the perception about earthquakes that uniformly denies an earthquake threat. The other is almost no region in U.S. is completely safe from a future earthquake. These two aspects are not contradictory, although they may seem so at first glance. This is the reason

that why a community is reluctant to prepare seismic safety in land use and why we have to have.

Actually, the risk of a major earthquake is faced by numerous jurisdictions all over the United States, from seismically active California to areas with great potential for a damaging earthquake, such as Charleston, South Carolina, Central Utah, parts of Missouri and Tennessee. In fact, all or parts of 39 states — populated by more than 70 million people — have been classified as having major or moderate seismic risk(Berke and Beatley. 1992; Berke and Beatley. 1993).

With the above facts, since much of the nation's population growth is taking place in high-risk seismic areas, the potential for catastrophe is ever increasing. A catastrophic earthquake can threat thousands of people, cause billions of dollars in property damage, and wreak havoc on financial systems. Earthquakes occur when plates of the earth's crust, floating on a molten substrate, grind past each other, releasing tremendous amounts of energy. The major hazards produced by quakes are ground shaking, surface faulting, liquefaction, landslides, and tsunamis(Darabek et al. 1983. p5).

In this situation, disaster specialists are increasingly emphasizing the need for planning techniques that prevent or lessen loss of life and property, rather than crisis-oriented approaches that take effect only after disaster strikes(Berke and Beatley. 1993; Drabek et al. 1983). Planning techniques provide a way to modify urban or regional development in order to reduce the earthquake damage potential. Myer R. Wolfe. et al(1986) identified 11 techniques that are commonly used in guiding community development, or that have been developed specifically to deal with seismic and related hazard.

These approaches include regulatory, incentive, and techniques that preclude subsequent private development. A majority of the techniques are regulatory. Regulatory approaches directly influence land use development activities by specifying use, structure location and type, construction standards, and building materials. Regulatory mechanisms are generally adopted legislatively and become the laws governing land use. Of the eleven techniques mentioned, the following have regulatory aspects: zoning ordinance, subdivision ordinance, sensitive area ordinance, building codes, hazardous building abatement ordinance, special use permits, and environmental impact statement. Most of these planning approaches are part of local government's standard repertoire.

Several other techniques work by offering incentives to owners and developers to modify development activity in hazardous areas. These approaches rely on presenting an

<Table 1> Planning Techniques to Earthquake Hazard Mitigation

Planning Techniques	Description	Loss Reduction Function
1) Zoning	Most cities and counties commonly use zoning to regulate the type and location of land uses, structure, siting, structure height and bulk, parcel size, land use intensity, and other development performance standards.	Restricts or prohibits new development in identified areas.
2) Subdivision Standards	Most cities have an ordinance that sets procedures and requirements for all land subdivisions. The ordinance may specify development standards for the size and shape of lots and blocks, or street dimensions.	Restricts new development location in certain areas. Sets standards for site layout and services(roads, utilities, open space).
3) Sensitive Area Ordinance	A sensitive area ordinance requires that any project falling within the boundaries of an identified area must submit a special study showing how fragile or hazardous conditions will be addressed in development, so that any potential degradation or hazards are minimized.	Can protect beaches and development from low-intensity coastal storms and flooding impact, and prevent the need for sand replenishment.
4) Building Codes	Building codes protect public welfare by regulating and controlling the design, construction, quality of materials, use and occupancy, location, and maintenance of all buildings and structures within a jurisdiction.	Establishes structural standards for different types of new construction.
5) Hazardous Building Abatement Ordinance	This type of ordinance is used to require property owners to bring designated substandard and hazardous buildings into closer conformance with condemnation and demolition.	Establishes standards for retrofitting specified existing buildings or building type. May relocation or demolition.
6) Special Use And Critical Facility Permits	A special permit review procedures can be developed for certain uses and critical facilities which the developer requires to prepare more detailed studies, demonstrating that the project will meet applicable safety standards.	May restrict the location of identified facilities or set design and structural standards for development.

<Table 1> Planning Techniques to Earthquake Hazard Mitigation

7) Environmental Impact Statements	For those states requiring an impact report prior to permits issuance, this review can be used to ensure that seismic concerns are addressed and mitigation options considered	Can be effective in changing the design and possibly overall intensity of individual projects to mitigate hazards
8) Tax Credits	This program reduces the property owner's tax liability as long as the land is left undeveloped or developed at a very low density	Provide incentive for owner to limit development in seismically vulnerable areas
9) Real Estate Disclosure	Within identified areas, realtors are required to provide prospective purchasers of real property information on the existence of a natural hazard	Informs purchaser of existing hazard affecting all real estate transactions
10) Property Acquisition	These actions put themanagement of identified hazardous area into the hands of local government	Restricts or limits development location through property purchases
11) Infrastructure Location And Design Standards	Policies and plans to locate lifelines away from known hazardous area reduce the community's exposure to losses by steering private development from these areas	Directs new development location away from hazardous areas. Ensures new lifelines are constructed to meet standards of seismic safety

Source: Myer R. Wolfe, et al(1986) and Burby(1998).

incentive to encourage risk-avoiding behavior. Tax credit programs and real estate disclosure laws are the two primary examples. Typically, these techniques are used to affect development location and intensity. However, tax credit program has not been used for mitigation aims(Burby. 1998. p198). It is completely ineffective as a stand-alone tool. Also, real estate disclosure laws have not been effective at all(Olshansky. 2001). Disclosure typically is perfunctory and is provided too late in the transaction to affect the purchase decision more than very marginally. Lastly, there are several techniques that preclude subsequent private development. Two such techniques are property acquisition and lifeline development standards. However, property acquisition is very limited and may be relatively meaningless as a mitigation device unless part of a management system for an entire hazard area.

In this article, while some methods such as incentive and techniques that preclude subsequent private development could have a

potential in hazard mitigation, regulatory approaches are focused on because it is mainly used in California. Now, using the above regulatory techniques, we ask: what are the effects in a real practice? To address this question, the 1994 Northridge earthquake was selected.

V. Northridge Earthquake in 1994: The Effectiveness of Land Use Planning

The magnitude 6.7 Northridge earthquake occurred at 4:31 in the morning of January 17, 1994, on a national holiday, when most Californian were at home asleep. The earthquake caused relatively few deaths(32 as a result of injuries and 28 as a result of illness or medical conditions that were exacerbated by the earthquake), but damage to buildings and infrastructure was extensive. Property losses of approximately $24 billion included thousands of homes and business establishments that were destroyed or left uninhabitable, the loss of ten highway bridges, and damage that closed three major freeways(California Seismic Safety Commission. 1995. ppix-xvi). Significant damages extended across the jurisdictions of a number of local governments, which varied in the degree of attention they had given to building code enforcement and the quality of the seismic elements of their general plans (California Seismic Safety Commission. 1994).

Before focusing on the effectiveness of land use planning in the Northridge earthquake, let's consider how California has used land use planning in mitigating earthquake hazard.

After the 1971 San Fernando earthquake, the state legislature passed a requirement that all city and county general plans include a seismic safety element. The seismic safety element thus became one of the land use plans' (termed general plans in California) nine required elements; the other eight were land use, circulation, housing, conservation, open space, safety, scenic highway, and noise (California Seismic Safety Commission. 1994. p63).

Six years later, the California Seismic Safety Commission(1977) surveyed local governments to see what had been accomplished by requiring attention to earthquake hazard in plan making. According to the commission, localities were paying more attention to seismic hazards than they had in the 1960s. In the mid-1970s, most cities and counties in California adopted seismic safety elements during this period, no doubt in part to avoid state enforcement pressures and private lawsuits challenging the legal adequacy of their general plans(Burby et al. 1998. p61).

In 1984, the state legislature streamlined general plan requirements, combining the

overlapping safety and seismic safety elements into a single safety element(California Seismic Safety Commission. 1994. pp63-70). Two types of requirements promote implementation of the safety element:

1. The various parts of the general plan must be internally consistent. This essentially means that seismic background information and policies must be reflected in the plan's other elements, such as land use and circulation.
2. Zoning, subdivision approvals, public works decision, and numerous other actions by local government must be consistent with the general plan, according to various state laws and supporting case law.

As mentioned above, there are difficulties in exploring the effectiveness of land use planning in hazard mitigation. One of the reasons is that it is very difficult to know the effects of land use planning in hazardous areas. To address this question, two preconditions must be met. One is that land use planning should be institutionalized in hazardous areas. The second is that the damages from two disasters in those areas should be compared to know the effect of land use mitigation. The 1994 Northridge Earthquake had these two preconditions, as shown above. The Northridge earthquake provided an opportunity to determine whether these land use provisions, which have been mandatory for more than two decades, actually result in lower damage. Recently, a few researches investigated the effectiveness of land use planning for local hazard mitigation, using various research

<Table 2> Researches about Land Use Mitigation Relating to 1994 Northridge Earthquake

Research	Method	Result
California Seismic Safety Commission(1994)	Interview and survey with planners and engineers review planning documents	Recommendation for local communities
Mader(1997)	Review planning documents	20% and 30% of local communities adopted land use mitigation
Burby, French, and Nelson(1998)	Multivariate models	Land use plan's quality is matter for reducing property damages in earthquakes
Olshansky(1998, 2001)	Review planning documents; interviews with planners and building officials; gis evaluation	The potential of land use planning in hazard mitigation

methods(See <Table 2>).

Mader(1997) studied whether the lesson on the 1971 San Fernando Earthquake serve as a basis for reviewing progress in reducing seismic hazards through land use planning in California during the last twenty-five years. In his paper, progress since 1971 in the normal planning tools to increase seismic safety is summarized. Using the 1995 report to the governor prepared by the California Seismic Safety Commission: Northridge Earthquake: Turning Loss to Gain, with respect to the land use planning field, he concluded we have reached somewhere between 20% and 30% of our goal of reducing seismic risk(Mader. 1997. p52).

Concrete results came out of more empirical researches (California Seismic Safety Commission. 1994; Burby, French and Nelson. 1998; Olshansky. 1998). In a report prepared by the California Seismic Safety Commission, from the 39 jurisdictions listed on damaged-structure inventory, eight were selected for further investigation. During May, 1994, planners and engineers from the following eight jurisdictions were interviewed: Los Angeles County, Fillmore, Los Angeles, San Fernando, Santa Monica, Santa Clarita, Simi Valley, and Whittier. The following is a summary of the major themes in the interviews and conclusions drawn from review of the safety elements(California Seismic Safety Commission. 1994. pp65-69):

1. Virtually all jurisdictions felt their seismic safety and safety elements had been useful either for their educational value or for providing the leverage to require mitigation of specific seismic hazards.
2. The typical safety element in the eight Northridge-area jurisdictions is four years old(median age) and was last revised as part of a comprehensive general plan update. The older the safety element, the less effective it is in guiding land use and other development decisions.
3. The quality of the safety elements varies dramatically; the newest elements are the best.
4. Few of the elements include earthquake damage scenarios.
5. Most jurisdictions said they felt their safety elements did a good job of describing the general nature of seismic activity their communities experienced during the Northridge earthquake (e.g. ground shaking)
6. All Northridge earthquake jurisdictions interviewed used geotechnical consultants in preparing their safety elements.
7. All jurisdictions relied heavily on data and maps provided by California Division of Mines and Geology(CDMG) and the US Geological Survey in preparing their safety elements.

8. Only those jurisdictions that have experienced a significant amount of recent development on vacant land reported their safety element had been instrumental in shaping land use decisions.
9. None of the jurisdictions had an operating GIS that included geotechnical information, but most were developing or planning to develop such a system.
10. Virtually all jurisdictions said they needed better geotechnical information to improve their safety elements.

And as another research in this case, Burby, French and Nelson(1998)'s research used data on the number of structures damaged in the Northridge event and performed multivariate modeling of the distribution of damages across census tracts. They found that damages were lower when local governments formulated broadened goals for seismic safety, developed policies to make the public more aware of seismic risks, and expended more resources on enforcing the seismic provisions of building codes. So, their conclusion is that seismic safety mandates on local governments can lead to lower property damages, and these benefits are enhanced when local governments expended more effort on their implementation. They say. we provide, for the first time, concrete evidence that the quality of the seismic safety element of the general plan can be an important tool for reducing property damages in earthquake(Burby, French and Nelson. 1998. p70).

Olshansky(1998) researched the feasibility of using land use planning to reduce earthquake risk. Using GIS evaluation from the 1994 Northridge earthquake, these articles reports on research that describe how several southern California jurisdictions implemented land use mitigation requirements and evaluates their success as tested by the 1994 Northridge Earthquake. He found buildings on soft soils would sustain relatively greater earthquake damage than buildings elsewhere in the LA area. Also, his research provided insight about the potential of land use planning in hazard mitigation.

VI. The Lesson on Northridge: Evaluating of Planning techniques

Through the 1994 Northridge earthquake, what have we learned in land use planning as mitigation tools? A few empirical researches, shown in the chapter V, support following important argument: land use planning is matter for reducing earthquake damages. Now, we proceed a more concrete question in this chapter. Which tools of land use planning techniques, as shown in <Table 1>, are effective? To answer this question, we rely on some of the findings and recommendations

contained in the prior research(California Seismic Safety Commission. 1995; Olshansky. 2000). This paper, in particular, focused on regulatory approaches among land use planning techniques because the use of other approaches are limited in the California and there is few prior research.

Olsahansky(2000) evaluated several policies and tools for land use mitigation. The tools are related to seismic safety plans, fault zone, hazard abatement programs, geological information used for project review, and recovery planning.

1. Seismic safety plans: seismic safety plans are an important first step. They establish the fact base for future planning and policy efforts. While seismic safety elements do not generally restrict land use type or intensity, it is clear that those elements played a key role in setting a framework for local seismic safety program.
2. Fault zone: while the Alquist-Priolo Act (1972) regulates construction in active fault zones but was not relevant in the 1994 earthquake because of the absence of surface fault rupture. At the time of the Northridge Earthquake only one of the maps had been completed, so evaluation of this act is not in the scope of his research.
3. Hazard abatement programs: A number of abatement programs, such as the unreinforced masonry(URM) retrofict program, played a significant role in reducing damages.
4. Geological information used for project review: Both environmental impact reports and geological review of subdivisions serve to reinforce the seismic safety element by reminding participants of earthquake hazards and of the need to carefully follow building and grading codes on sensitive sites.
5. Recovery planning: Although not contributing to 1994 damage reduction, the City of Los Angeles' Recovery and Reconstruction Plan is a notable planning success. This facilitated the City's institutional ability to initiate recovery programs and to integrate mitigation into these programs. Finally, he argues that planning has an important role to play in developing strategies for existing hazard prone buildings and in establishing procedures, in advance, for post-earthquake reconstruction.

The 1995 report to the governor prepared by titled: Northridge Earthquake: Turning Loss to Gain recommends general plans, zoning, and subdivision for earthquake mitigation. The contents are as follows: first, with respect to general plans, the 1995 report recommends as

follows: The state should require that safety elements be updated at least five years; the current optional review of safety elements by CDMG[2] should be made mandatory; Safety elements should be required to include seismic vulnerability of the existing building stock and contain risk-mitigation strategies.

Second, how do we stand on the topic of zoning? In order to answer this question, the recommendations are as follows: Zoning regulations can require review procedures or development standards to reflect the seismic hazards in specific areas of a community; Zoning can be used to provide incentives such as development bonuses to encourage risk mitigation in buildings vulnerable to earthquake; Areas with seismic or geological hazards, such as unstable slopes or liquefaction potential, can be zoned to allow only low-density uses, such as agriculture, open space, or very-low density residential development.

Third, in subdivision controls, 1995 report notes as follows: Under the State Hazard Mapping Act, by providing maps of potential hazards and requiring site-specific analysis on the hazard, the subdivision review process will be improved; The Subdivision Map Act should be amended to require that geological and geotechnical reports addressing seismic hazards be required for all subdivisions of five lots or more unless adequate information is already available or superseded by the State Hazards Mapping Act maps.

VII. Policy Implication and Conclusion

This Northridge case was selected as an area with innovative land use planning tools for earthquake mitigation. It was also selected based on two primary criteria: ripeness and transferability. Since 1971 San Fernando Earthquake, the California's land use mitigation for earthquake was to have been adopted, implemented and been operating long enough to be evaluated and to have produced some outputs / outcomes. Transferability was considered to be an important component in this case study selection because it was determined that studying an anomaly would not be beneficial for the purposes of making future cross case comparisons. This case study, through prior empirical research, focused on the effectiveness of land use planning and the evaluation about concrete tools of land use planning, such as plans, zoning and subdivision. While the evaluation about land use planning tools in his paper is limited in some parts of regulatory approaches, the

2) CDMG is The California Division of Mines and Geology. The California Division of Mines and Geology reviews and comments on locally prepared safety elements, but it does not have the power to formally approve or reject whatever local governments put forward.

lesson of Northridge earthquake can be implied to other places with the potential of earthquake. Making general plans including seismic safety elements, identifying fault zone, and strengthening subdivision review process for seismic safety are basic steps for land use mitigation for reducing earthquake damages. Although the institutional settings in planning can be different in the U.S. as well as in the World, the land use mitigation can be applied in other places because most local governments in the World have or can make general plans, zoning, and subdivision. However, the effectiveness of land use planning in hazard mitigation does not automatically lead to the adoption of the land use mitigation(Berke, Beatley & Whihite. 1989; Dalton and Burby. 1994; Berke et al. 1996; Burby and May. 1997). The adoption of land use mitigation is another research issue.

In conclusion, the Northridge earthquake showed how land use planning could be used to reduce earthquake damage. Land use planning—community general plans, zoning regulation, and environmental impact reviews—can reduce damage by identifying the seismic hazard caused by geological conditions as well as vulnerable buildings and lifelines and by instituting measures to avoid or mitigate them. This paper argues that land use planning policies and laws can and should be far more effective in reducing risk from earthquakes than they have been. Management of seismic risk should be a major factor in future land use planning policies and decisions.

Reference

Beatley, Timothy. 1995. Promoting Sustainable Land Use: Mitigating Natural Hazards.

Insurance Institute for Property Loss Reduction. *Through Land Use Planning*. pp31-36.

Berke, Philip., Beatley, Timothy & Suzanne Whihite. 1989. Influences on Local Adoption of Planning Measures for Earthquake Hazard Mitigation. International *Journal of Mass Emergencies and Disasters*. 7(1) : pp33-56.

Berke, Philip and Timothy Beatley. 1992. Planning for Earthquake: Risk, Science and Politics. Baltimore. Md.: The Johns Hopkins University Press.

Berke, Philip and Timothy Beatley. 1993. Time to Shake Up Earthquake Planning. *Issues in Science and Technology* 4(2) : pp82-89.

Berke, Philip R., Dale Roenigk, Edward J. Kaiser and Raymond J. Burby. 1996. Enhancing Plan Quality: Evaluating the Role of State Planning Mandates for Natural Hazard Mitigation. *Journal of Environmental Planning and Mandate*. 17(2) : pp178-199.

Berke, Philip. 1998. Reducing Natural Hazard Risks Through State Growth Management. *Journal of the American Planning Association* 64(1) : pp76-87.

Burby, R. J. and Peter J. May. 1997. Making Governments Plan: State Experiments in Managing Land Use. Baltimore : Johns Hopkins University Press.

Burby, R. J.(Ed). 1998. Cooperating with Nature: Confronting Natural Hazards with Land Use Planning for Sustainable Communities. Washington. DC : Joseph Henry/National Academy Press.

Burby, R. J., French, S. P. & A. C. Nelson. 1998. Plans, Code Enforcement and Damage Reduction: Evidence from the Northridge Earthquake. *Earthquake Spectra* 14(1) : pp59-74.

Burby, R. J. 1999. Unleashing the Power of Planning to Create Disaster-Resistant Communities. *Journal of the American Planning Association.* 65(3) : pp247-258.

California Seismic Safety Commission. 1994. Compendium of Background Reports on the Northridge Earthquake for Executive Order W-78-94. SSC 94-08. Sacramento. Calif. : California Seismic Safety Commission.

California Seismic Safety Commission. 1995. Northridge Earthquake: Turning Loss to Gain. SSC Report No. 95-01. Sacramento. Calif. : California Seismic Safety Commission.

Dalton, Linda C. and Raymond J. Burby. 1994. Mandates, Plans, and Planners: Building Local Commitment to Development Management. *Journal of American Planning Association.* 60 : pp444-461.

Godschalk, D. R., Kaiser, E. J. & P. R. Berke. 1998. Integrating Hazard Mitigation and Local Land Use Planning. In R. Burby (Ed.) Cooperating with Nature: Confronting Natural Hazards with Land Use Planning for Sustainable Communities : pp85-118.

Mader, G. G. 1997. Enduring Land Use Planning Lessons from the 1971 San Fernando Earthquake. *Earthquake Spectra.* 13(3) : pp45-53.

Olshansky. R. B. 1998. Land Use Planning and Hazard Mapping for Seismic Safety in Los Angeles County. 1971-1994. Paper presented at the 40th Annual Meeting of the Association of Collegiate Schools of Planning. Pasadena. CA.

Olshansky. R. B. 2001. Land Use Planning for Seismic Safety: The Los Angeles County experience. 1971-1994. *Journal of the American Planning Association.* 67(2) : pp173-185.

T. Drabek. A., Mushkate and T. Kilijanek. 1983. Earthquake Mitigation Policy: The Experience in Two State. Boulder. Colo. : Institute of Behavioral Studies. University of Colorado.

White, G. F. 1936. Notes on Flood Protection and Land Use Planning. Planners Journal. 3(3) : pp57-61.

Wolfe, M. R., Bolten, P. A., Heikala, S. G., Greene, M. M & Peter J. May. 1986. Land Use Planning for Earthquake Hazard Mitigation: A Handbook for Planners. Natural Hazard Research and Applications Information Center.

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ABSTRACTS

자연재난 완화에 있어서의 토지이용계획의 효과에 관한 연구 : 1994 미국 Northridge 지진 사례연구를 통해

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※ 주요단어: 자연재난 완화, 토지이용계획, 사례연구, 미국 1994 노스릿지 지진

최근에 토지이용계획이 자연재난을 완화하는 데 많이 이용되고 있다. 그 내용의 핵심은 토지이용계획이 자연재난지역을 파악하고 그러한 지역에 있어 무분별한 개발을 규제하는 데 중요한 역할을 할 수 있다는 것이다. 본 연구의 목적은 재난완화 도구로서 토지이용계획의 효과를 소개하고 검토하는 것이다. 이러한 목적을 위해 본 논문에서는 재난완화에 이용되는 토지이용계획 기법들을 소개하고, 1994년 미국 캘리포니아주 노스릿지 지진 사례를 통해 토지이용계획의 효과를 검토하였다. 1971년 샌 페르난도 지진 이후, 캘리포니아주는 토지이용계획을 통한 재난완화 노력을 기울여 왔기 때문에 1994년 노스릿지 지진은 토지이용계획의 효과성을 검토하는 데 적절한 기회를 제공하였다. 방법론적으로 본 논문은 토지이용계획과 자연재난 완화와의 관계를 이론적으로 살펴본 뒤, 특히 지진피해를 완화하기 위한 토지이용기법들에 대해 조사하였다. 마지막으로 1994년 노스릿지 지진 이후 수행된 몇몇 경험적 연구들을 토대로 토지이용계획의 효과를 검토하였다.

결론적으로 본 연구는 재난지역 내의 토지이용규제와 정책 등이 자연재난으로부터의 위험을 줄이는 데 매우 효과적일 수 있음을 주장하고 있다. 구체적으로 토지이용계획 — 이를테면 도시기본계획, 지역지구제, 환경영향평가 등을 포함하는 — 은 지질학적 지진지역과 그러한 지진대 위의 인명 및 재산 등을 파악함으로써, 또한 그러한 위험들을 완화하거나 피하기 위한 조치들(예: 개발규제 및 방재설계)을 제도함으로써 재난(지진)으로 인한 피해를 감소시켜 준다는 것이다.