LOCAL RESPONSE TO GLOBAL CLIMATE CHANGE:

THE ROLE OF LOCAL DEVELOPMENT PLANS IN

CLIMATE CHANGE MANAGEMENT

A Dissertation

by

HIMANSHU GROVER

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2010

Major Subject: Urban and Regional Sciences

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Approved by:

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ABSTRACT

Local Response to Global Climate Change: The Role of Local Development Plans in Climate Change Management. (August 2010)

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Climate change is possibly the greatest threat facing human society in this century. The response to this challenge has been dominated by international negotiations for controlling greenhouse gas emissions. More recently there are efforts by the international community to engage other levels of governance in mitigation and adaptation response. While the framework for international action on climate change continues to evolve, there is mounting pressure from researchers to include cities as significant actors in the global climate change management strategy. Cities are centers of production and consumption in our society and as such will be crucial for global climate change management strategy. Despite these links, demands for consideration of climate change management issues in local policy making have remained a research rhetoric and have not yet translated into planning action. This gap between planning research and practice is probably due to lack of evidence based research on this issue.

This study fills in this gap and provides empirical evidence supporting the key role of local development plans in climate change management. Specifically, in the first step, this research investigates the influence of local development plans on climate change mitigation by comparing change in carbon dioxide emissions in groups of cities with and without plans. Thereafter, climate change management capacity in local development plans is analyzed through policy analysis. Finally, this research study examines the effect of plan quality on the change in carbon dioxide emissions, while controlling for socio-economic, landscape and policy characteristics.

Results of this study support the demands for using local development plans as tools for climate change management. This study identifies numerous planning policies in local development plans with potential to influence climate change management. The analysis also reveals wide variation in the quality of the climate change management policies. For example, policies related to site planning regulations and transportation are fairly detailed, whereas acquisition and incentive/disincentive tools are not. The detailed review of plan quality suggests that although development plans have the potential to significantly influence climate change, there is need for further improvement, especially of the overall plan implementation capacity.

Finally, the research findings show that the quality of climate change management planning policies in local development plans have a significant impact on a communities' emissions. Communities with better plan quality had significantly lower increase in per-capita emissions over the period of analysis. The study also discovered significant effects of wealth, travel behavior, occupation base and state policy on the

change in emissions. Based on the research findings this study recommends evolving integrated local development policies that focus on dual goals of climate change management and sustainable development. Further studies are recommended to examine the opportunities and challenges to use of local development plans for climate change management.

DEDICATION

To Hazard Reduction and Recovery Center

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Thanks also go out to my friends, the department faculty and staff for making my time at Texas A&M University a great experience. I also want to extend my gratitude to the Hazard Reduction and Recovery Center that has been my home for past many years. I am thankful to Carla Prater and Mike Lindell for sharing their research experiences and for providing support throughout my association with the center. I also thank my present and past colleagues at the center who have provided me with unconditional support and guidance.

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1. INTRODUCTION

1.1 Background

New and improved scientific data reveals that climate change is happening and will be the most daunting challenge to sustainable growth and development of human settlements in the 21st century. Global warming associated with increasing atmospheric concentration of greenhouse gases is identified as the underlying cause of climate change (IPCC, 2007d). Among the various greenhouse gases responsible for global warming, carbon dioxide is considered the most critical (Hofmann et al., 2006; Nordhaus, 1991). Since the industrial revolution, atmospheric concentration of carbon dioxide has risen from 280 ppm to 397 ppm in 2005 (Hughes et al., 2003; IPCC, 2001b, 2007d; Parmesan & Yohe, 2003). Most researchers agree that anthropogenic activities are the main cause of increasing concentration of carbon dioxide (Etheridge et al., 1996; Holtz-Eakin & Selden, 1995). By some estimates cities account for almost 78% of these carbon dioxide emissions (Stern & Taylor, 2007). Concentration of population and economic activities in cities results in high energy consumption to meet the demands of heating, cooling, transportation, industrial and commercial activities (Grimm et al., 2008). With most energy production based on fossil fuels, increased consumption leads to higher carbon dioxide emissions.

Cities not only contribute to the problem of climate change through increased greenhouse gas emissions but are also the locations where the resulting impacts will be most acutely felt (Bell & Batterson, 1978). Anticipated impacts of global climate change are alarming and are expected to impact all aspects of human life (Post & Altman, 1994). Recent scientific evidence points to the unprecedented global threat that climate change poses to lifestyles, the built environment, sustainability, economy and ecosystems. Sea-level rise alone is expected to directly impact more than 160 million people in 20 coastal mega-cities of the world (Nicholls, 1995). Urgent and effective

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This dissertation follows the style of *Journal of American Planning Association.*

action is required to reduce this threat to sustainable development from the impeding climatic changes.

In the United States (U.S) almost 80% of the population lives in urban areas and a significant proportion of activities that contribute to climate change are concentrated in these cities (Kates & Torrie, 1998; Rayner & Malone, 1997). In most urban communities, spatial planning is used as the primary tool to guide development in a sustainable manner and also to safeguard the citizens from various hazards (Berke, Godschalk, Kaiser, & Rodriguez, 2006; Brody & Highfield, 2005; Godschalk, Edward J. Kaiser, & Berke, 1998). Local governments exercise control over allocation of resources and planning decisions related to local development that have significant implications for greenhouse gas emissions (Agyeman, Evans, & Kates, 1998; Collier, 1997). Despite these evident links, urban and regional planning is yet to be accepted as a viable tool in global climate change management. In their recent review of climate change research, Betsill and Bulkeley (2007) identified persistent 'gap' between the policy discourse on the relevance of cities and the reality on the ground. Although various United Nations (UN) agencies and the Intergovernmental Panel on Climate Change (IPCC) have repeatedly reaffirmed that urban planning has become increasingly important in managing climate change, there is an evident lack of initiative in integrating climate change issues with local development priorities at the community level. Only recently, there have been noticeable efforts by local jurisdictions in the U.S. to proactively undertake climate change mitigation and adaptation actions through associations such as U.S. Mayors Climate Protection Agreement, Regional Greenhouse Gas Initiatives, and Local Governments for Sustainability (ICLEI). In the last few years, a number of states have also embarked on creating ambitious climate change action plans (Rabe, 2002). But, these initiatives are expected to have limited impact as they focus on containment of greenhouse gases through sectoral policies using a top-down approach, rather than promoting a more comprehensive place-based approach.

The place-based approach to climate change management requires communities to adapt existing land use and developmental policies in a manner that limits the overall greenhouse gas emissions. The choice of future path of urbanization and growth is critical for stabilization of emissions (Dhakal & Betsill, 2007). Local planning can be instrumental in implementing a growth strategy that controls local emissions. Climate change mitigation actions will provide numerous benefits and also significantly reduce the need as well as the associated costs of adaptation actions required (Bulkeley & Betsill, 2005; Bulkeley, Betsill, & Betsill, 2005; McEvoy, Lindley, & Handley, 2006; Smit & Pilifosova, 2003; Wilbanks, 2003). Along with incorporating climate change sensitive development policy, local authorities can also play an important role in influencing individual and organizational behavior. Local authorities are direct agents in contact with the community and thus can promote behavioral changes that lead to reduced emissions in individuals and organizations.

1.2 Problem Statement

Traditionally, local development plans have been an important tool for guiding and regulating the growth of cities (Kaiser & Godschalk, 1995b). There is sufficient research on the role of good plans in promoting sustainable urban land use patterns, environmental protection, and reducing risks (Berke, Roenigk, Kaiser, & Burdy, 1996). Researchers also have found evidence supporting the success of local comprehensive plans in managing threats from natural hazards (Berke & Beatley, 1992; Brody, 2003a; Nelson & Steven), managing land use distribution (Kent & Jones, 1990), enhancing ecosystem management (Brody, 2003c; Brody, Carrasco, & Highfield, 2003; Brody, Highfield, & Carrasco, 2004; Brody & Highfield, 2005), promoting sustainability (Berke, 1995; Berke & Conroy, 2000; Berke, Crawford, Dixon, & Ericksen, 1999; Conroy & Berke, 2004; Laurian et al., 2004), encouraging intergovernmental collaboration (Burby & May, 1997; Godschalk, parham, Porter, Potapchuk, & Schukraft, 1994) and improving plan implementation (Brody & Highfield, 2005; Laurian, et al., 2004). It is logical to assume that with their ability to influence the local growth pattern, development plans significantly impact the local carbon emissions (Bulkeley, et al., 2005; Wilbanks, 2003; Wilbanks & Kates, 1999). Although the impact of good quality development plans on local growth patterns has been widely analyzed, there is lack of research analyzing the influence of development plans on local emissions.. This evident gap in research needs immediate attention.

1.3 Research Purpose and Objectives

The goal of this study was to assess the influence of local planning policies on local emissions. This study analyzed in detail the quality of planning policies in local development plans in a sample of cities, and evaluated their effect on local emissions. Overall this research sough to assess, *whether local development plans had any influence on local emissions, and if they did, what was the nature of this influence*. Specifically, the research objectives of this dissertation were to:

1. Determine the influence of local development policies on emissions.
2. Assess the present level of climate change management capacity in development plans.
3. Assess the nature of influence of climate change management policies in local development plans on a community’s contribution to climate change (mitigation influence).
4. Propose local development guidelines that foster effective and efficient climate change response.

1.4 Research Justification

Recent events such as the devastation of New Orleans from Hurricane Katrina, intense flooding in the mid-west and submergence of Galveston from Hurricane Ike provide the stimulus for this research. While human settlements continue to bear the brunt of extreme natural events that are projected to intensify with changing climate, failure of international negotiations to achieve a definitive agreement for climate change mitigation at Copenhagen, provide the backdrop that highlights the need for this research.

With the understanding that urban settlements are important drivers of climate change, there is an urgent need for research to identify a viable role for local developmental planning in managing global climate change. World over, various forms of local development plans are utilized to manage urban ecological impacts and growth patterns (Berke & Godschalk, 2008; Blanco, 2006; Brody, 2003a; Hall & Hall, 2002). Logically, such local development decisions impact social, economic and urban form characteristics of a settlement, that in turn influence local greenhouse emissions and vulnerability to climate change. For example, almost 40 percent of the total U.S carbon dioxide emissions are associated with residences and car travel that can be significantly controlled through changes in existing patterns of development (Glaeser, 2008). There is a rich body of planning literature that analyzes various aspects of poor urban performance of human settlements (Layard, 2001; Kenny, 1999; Murdoch, 2004; Hanna, 2005; Campbell, 1996; NÆSs, 2001; Berke, 2000). There is also an ever-increasing body of research that emphasizes the need for strategic action and proactive planning for meeting the threats of natural disasters (Berke, 1995; Birkmann, 2007; Kelly & Adger, 2000). For example, Godschalk (2003) has suggested a vision of "resilient cities" that recommends proactive allocation of resources for moderating the impacts of natural hazards. Researchers also suggest the need to integrate developmental requirements with the considerations of natural resource conservation and ecological sustainability (see Rees & Wackernagel, 1996). However, research on active consideration of the role of local planning in climate change management is still lacking. Thus, there is no doubt that human settlements are at the center of the issue and are also the key to the solution. They need to be the focus of action-oriented climate change research. The need to safeguard the environment from the impacts of human settlements and the parallel need to guard human settlements from environmental impacts of global climate change is the motivation for this research.

Local development plans are the primary policy documents that guide and shape urban form. Previous research has highlighted the role of plans in dealing with a variety of development issues within the broad umbrella of sustainability (Blakely, 2004).

Researchers focusing on quality of plans have come with numerous content characteristics that ensure better sustainability, livability and resiliency performance of urban settlements (see Berke et al., 2006; Berke & Godschalk, 2008; Brody, 2003b; Brody, Carrasco, et al., 2003; Burby, 1999; Burby, French, & Nelson, 1998; Burby & May, 1997; Dalton & Burby, 1994; Godschalk, Beatley, Berke, Brower, & Kaiser, 1999). Similarly, climate change researchers have identified desired policies and actions that can facilitate effective mitigation and adaptation (McEvoy, et al., 2006; Peltonen, Haanpaa, & Lehtonen, 2005; Smit & Pilifosova, 2003; see Smith & Lenhart, 1996). However, very few of the researchers of beyond rhetorical calls and identify tools for local implementation of climate change management policies. Few researchers that have addressed the issue of local implementation, recommend creation of a new local climate change policy framework (see Pizarro, Blakely, & Dee, 2006). In my opinion, any radical shift and change in planning practice to accommodate climate change management is unrealistic and will take a long time to be realized. In the case of climate change, it may just be too late. Guided by the ‘precautionary principle’ (O'Riordan, 1994), my research seeks to identify opportunities for creating synergistic linkages between local developmental priorities and climate change management objectives within the existing framework of local development plans.

Finally, the study area chosen for this research consists of cities that have historically been urban centers of regional and national importance. They have been areas of increased urban growth and drivers of economic development. As such, the high level of production and consumption activities in these cities is also associated with highest carbon dioxide emissions. Thus, these urban centers have a key role to play in managing climate change.

1.5 Dissertation Structure

This dissertation consists of ten sections. Section 1 gives a brief background on the research, presents research purposes and objectives, and describes the motivation for conducting this study. Section 2 reviews the climate change management and urban development plan evaluation literature in the context of the research goals of this study. This review forms the underlying foundation for subsequent research including the research framework, specific hypotheses, and selection of appropriate statistical analyses. The first sub-section in section 2 outlines the existing state of knowledge on climate change. Local implications of global climate change are identified in this sub-section. The next sub-section reviews the state of research on studies related to local climate change issues. Studies related to opportunities, challenges and synergies in climate change management are included in this review. The final sub-section examines the literature specific to development plan evaluation studies and techniques.

Section 3 outlines the research framework of this dissertation. All research components and relationships between them are identified in this section. Specific hypotheses for statistical analyses are also presented in this section. Variable measurements for dependent and independent variables to achieve the desired research goals are also presented. Section 4 presents the research methods used in this dissertation. Sample frame is described and procedures for sample selection are explained. Selection of research design for each phase of the research to facilitate appropriate hypotheses testing is also included in this section. Concept measurements and variable constructs are described within appropriate sub-sections in section 4.

Section 5 presents the results of the exploratory phase (Phase-I) of this research. Specifically, the results of statistical analyses to determine the influence of local development plans on emissions are presented. Section 6 presents a detailed analysis of climate change management capacity of selected local development plans. Various components of the climate change management plan quality index are described using descriptive statistics. A summary of plan quality results is included at the end of the section. Section 7 presents the results of the explanatory analysis (Phase-II) focusing on the mitigation influence of development plans. Results are presented and summarized with respect to each independent variable.

Section 8 summarizes and discusses the results of exploratory and the explanatory analyses. It addresses the potential policy implications of the research results. It also presents recommendations and identifies possibilities for incorporating climate change management sensitivity in local planning. The final section 9, summarizes the key findings of this dissertation results and presents overall conclusions. Research limitations and suggestions for future research are presented at the end of this section.

2. LITERATURE REVIEW

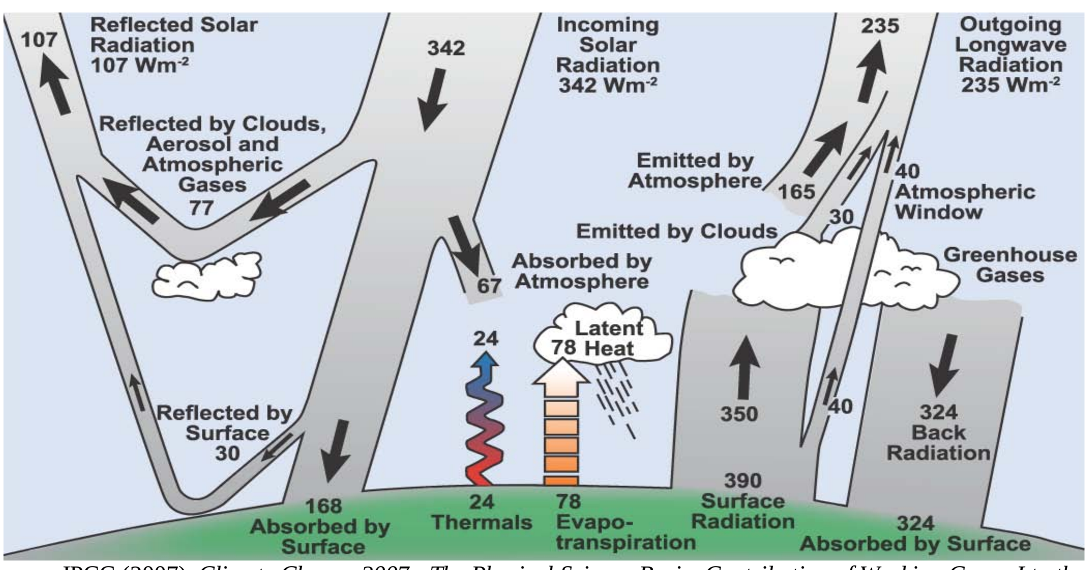
In this section, I review the existing literature and research in the thematic areas of climate change, response to climate change and role of development plans. Analysis of these thematic areas will provide the basis for developing a conceptual framework for this research. Understanding and insights gained in this review will also guide the future selection of variables, measures and analysis.

2.1 Understanding Climate Change

Climate is defined as the long term mean and variability of temperature, precipitation, and wind over a number of decades (usually 30 years) for a geographic location (Glickman, Frey, Hendl, & Podsiadlo, 2000). Often climate is interpreted as the statistical collection of weather experienced at a location over a long period of time (Trewartha & Horn, 1954). Inter-governmental Panel on Climate Change (IPCC) defines climate change as any significant change in climate over time whether due to natural variability or as a result of human activity (IPCC, 2007e). This change is scientifically assessed through the common climatic measures of temperature, precipitation, or wind, over an extended period, usually decades or longer. Often, the phrase ‘climate change’ and ‘global warming’ are used interchangeably but National Academy of Sciences recommends using ‘climate change’ as it implies changes in addition to the rising temperatures (NAS, 2008).

2.1.1 Global Warming

The term global warming describes the general warming up of our planet due to the effect of human activities, particularly due to burning of fossil fuel and large-scale deforestation, that result in large ‘greenhouse gas’ emissions into the atmosphere (Houghton, 2005). It is the main component of climate change, and receives the most attention due to its apparent link with post-industrialization anthropogenic activities. The science behind global warming is explained through the greenhouse effect (figure 2.1). This phenomenon was first proposed by the French mathematician Fourier in 1827 and followed up by the British scientist Tyndall in 1860, who discovered that the effect was a result of the absorption of heat by the minority gases, predominantly water vapor, carbon dioxide and methane (King, 2005). On average, the radiation energy from the Sun that heats the earth's surface is balanced out by the thermal radiation, radiated out into the space from the earth and the atmosphere. The presence of greenhouse gases such as carbon dioxide, methane, nitrous oxide and chlorofluorocarbons, in the atmosphere results in the greenhouse effect. A part of the energy radiated back into the atmosphere by earth is trapped by the atmospheric greenhouse gases retaining heat somewhat like the glass panels of a greenhouse. These gases act as a blanket, absorbing the thermal radiation from the earth's surface. Without this natural "greenhouse effect," temperatures would be much lower than they are now, and life as known today would not be possible. As a result of this effect the earth's average temperature is a maintained at a comfortable 60°F.



Source: IPCC (2007). *Climate Change 2007 - The Physical Science Basis: Contribution of Working Group I to the Fourth Assessment Report of the IPCC.* Cambridge: Cambridge University Press: pgs. 32.

Figure 2.1. Greenhouse Effect

Increased concentration of greenhouse gases in the earth's atmosphere enhances this effect. As a result, there is an increasing deficit in the radiation balance which forces warming of the earth's surface and lower atmosphere (Averch & Dluhy, 2000). In reality, it is a complex process with changes across the various components of the climatic system. Some changes will enhance the warming effect (positive feedback) and some will reduce the warming (negative feedback). Of the various greenhouse gases, increase in carbon dioxide has been substantial (over 30%) since the industrial revolution and is considered one of the primary drivers of global warming (IPCC, 2001b) . In absence of any controlling factors, it is expected to double from its pre-industrial value, by the end of this century. In 1896, Svante Arrhenius, estimated that doubling of the carbon dioxide concentration in the atmosphere would result in an increase in the global average temperature by 9.0-10.8^{o}F (Dickinson & Cicerone, 1986). Recent IPCC report estimates a likely increase of 2-11.5 ^{o}F in global mean temperatures by the end of the century (IPCC, 2007c).

2.1.2 Predicting Climate Change

Future predictions of climate change are based on climate scenario outputs from various models that use mathematical algorithms to signify relationships among the various components of the climate system. The commonly used models are General Circulation Models (GCMs), synthetic scenarios and analogue scenarios (IPCC, 2007e). Of these the synthetic and analogue scenarios, use past climatic data variables to predict the future climate, typically the temperature and the precipitation. GCMs are more complex and utilize a variety of climatic characteristics and incorporate detailed analysis of various components of the climatic system. The most advanced forms of the GCMs couple atmosphere and ocean circulations. These are called Atmosphere-Ocean General Circulation Models (AOGCMs). These full climate models also include detailed algorithms for incorporating changes in ice, land surface, and all the components of the climate system.

IPCC employs the coupled AOGCMs which solve the equations of the atmosphere and oceans approximately by breaking their domains up into volumetric grids, or boxes, each of which is assigned an average value for properties like velocity, temperature, humidity (atmosphere) and salt (oceans)(Houghton, Filho, Griggs, & Maskell, 1997). The number of volumetric grids is the resolution of the model. The starting point is estimates of likely concentration of greenhouse gases. These estimates depend on a variety of assumptions regarding human behavior and activities. IPCC relies on four storylines and associated family of scenarios for climate change predictions. These scenarios are used to estimate future greenhouse emissions that are then used by various models to estimate the future climate characteristics (IPCC, 2000, 2001a). The fourth IPCC assessment report uses A1T, A1B, A1F1, A2, B1 and B2 scenarios (Nakicenovic et al., 2001). Scenario family, A1 assumes a future world of rapid economic growth, a global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Scenario A1F1 assumes intensive use of fossil fuels, AIT assumes emphasis on non-fossil fuel sources and A1B assumes balanced technologies. Scenario A2 assumes a very heterogeneous world with continuously increasing population. Scenario B1 assumes a convergent world with global population as in the A1 storyline, but with rapid changes towards a service and information economy, with emphasis on global solutions to economic, social, and environmental sustainability issues. B2 scenario assumes a world in which the emphasis on local solutions to economic, social, and environmental sustainability and global population increase at a rate lower than A2.

Computing and analytical resources usually limit the resolution of the climate models. Most full climate models provide continental scale analysis (Giorgi & Francisco, 2000a, 2000b). For studies on smaller scales, they possess several limitations. To overcome these limitations regional climate models (RCMs) are being constructed (Dickinson, Errico, Giorgi, & Bates, 1989). These models cover a limited region and are nested in the global circulation models that provide varying conditions at the edges of the RCMs. It is important to realize that due to the greater natural variability in local climate captured at higher resolutions, climate change projects by the regional models have a higher degree of uncertainty than the global models.

Over the years these models have become better and are more reliable (Busuioc, Chen, & Hellström, 2001). Most of the recent models can not only simulate the mean variables but also the natural occurring variability in the climate (Tett, Johns, & Mitchell, 1997). The coupled models have shown to have a higher degree of reliability in producing realistic simulations of the climate change that has already been observed in the 20th century (Tett, Stott, Allen, Ingram, & Mitchell, 1999). The past climate simulation with these models have also been increasingly successful (Hougton et al., 1996). Thus, there is increasing confidence in the presently used climate models to provide projects of change that may be anticipated in the future climate (Meehl et al., 2000).

2.1.3 Anticipated Global Impact

The following synthesis of the anticipated global climate change impact is primarily based on the recent IPCC (2007a) assessments. Future climate change is dependent on the existing and the future changes in the atmospheric compositions. Future emissions are determined by various driving forces such as the population, socio-economic development and technological change. Evidently most of these are highly uncertain and cannot be predicted. Therefore, IPCC utilized the six scenarios detailed out in the Special Report on Emissions Scenarios for predicting the future climate change. These scenarios are based on the respective storylines and comprise a wide range of driving factors. No probabilities have been assigned to them as all scenarios are considered plausible and internally consistent.

The predictions in each of the SRES scenarios are different in magnitude but do provide a number of similar propositions. Carbon dioxide concentrations, globally averaged surface temperature, and sea levels are projected to increase in the 21st century under all IPCC emissions scenarios. The global average surface temperature is projected to increase by 1.4 to 5.8 deg C over the period 1990 to 2100. The global average annual precipitation is also expected to increase further during the 21st century. The global mean sea level rise is projected to rise by 0.09 to 0.88 m by the year 2100 (base year 1990).

IPCC models predict substantial regional differences in climate and sea level, compared to the global mean in the various climate change scenarios. It is likely that all land areas, particularly those at northern high latitudes, will warm more rapidly that the global average. Most notable would be the warming in northern regions of North America, and northern and central Asia, which is expected to increase by almost 40% in all the modeling scenarios. The glacier and ice caps are expected to continue their retreat. The regional variations in the sea level rise are expected to be much more than the climate. This is because the level of sea level rise is dependent to a large extent on a variety of local physiological as well as climatic factors. However, the models are consistent in the prediction that a greater average rise may be expected in the Arctic Ocean and a less than average in the Southern Oceans. It is expected that projected climatic change may have beneficial effects for some regions, but the larger the changes and the rate of change in climate, the more the adverse effects would be.

2.1.4 Anticipated Impact in the U.S.

Herein, I summarize the impacts as identified by the National Assessment Synthesis Team, US Global Change Research Program (2000). These assessments were created by the team using a combination of models developed by the Hadley Center in the United Kingdom and the Canadian Center for Climate Modeling and Analysis (NAST, 2001). The assessments are based on the mid-range emissions scenario for the future (IPCC emissions scenarios). The identified possible impact of global warming on US has been identified as:

a. Increased warming: Assuming continued growth in world greenhouse gas emissions, the primary climate models used in the assessment project that temperatures in the US will rise 5-9ºF (3-5ºC) on average in the next 100 years.

b. Increased damage in coastal and permafrost areas: Climate change and the resulting rise in sea level are likely to increase the threat to buildings, roads, power lines, and other infrastructure in climatically sensitive places.
c. Vulnerable ecosystems: The report suggests that a few vulnerable ecosystems, such as alpine meadows in the Rocky Mountains and some barrier islands, are likely to disappear entirely in some areas. Others, such as forests in the Southeast, are likely to experience major species shifts or break up into a mosaic of grasslands, woodlands, and forests. The loss of goods and services lost through the disappearance or fragmentation of these ecosystems is expected to be costly or even impossible to replace.
d. Differing regional impacts: Climate change is expected to vary widely across the US. Temperature increases will vary somewhat from one region to the next. Though heavy and extreme precipitation events are likely to become more frequent, yet some regions of US are expected to get drier.

In addition to the above the report suggests that climate change will very likely magnify the cumulative impacts of other stresses, such as air and water pollution and habitat destruction due to human development patterns. For some systems, such as coral reefs, the combined effects of climate change and other stresses are very likely to exceed a critical threshold, bringing large, possibly irreversible impacts. The report also cautions of uncertainties and surprises. It is accepted that significant uncertainties remain in the science underlying regional climate changes and their impacts. Thus it is likely that some aspects and impacts of climate change will be totally unanticipated as complex systems respond to ongoing climate change in unforeseeable ways and recommends a cautious approach.

2.1.5 Community Level Impacts

Even though the above impacts are broadly accepted, many researchers find them too general for any effective adaptive actions at local level (De Aranzabal, Schmitz, Aguilera, & Pineda, 2008; Rounsevell, Ewert, Reginster, Leemans, & Carter, 2005). Sea level rise impacts and worsening of extreme environmental hazards do provide some measure of localized interpretation, but are also common issues of contention in scientific debate. This contention has delayed acceptance of the climate change concerns in mainstream policy making (Boehmer-Christiansen, 1994; Jamieson, 1990; Shackley & Wynne, 1996). Therefore, at the community level, planners have to develop their own understanding of the issues and use generic impact assessments to extract relevant local challenges applicable to their community. Some of the major issues that the planners need to be concerned with in the context of the anticipated climate change are summarized in the following sub-sections.

2.1.5.1 Physical Issues

Built Environment : The impact of the changes in the local temperature and the rainfall pattern are likely to impact the exiting stress on the built structure (LisÖ, Aandahl, Eriksen, & Alfsen, 2003). For instance, frequent changes in temperature extremes will put more stress on cement structures and increase temperature would make timber prone to frequent insect attacks. Increased frequencies of extreme weather events would also necessities a revision of local building codes (Shimoda, 2003).

Transportation: Changes in the climatic systems could severely damage existing transportation systems and increase costs of maintenance and repair (Smith & Tirpak, 1989). Higher frequency of extreme weather events would also increase the threat to transportation infrastructure and need to be incorporate in cost-benefit analyses.

Other Infrastructure: Similar to the built environment, the lines of physical infrastructure would be affected (Jones, 2001). Power consumption pattern would also change along with the changes in the local temperature (Watson, Zinyowera, & Moss, 1997). Increased threat to transmissions lines due to extreme natural events, changing power demands and more recently concerns over fossil fuel emissions are all expected to result in increased variability, challenges and economic costs in power generation and distribution.

2.1.5.2 Environmental Issues

Air quality: Climatic changes affect weather systems that can result in changes in local pollution concentrations and distribution of local emissions (Wilby, Cranston, & Darby, 1998). This will have a direct impact on the community's quality of life. Recent modeling results suggest that a warming climate could increase the severity of summertime pollution episodes in the north-eastern and mid-western United States (Mickley, Jacob, Field, & Rind, 2004). Results of other similar studies also point out important potential contributions of growing global emissions, intercontinental transport, and the changing climate to ozone air quality in the United States for future decades which will effect planning for the future attainment of regional-scale air quality standards such as the U.S. National Ambient Air Quality Standards (NAAQS) (Aw & Kleeman, 2003; Hogrefe et al., 2004; Jacob, Logan, & Murti, 1999).

Hydrology: Changes in the precipitation pattern, temperatures and the extreme weather events due to global climate change will have numerous impacts on the urban hydrology. Urban lakes could witness increase in temperatures leading to lower ice cover in colder regions (Webb, 1996). Combination of these climatic factors could lead to increased nitrogen decomposition in lakes (Murdoch, Barron, & Miller, 2000), increased primary production, eutrophication and deoxygeneation of water (Hassan, ramaki, Hanaki, Matsuo, & Wilby, 1998). Climate changes may result in changes in the biogeochemical cycles and shifting of the wetland areas (Shackley, Kersey, Wilby, & Fleming, 2001) . Ground water aquifers, surface runoff flows and flooding patterns are also expected to be impacted (Keleher & Rahel, 1996). Reduced summer flows in rivers and result in increased pollution loads (Wilby, et al., 1998) and settlement on the river beds affecting ground water recharges will increase urban water stress (Robertson, Taylor, & Hoon, 2003). Coastal cities will affected by the interaction between sea level rise, surface run-off and extreme coastal storm surge events (Holt, 1999).

Urban Ecology: Changes in the local climate coupled with the changes in natural landscape would necessarily result in changes in the urban ecology. Most of the literature in his this field primarily focuses on species-specific impact on plants or animals (Graves, Watkins, westbury, & Littlefair, 2001). According to the existing research, general impacts on urban greens can be summarized as; possible damages to vegetation and increased threat of pests (Krupa & Manning, 1988). Even though it is expected that carbon dioxide combined with increasing temperature may initially stimulate better growth, the end result may not necessarily be high yields (Bisgrove & Hadley, 2002). Seasonal changes in vegetation pattern are also likely (Hulme et al., 2002). With these changes it is expected that local animal and plant species may also undergo a change in habitat distribution (Krupa & Manning, 1988). Exact modeling of such changes is location specific and will have to be considered while planning new growth and development areas.

2.1.5.3 Socio-economic Issues

Human health: Increasing temperatures will have a negative impact on human health (McMichael, Woodruff, & Hales, 2006; Pan, 1995). Changes in the local climate may result in reduced comfort in warmer areas whereas colder regions may witness better outdoor conditions (Langford & Bentham, 1995). There is increasing evidence that changes in the broad-scale climate system may already be affecting human health, including mortality and morbidity from extreme heat, cold, drought or storms; changes in air and water quality; and changes in the ecology of infectious disease (Kovats, Campbell-Lendrum, McMichel, Woodward, & Cox, 2001; Patz, Epstein, Burke, & Balbus, 1996; Stott, Stone, & Allen, 2004).

Tourism: Cities with active tourism activity may have to incorporate new anticipated local changes in the weather as tourism industry is known to be significantly impacted by local climatic conditions (Giles & Perry, 1998) Changes in the peak season, change in attractiveness of the location and the resulting impact on the economy are just some of the dimensions that planners may have to deal with (Hamilton, Maddison, & Tol, 2005).

Social behavior: The social behavior of the community will also be impacted with the changes in the local climate. Warmer temperatures in presently cold places would encourage outdoor activities whereas increasing temperatures in warm place may result in lower usage of public spaces (Shackley, et al., 2001). Planned distribution of such places will have to be modified accordingly.

Industry and business: Changes in the local climatic conditions could also result in relocation to or away of business and industries in a city (Parry & Carter, 1998). The consequent impact on the socio-economic conditions of the city may be crippling for industrial towns dependent on a single large industry (Nakincenovic & Swart, 2000). Communities will have to anticipate these future changes and plan to diversify their economic base much in advance.

Insurance: The insurance industry is now incorporating climate change considerations into its policy considerations (Tucker, 1997). It is expected that the areas more vulnerable to negative impacts of climate change may witness an increase in the property insurance costs. The changing probability distributions of many disasters and extreme weather events can make loss potential of individual catastrophes reach a level at which the national and international insurance industries may run into serious capacity problems (Berz, 1999).

Economic stress: With the increasing realization of climate change there is bound to be increased pressure on the local communities to adopt mitigation and adaptation measures (Peltonen, et al., 2005). These measures usually have high costs associated with them. With the associated climate changes impacting all the sectors of the local economy communities may find them in financial stress and would need to evolve innovative mean to continue financing local growth along with climate change management.

2.2 Local Climate Change Management

Preceding discussion on scientific assessments and climate change impacts scientific evidence suggests that the local environment is the interface between urban development and the global climatic system. Various urban development activities result in increased greenhouse gas emissions contributing to the phenomenon of global warming (Betsill, 2001; Grimm, et al., 2008). This increase in temperature results in changes in the global climatic system, which subsequently impact the local environment. These anticipated changes are expected to increase the present levels of risk to the human settlements (Brown, 2001; Nicholls, 1995). Thus, local developmental activities result in increased stress on the global climate and are also expected to be at risk from the impact of resultant changes in the global climatic system. In order to effectively face the challenges imposed by the global climate change, the communities will have to adopt a combination of measures and policies that result in reduced stress on the climatic systems (mitigation action) and also reduce vulnerability to local environmental impacts of climate change (adaptation action) (Ausubel, 1993; McEvoy, et al., 2006; Peltonen, et al., 2005; Turner et al., 1990).

2.2.1 Climate Change Mitigation and Adaptation

In the climate change literature mitigation activities are broadly defined as anthropogenic interventions that reduce the sources of greenhouse gases or enhance greenhouse sinks (IPCC, 2007b). Climate change mitigation policies and practices are primarily designed to protect the climate from human impact (Stehr & Storch, 2005). Such activities include technical and infrastructural investments, renewable energy implementation (to reduce climate change and improve energy security), as well as improving energy efficiency at the regional level (Laukkonen et al., 2009). Mitigation of climate change is predominantly viewed as a global responsibility. It is expected that if large stressors such as the industrialized nations and power generation industries, can cut their emissions, the overall global concentrations can be controlled. According to most researchers, international and national policy regimes are expected to play a dominant role in climate change mitigation (Lashof & Tirpak, 1990; Lim, Spanger-Siegfried, Burton, Malone, & Huq, 2005).

More recently, there is increasing understanding of the important role of local policies and individual actions (behavioral) to ensure effective implementation of mitigation options (Bohannon, 2007). Local policies promoting sustainable and low-carbon energy development are necessary to support the carbon reduction initiatives in the power generation sector. Individual choices to use bicycles or walk for short trips will cumulatively reduce the emissions from vehicular trips. Mitigation policies and actions are no longer limited to international carbon emissions negotiations (Kyoto protocol), but are also being implemented at the city level too (e.g Cities for Climate Protection).

While mitigation is necessary to prevent further changes in the natural climatic systems, scientific evidence also suggests that certain changes may be unavoidable. In addition to the committed changes due to past emissions, there is a high level of uncertainty associated with the effect of the mitigation actions (Reilly et al., 2001; Smit, Burton, Klein, & Wandel, 2000; Smith & Lenhart, 1996). The response of natural climate to changes in the production patterns, socio-economic and demographic patterns and alternate technologies cannot be easily ascertained. Thus, it is likely that some impacts are inevitable. So it has become imperative to incorporate adaptation actions along with the mitigation initiatives (Frankhauser & Tol, 1996; Smith & Lenhart, 1996).

Climate change adaptation is defined as the adjustments in the natural or the human systems in response to climatic stimulus or its effect (actual or expected), which reduces the harmful effect or exploits beneficial opportunities (IPCC, 2007a). Intentional efforts and changes are necessary in our existing society to safeguard it from the dangerous impacts of climate change (Stehr & Storch, 2005). Adaptation policies are associated with greater uncertainty than mitigation action and are usually unpopular with the government policies, which prefer short term ‘fixes’(Huq, Reid, & Murray, 2006). Researchers lament that there is a lack of attention to adaptation policies at all levels due to the lack in infrastructure to deal with uncertainties, and requirement to allocate scarce public resources for an activity with only perceived benefits in the future (Laukkonen, et al., 2009; Shackley & Wynne, 1996).

Adaptation options include both; enhancing the ability of individuals, organizations, communities or government to adapt to climate change effects and; transformation of the capacity into action by implementing adaptation decisions (Tompkins & Neil Adger, 2005). Even though early IPCC recommendations limited adaptive actions to the local level, most researchers now agree that such measures have to be undertaken across all scales and in most sectors. They can occur as policy facilitated market process, extension of social networks, social capacity building or building works (Smit, et al., 2000). The nature of the adaptive action will depend on the level of threat from a particular climatic impact on the local environment and the inherent adaptive capacity of the actor (Mendelsohn, 2000). Anticipated impacts are a function of locational attribute, and adaptive capacity is a function of the socio-economic capacity. It is known that society responds and reacts to short-duration extreme hazard events that are experienced by a substantial group of individuals. Rich literature on natural hazards clearly distinguishes between the biophysical and social dimensions of vulnerability (Blaikie, Cannon, Davis, & Wisner, 1994; Cutter, 1996; Kasperson et al., 1988; Mileti, 1999; Peacock, Morrow, & Gladwin, 2000). Therefore, adaption to climate change needs to be guided by an assessment of the bio-physical risk of environmental impacts imposed by climatic changes along with the social vulnerabilities that limit the adaptive capacity (Adger, 1996). Researchers borrow the construction of social vulnerability, as used in the natural hazards literature, to predict and plan for impacts of climate change (Adger & Kelly, 1999; Nichol et al., 2008; Ribot, Magalhaes, & Panagides, 1996). It is expected that the societal response to climate change impacts will be stimulated primarily by the climatic extremes and weather abnormalities threatening the immediate environment (Handmer, Dovers, & Downing, 1999; Pearce et al., 1996). The response itself is expected to similar to that anticipated during short-term natural disasters (Kelly & Adger, 2000). Therefore, it is reasonable to take advantage of the rich hazards vulnerability literature to inform climate change vulnerability assessments.

2.2.2 Synergies and Conflicts

In climate change debate, lack of analysis and research on adaptation is quite evident. A definitive shift towards more adaptation research is necessary as there is increasing scientific realization that mitigation policies cannot protect the society from the environmental impacts of climate change in the foreseeable future (Tompkins & Neil

Adger, 2005). Efforts to protect climate from the society (mitigation) have to be supplemented with efforts to protect the society from the inevitable changes in the climate (adaptation) (Stehr & Storch, 2005). Synergies between mitigation and adaptation exist and can be utilized to moderate climate change impact risks in a cost efficient manner (Adger, 2001; Kane & Shogren, 2000; Michaelowa & Wirtschaftsforschung-Hamburg, 2001; Wheaton & MacIver, 1999). Mitigation policies are directed towards controlling the future concentration of greenhouse gases in the atmosphere, which moderates consequent environmental impacts. By reducing the stress on the climatic systems, mitigation activities can reduce the adaptation costs (IPCC, 2007c). Many adaptation activities such as creating urban forests and forestation of the floodplains can limit storm water run-off and have mitigation benefits of carbon sequestering too.

Mitigation actions reduce the need for adaptation in the future while, cost-effective adaptation actions help insulate society from the climate change impacts and also reduce the degree of required mitigation actions. It is therefore not a question of choice but rather what mix that should dictate public policy and societal action (Dessai et al., 2004). Mitigation and adaptation policies jointly determine the effective risks and the costs to reduce them (Kane & Shogren, 2000). Increasing number of researchers now claim that mitigation and adaptation actions will have to be carried out incrementally (Klein, Schipper, & Dessai, 2005). Each policy option has some initial actions with lower costs, and then higher marginal costs as the extent of actions becomes more ambitious. Thus, it is optimal to start from both directions and balance the costs at an optimal mix of mitigation and adaptation policies (McKibbin & Wilcoxen, 2003). In practice, it is unwise to choose one option over the other as both help reduce the severity of climate change impacts and can jointly result in efficient utilization of public resources (Nordhaus, 2008).

However at times, mitigation and adaptation policies can also result in undermining the objectives of the other. Policy actions that are implemented without adequately addressing the cross-links and the conflicts in the strategies, can be counterproductive and waste precious public resources (Wheaton & MacIver, 1999). For example, emphasis on urban forests can lead to lower residential densities resulting in more vehicular trips, that will be counterproductive to the mitigation efforts. On the other hand an optimal mix of urban greenery and density can achieve the balanced objective of mitigation and adaptation (Hamin & Gurran, 2009). Mitigation activities that result in increasing the economic burden on the society such as increased carbon taxes on gas to discourage use, reduce the adaptive capacity of individuals in the society to undertake low-cost actions such as buying new energy efficient appliances. The primary challenges in integrating mitigation and adaptation activities are the differences in scale and time of each activity. Mitigation activities are undertaken within the framework of international commitments and national policy, whereas adaptation activities are more within the local and regional jurisdictions. The benefits of mitigation activities will be achieved over a long period of time so immediate action is imperative, whereas the adaptation benefits will be evident almost immediately and so can wait till the impacts are evident (McEvoy, et al., 2006).

With the current knowledge and uncertainty, researchers highlight the need to develop a socially and economically justifiable mix of mitigation, adaptation and development policy, based on the local context (Klein, et al., 2005). Wilbanks (2005) recommends place-based integrated approach that takes advantage of local data, offers opportunities for active stakeholder participation and integration across various sectors. This is also a manageable scale at which nature-society integration is most feasible (Kates et al., 2001). Local communities can undertake conscious local actions that provide adaptive and mitigation benefits. The challenge here is to evolve a local policy system that integrates the climate change concerns with the local developmental priorities and help achieve multiple objectives (Hamin & Gurran, 2009).

In most communities mitigation activities may seem to be an obstacle in meeting the increasing energy needs of development, increasing energy demands for construction and manufacturing to generate employment and increasing vehicular trips in a low-density residential pattern (IPCC, 2007b). The local policy regime is thus faced with the dilemma of sustaining the economic vitality and the development of the community or to address long term issues of climate change management (Collier, 1997; DeAngelo & Harvey, 1998). With the lack of any federal or state directive for controlling carbon emissions, the local jurisdictions decision to undertake any mitigation action is then driven by community values (Adger, 2003; Ausubel, 1991; Betsill, 2001; Zahran, Brody, Vedlitz, Grover, & Miller, 2008). Various studies have shown this to be a function of civic capacity, risk and the existing developmental regime (Betsill, Belfer Center for, International, Environment, & Natural Resources, 2000; Betsill & Bulkeley, 2004a; Brody, Zahran, Vedlitz, & Grover, 2008; Zahran, Grover, Brody, & Vedlitz, 2008).

Climate change research also suggests that economic, social and environmental impacts of climate change will vary across regions ecological, social, and economic impacts of climate change are geographically uneven (Mendelsohn, 2001; Mendelsohn, Nordhaus, & Shaw, 1994). Within the United States, climate change impact studies forecast regional differences in economic growth, loss of habitat, species, and sensitive ecosystems, costly disruptions to water supply, increases in extreme weather events and weather-related mortality, and even region-specific disruptions to recreational activities (Scheraga & Grambsch, 1998; Watson, et al., 1997). Based on rational premise, the willingness of a community to participate in policy solutions to mitigate and adapt to climate change may be geographically determined by the selective risks they face (Tol, 2001; Victor, 2003). With the present state of climate change science where high resolution impact models are still not available, the perception of climate risk will primarily be shaped by past changes in the weather pattern and natural hazards (Oreskes, 2004; Parry, Carter, & Hulme, 1996; Zahran, Brody, Grover, & Vedlitz, 2006).

2.3 Local Community Development Plans

Increasing number of communities in U.S use local community development plans as means to manage growth and direct development to achieve desired community goals. Plans are the final result of the community planning process. A local development plan is usually a long-range policy document that provides legal, political and logical rationale to the community's long-term development management strategy (Berke, Godschalk, et al., 2006). Such plans can be identified as master, general or comprehensive plans and are a key tool that provides a framework for managing the developmental pattern of the community to achieve the desired goals and objectives (Nelson & Steven). These plans cover all aspects of local development and may include specialized sector specific or area plans for specific objectives.

Community development plans typically include elements of land use, housing, transportation, environment, energy, land use, economic development and public facilities (Berke & Conroy, 2000). This broad approach enables effective cross-thematic integration of local developmental policies and actions. This integrative nature of the plan and the underlying planning process has made development plans a useful tool for accomplishing variety of community goals. Previous research identifies use of development plans for achieving sustainable development (Berke 1995; Berke et al. 1999; Berke and Conroy 2000; Conroy and Berke 2004; Laurian et al. 2004), mitigating natural hazards (Nelson and Steven; Berke and Beatley 1992; Brody 2003c), and ecosystem management (Brody, 2003a; Brody, Carrasco, et al., 2003; Brody, Highfield, & Alston, 2004; Brody & Highfield, 2005).

The nature of the local planning process that underlies the plan itself represents an ideal institutional framework for evolving solutions to the challenges of climate change. The dynamic and adaptive nature of the local planning process is suitable for managing common goods issues such as climate change. Planning systems have traditionally been a dynamic arena of public policy that is continually shaped by power equations between the interest groups competing and cooperating for limited local resources (Innes & Booher, 1999; Kaiser & Godschalk, 1995a). This dynamism provides an opportunity for local planning to be more adaptive and responsive to the changing and evolving needs of effective climate change management.

Enhanced public participation in local planning is widely accepted in the U.S. (Tauxe, 1995) Brody et al. (2003) describe a long tradition of participatory approaches to local planning since the 1920s when the model state planning enabling legislation was drafted by the U.S Department of commerce. Principles of participatory approach include rights of the stakeholders to be informed, allowed to bring in new issues and evaluate alternative perspectives (Arnstien, 1969; Brody, 2003a; Burke, 1968; Day, 1997; Fainstein, 2000; Glass, 1979; Godschalk & Mills, 1966). Such participation-based local policy formulation and implementation result in effective implementation of planning goals (Barrett & Fudge, 1981). Policy and planning research accepts this method of decision making as one of the most suitable for evolving innovative solutions to challenging problems (Rydin & Pennington, 2000). This nature of planning process increases my confidence in local community planning systems to deal with climate change management. The actors, stakeholders and the community representatives that are part of the existing planning process are aptly suited to evolve appropriate local innovations for effective climate change management.

Comprehensive plans are the results of this elaborate social learning that is facilitated through the local planning process. Berke et al. (1996) argue that there is enough research to support the impact of good plans on local decision making regarding urban land use patterns, environmental protection, natural and technological hazards and housing. Previous studies have highlighted the success of local comprehensive plans in managing issues related to natural hazards (Berke & Beatley, 1992; Brody, 2003a; Nelson & Steven), land use pattern (Kent & Jones, 1990), ecosystem management (Brody, 2003c; Brody, Carrasco, et al., 2003; Brody, Highfield, & Carrasco, 2004; Brody & Highfield, 2005), sustainability (Berke, 1995; Berke & Conroy, 2000; Berke, et al., 1999; Conroy & Berke, 2004; Laurian, et al., 2004), intergovernmental collaboration (Burby & May, 1997; Godschalk, et al., 1994) and plan implementation (Brody & Highfield, 2005; Laurian, et al., 2004). The collaborative and integrative nature of good community planning systems that are underlie comprehensive plans are expected to enhance community governance and participatory structure necessary for efficient climate change management.

2.4 Plan Evaluation

Development of a good plan is the starting step in achieving the desired planning goals for realizing the community's vision of development. To effectively achieve its objective a good plan must be appropriate for the local context, address the needs and limitations of the community, and have high quality content and format (Berke, Godschalk, et al., 2006). In the past decade, the research on plan quality analysis has become more organized and structured. Probably the impetus to search for the 'good plan' is fueled by the multitude of community goals that local development plans are now expected to pursue.

Previous research in plan effects and effectiveness suggests three distinct approaches (Knaap et al. 1998). The first compares the final spatial pattern of development (cumulative physical impact) to the planned spatial distribution as undertaken by Aletrman and Hill (1978). This is a post plan evaluation that does not adequately assess the effectiveness or the effect of planning as results cannot be compared to possible growth pattern in the absence of the plan. This evaluation is guided by the systems approach wherein the evaluators have sought to analyze the compared the level of spatial patterns of service provision to those desired (see Calkins 1979; Talen 1996). The second approach is based on the deductive argument that suggests that the plan quality is a strong determinant of the planning outcomes. These evaluators assess the quality of plan documents with respect to a suite of measures of a good plan (Berke and French 1994; Dalton and Burby 1994). The third approach is based on the game theory wherein decisions to plan, regulate and develop land are modeled independently with rational players and factoring in uncertainty (Schaeffer and Hopkins 1987).

A comprehensive evaluation of the planning regime that underlies every plan, involves all components of planning process, the resultant document and the implementation. Baer (1997) lists various contextual elements against which various stages of planning can be evaluated. However, lack of adequate data for all stages of planning often forces researchers to use a more restricted approach. With plan documents available readily and existing research supporting the deductive approach, plan quality evaluation is commonly preferred in the field of environmental resource management and hazard mitigation. A number of earlier research studies have suggested various plan characteristics against which the plan documents can be evaluated: Alexander and Faludi (1989) suggest five criteria - conformity, rational process, optimality ex ante, optimality ex post and utilization; Kent (1990) identifies - clear policies and strong maps with spatial intent of policies or land-use design; Healy (1996) emphasizes that consistency of normative with community. Berke and French (1994), Kaiser et al (1995) (1995) and Kaiser and Godschalk (1995) suggest factual basis, goals and policies. On the basis of past plan evaluation studies, Berke et al (Berke, Godschalk, et al., 2006) suggest two key conceptual dimensions for inclusion in any plan evaluation: first, is the internal plan quality that includes content and format of key components; and second is external plan quality that assess the relevance of the scope and coverage of the plan in fitting the local dimensions. Internal quality analysis is recommended to be applied to each of the four basic components of a plan, namely: issues and vision statement; fact base; goal and policy framework; plan proposals. The external plan quality as outlined by Hopkins (2001) includes criterion that maximize use and influence of plans. Good plans are expected to encourage opportunities to use plans, create clear views and understandings of plans, account for interdependent actions in plan scope, and reveal the participation of actors.

Even though the research on plan quality is growing, there is an evident lack of research in evaluating plan quality against the actual outcomes. Brody and Highfield (2005) identify four obstacles that have hindered systematic evaluation of plan implementation: firstly, lack of clarity in establishing a time-frame for evaluating success; second, disagreement over what constitutes planning effectiveness; third, lack of longitudinal datasets and acceptable research methods; and, finally, debate over the meaning of planning success and evaluation of plan conformity. They examined the implementation of environmental component of plans in Florida and found that presence of environmental policies in the local development plans did not necessarily result in desirable environmental impact of limiting wetland development. Interestingly, the plan implementation index, that measured that measured the mechanism and procedure for implementation, was found to be associated with a greater degree of nonconformity. The possible explanation for this could be the lack of flexibility and ease in the specified plan implementation mechanism that hindered effective action.

Only a handful of prior plan evaluation studies exist that compare actual outcomes with the planned intentions. Alterman and Hill (1978) found that the master plan was followed for only about 66% of the land area planned. Their multiple regression model explained variation in plan conformity through several variables such as time and flexibility. Calkins (1979) study uses a "planning monitor" to measure the extent to which plan goals/objectives were met and explain the difference between the planned and actual states of environment. This research also attempted to explain the reasons for any observed differences between the plan and the outcome using algebraic expressions. Talen (1996a) used GIS and spatial statistical analysis to compare the actual access to public facilities with the planned intentions. Burby (2003) examined the relationship between stakeholder participation in the planning process and implementation of hazard mitigation action in states of Florida and Washington. Recently, Brody and Highfield (2005) The results of all these studies suggest that there exist gaps between the anticipated impact of plan policies and the actual development impact. Mere analysis of plan quality does not guarantee plan implementation but does offer a tool for evaluating the degree of success of various planning goals.

2.4.1 Evaluating Environmental Change Management Capacity of Local Plans

Discussion of incorporating climate change considerations into mainstream planning as another dimension of sustainability or as a new criterion of impact analysis have just started. Community vision of development in the existing plans is very unlikely to include considerations of good environmental change management policies/actions that reduce the effective stress on the local climate or moderate the local environmental impacts of climate change. However, themes of sustainability, new urbanism, smart growth, and resilience to natural hazards have been a part of planning consideration for sufficient time to be mainstreamed into most development plans.

Researchers advocating integration of climate change considerations into mainstream planning identify numerous planning actions that can achieve mitigation and adaptation benefits. Planning policies that contribute to denser urban environments reduce vehicle miles travelled and lower building energy use, are effective mitigation measures. Adding green space in the urban areas is identified as an important step in reducing the urban heat island effect (Stone 2005). Ewing and colleagues (2008) suggest five key ways for mitigation climate change. These are: high density; greater diversity of land uses; smaller block design; better destination accessibility; and shorter distance to transit. The primary benefits of these is anticipated in terms of reduced vehicle miles traveled, which will result in significant reduction in greenhouse emissions from vehicular travel. In addition to these, the authors also suggest use of urban growth boundaries, ensuring proximity of the workforce housing near jobs, and adopting pedestrian friendly site and building design standards. Advantages of a compact urban form have also been related to non-transportation related mitigation benefits (Randolph 2008). The rationale is that low density development is associated with detached units, larger interior space and therefore requires more energy to cool and heat. Transmission of energy across low density developments tends to increase energy demands. This aspect of energy savings is particularly important in the U.S where residential sector is responsible for more than one-fifth of nation’s energy usage (Ewing & Rong 2008).

The US Mayor’s climate Protection Agreement, which includes 300 cities, recommends a variety of short-term and long-term measures for climate change mitigation (ICLEI, 2005). Some of the short-term measures relevant to planning include: planting of shady trees; maintain healthy urban forests, street trees; encourage car-pooling, van-pooling, use of mass-transit; encourage telecommuting; improve traffic signal synchronization; promote alternative fuel stations; promote purchase of green energy; stringent residential and commercial energy codes; establish recycling and reuse programs; education government staff and public; and provide easily accessible technical support. Long-term planning actions include: co-locate facilities to reduce travel time; Brownfield redevelopment; preserve open space; promote high-density and infill development; institute growth boundaries, ordinances to limit sprawl; and institute financial disincentives for suburban expansion. In a survey of selected local plans in U.S and Australia, Hamin and Gurran (2009) identify numerous climate change mitigation and adaptation policies. These include: coastal setbacks; habitat corridors; retain and restore biodiversity; detailed environmental impact assessments; energy and water demand management; shorter trip lengths; waste recycling; and efficient emergency management services.

Researchers agree that for a plan to be effective in managing environmental changes caused by global warming, a mix of climate change mitigation and adaptation actions is required. Responses to climate change require local knowledge that inform the appropriate actions (Laukkonen, et al., 2009). Policies and actions that result in limiting or reducing the greenhouse gas emissions along with measures that increase carbon sinks (green areas) will contribute to the global mitigation initiatives. Adaptation actions and policies reduce the risk of damage to the community from the anticipated changes in the local environment as a result of climate change. A combination of these actions impacts a greater degree of resiliency to the settlement from climate change. Table 2.1 summarizes the planning actions that promote mitigation and adaptation based on the existing scientific knowledge and research.

Table 2.1. Summary of Mitigation and Adaptation Actions

Plan Component	**Recommended Environmental Change Management Policies/Actions**
Land use and zoning	Promote mixed use development
	Promote Brownfield (or Greyfield) redevelopment
	Promote Infill development
	Limiting use of hazardous areas/ marginal areas (Overlay zones/ reduced densities)
	Relocation of vulnerable structures out of hazard zones
Urban Design/Built form	Promote high density development
	Promote low-water intensive urban landscape
	Building height/ orientation guidelines, street width to building height ratios
	Proposals/actions to decrease urban heat island effect (urban forests, tree lined streets)
Site Planning	Site plan review requiring land suitability assessment/ Special study/impact assessment
	Setbacks/Buffers
	Subdivision regulations
Building design	Storage, collection and recycling of wastes
	Water-efficient construction
	Recycling of grey-water
	Rainwater harvesting
	On-site water treatment
	Building standards/Building code for enhanced protection from natural hazards
Transportation	Creating/implementing/enhancing public transportation systems
	Increased public transportation stops/nodes
	Management of no traffic zones
	Creation/ upgrading of bicycle paths
	Creation/ upgrading of pedestrian facilities
Transportation Facilities	Creating/implementing/ enhancing public transportation systems
	Increased public transportation stops/nodes
	Management of no traffic zones
	Creation/ upgrading of bicycle paths
	Creation/ upgrading of pedestrian facilities

Table 2.1. Continued

Plan Component	Recommended Environmental Change Management Policies/Actions
Natural resource management	Emergency/ Disaster/Hazard Management guidelines
	Environmentally sensitive area protection (national/state parks, coastal barriers, breeding areas)
	Conservation of forests, vegetation, and riparian areas
	Creating wildlife corridors
	Preventing habitat fragmentation
	Sediment and erosion control regulation
	Stream dumping regulations/ prevention
	Wetlands restoration
Public facilities and Infrastructure	Structural tools for controlling hazard losses (dams, dykes, flood gates etc)
	Capital Improvements for phased development
	Redevelopment /Retrofitting/ Maintenance of public structure
	Locating critical facilities in non-hazardous areas
Acquisition tools	Land and property acquisition (fee simple purchase/eminent domain)
	Dedication of hazardous open space (conservation easement)
	Transfer of development rights
	Purchase of development rights
Incentive/disincentive tools	Subsidized mass transit / incentives for car pooling
	Impact fees for development in ecologically sensitive areas
	Density bonuses
Awareness/Educational Tools	Education and outreach program during plan implementation
	Information dissemination regarding location of hazardous (including posting of signs, information booklets etc)
	Disaster warning and response program - awareness
	Training/Technical assistance to developers or property owners
	Computer models/evacuation systems/transportation models/ GIS (e.q. HEC, web-based modeling system)

3. RESEARCH FRAMEWORK

In this section I present the overall structure of this research. I describe the underlying theoretical framework, study area, and identify measurement variables. I also list specific research questions and hypothesis in regards to each of the selected variables. Finally, I detail out the statistical approach adopted for testing these hypotheses.

3.1 Conceptual Framework

Urban environment is conceptualized as consisting of three components: human, biophysical and public policy. The human environment includes all artifacts and structures of individuals and the community such as the social system, cultural values, housing and work institutions. The bio-physical environment consists of biotic and abiotic components of the landscape. The policy environment is the local framework of rules, regulations, visions and strategies for managing the human and the bio-physical environment. Local development plans are an important part of this local policy environment as they provide guidelines for spatial distribution of various economic and social functions. Urban form including distribution of various land uses, economic functions, and infrastructure is a result of interactions among these three components, over time and space. Figure 3.1 provides a simplistic representation of the local urban environment.

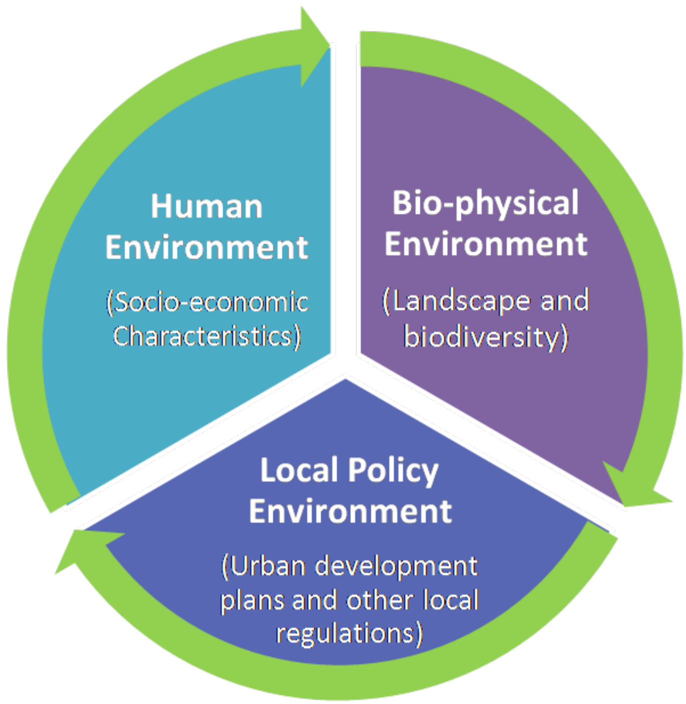


Figure 3.1. Components of the Local Urban Environment

The preceding literature review identified the dual nature of relationship between cities and climate change. Various development activities in cities that result in burning of fossil fuels and land cover modifications directly impact the local environment by disturbing the natural carbon cycle and emitting greenhouse gases. These local impacts lead to changes in the global climatic characteristics that are expected to result in future changes in precipitation, temperature, ocean circulation, ice cap melting or abrupt events like gulf stream modification. Figure 3.2 summarizes this dual relationship between the cities and climate change.

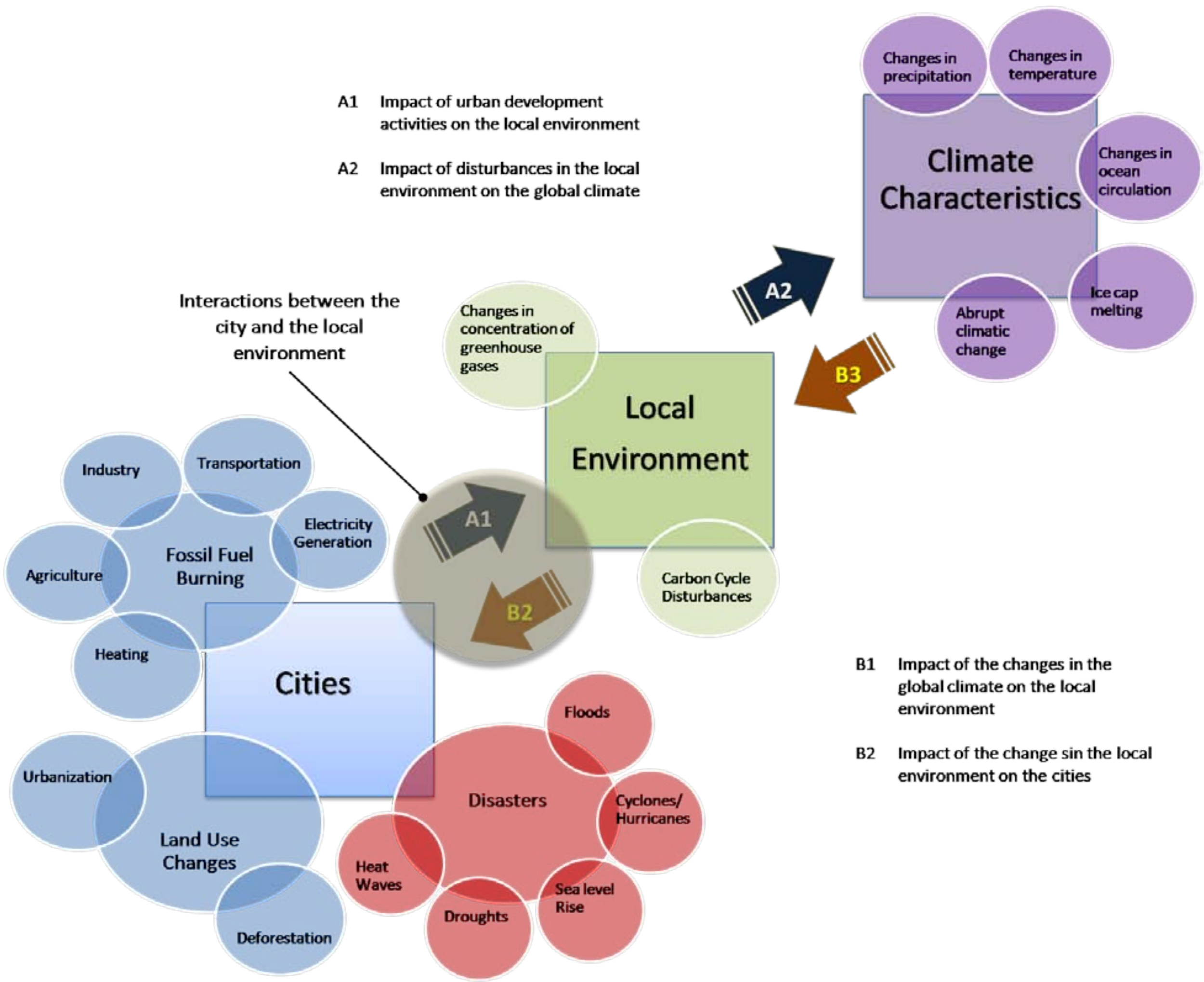


Figure 3.2. Cities and Climate Change

The literature review in Section 2 also confirmed that contemporary urban development plans are blueprints for guiding future growth and development of a community, primarily through land use planning (Berke, Godschalk, et al., 2006). Urban development plans cover most aspects of city management and influence quality of life of its citizens. The existing literature also suggests that all development plans are developed within the overall constraints and opportunities of the local bio-physical environment and are responsive to the community's socio-economic characteristics. As urban development plans are the primary policy guides for local growth, including the intensity and the distribution of various urban uses, they play a key role in influencing the interaction between the various processes within a city and local environment. Also, community-level planning to achieve a desired community vision is subject to influences of human environment characteristics, as well as the bio-physical environment and applicable policy mandates. The effect of local development plans on global climate change by influencing greenhouse emissions is the primary focus of my research (figure 3.3).

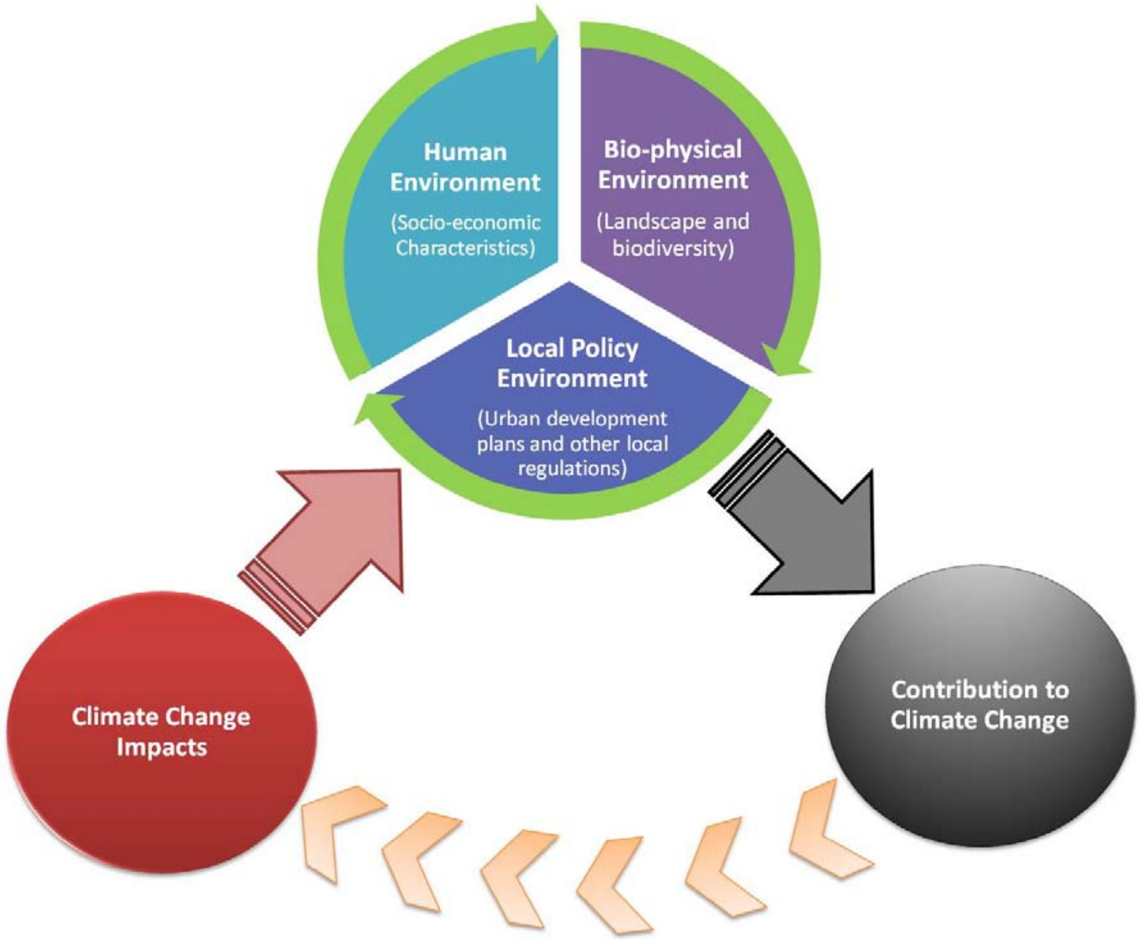


Figure 3.3. Research Focus

3.2 Research Outline

Based on the preceding conceptualization of the urban environment, and identified linkages between cities and climate change in the context of my research goals, figure 3.4 illustrates the adopted research framework.

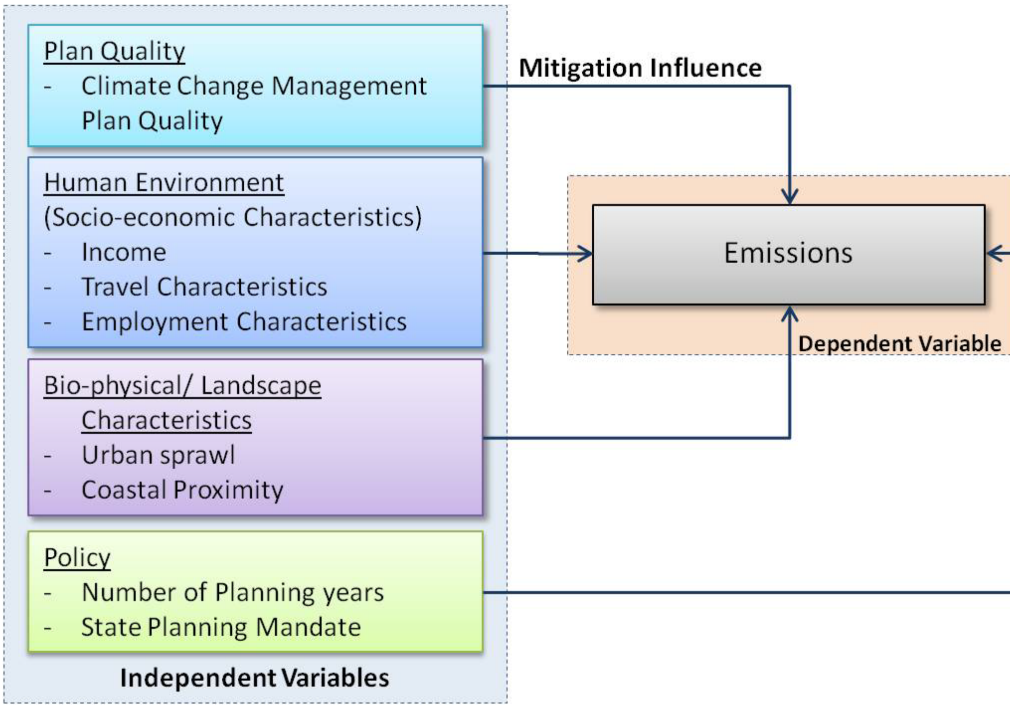


Figure 3.4. Research Framework

In this study, I evaluated the influence of local development plans on local carbon dioxide emissions. Measures of human environment (socio-economic characteristics), bio-physical\landscape characteristics, and other policy parameters were also included in the analysis. The measures of human environment included socio-economic characteristics of income, travel characteristics and employment characteristics. Within the bio-physical characteristics, measures of urban sprawl, and coastal proximity were considered. Policy influence measures included number of planning years and the state planning mandate.

Within the framework of proposed conceptual framework and research goals this study was carried out in two phases. The first phase (Phase – I) was the exploratory phase that focused on determination of presence or absence of empirical evidence supporting the influence of local developmental policies on emissions. The second phase (Phase-II) focused on detailed policy analysis of local development plans to assess its potential to influence climate change in a sample of cities with local development plans. In this phase, a detailed analysis of influence of climate change management plan quality on climate change emissions was also undertaken.

3.3 Phase I – Determining the Influence of Development Plans

In the first phase of this research I empirically tested for the influence of local development plans on emissions. Specifically, this initial exploratory research phase addressed the following research question:

> Research Question 1 (RQ1): Do local planning policies have any significant impact on the local emissions?

3.3.1 Dependent Variable – Change in Emissions (1990-2005)

This variable is the measure of a community's contribution to climate change. It was measured as the change in per capita anthropogenic carbon dioxide (CO2) gas emissions from 1990 to 2005. More than 60% of global warming is attributed to carbon dioxide emissions and is the primary constituent of anthropogenic activities related to urbanization (IPCC, 2007d). The anthropogenic CO2 emissions data for the central cities (1990 and 2005) was derived from the Emission Database for Global Atmospheric Research (EDGAR) version 4 dataset (European Commission, 2009). This dataset was created by the National Institute of Public Health and the Environment and The Netherlands Organization for Applied Scientific Research (RIVM and TNO) in the Netherlands. The dataset is well reputed and often used by United Nations agencies and International Energy agency (Marland, Brenkert, & Olivier, 1999; Olivier, Bloos, Berdowski, Visschedijk, & Bouwman, 1999; Olivier, Van Aardenne, Dentener, Ganzeveld, & Peters, 2005). Because this dataset enables trend analysis it has been used extensively for emissions change analysis over the past years (see Chameides & Bergin, 2002; Janssens et al., 2003; Olivier & Peters, 2005; Stern, 2006; Stohl, Eckhardt, Forster, James, & Spichtinger, 2002). The raw dataset was available at a resolution of 0.1 deg by 0.1 deg geo-grid cells. The emissions for each of the central city were estimated through geo-processing using area based proportional allocation in a Geographic Information Systems (GIS) software environment.

3.3.2 Independent Variable - Local Development Plans

Some communities prepare a number of plan documents that together provide a framework for future development and investments in various sectors. Often these plans are developed independently as stand-alone sectoral plans and may not necessarily be integrated into a common development strategy. On the other hand, a growing number of communities are adopting comprehensive plans that integrate all sectoral development strategies into a single local planning document. These plans, though comprehensive in nature, may necessarily not be called comprehensive plans. In some cities they are also known as master plans or community development plans. All such plans that a minimum addressed policies and proposals related to land use management, circulation/ transportation, housing, economic development, and environmental management were considered as local development plans in this research study.

Such comprehensive local development plans usually have a long implementation period ranging from 15-30 years. Therefore, it was important in this study to identify plans that have had sufficient time to have a measurable impact on the community. For this reason, the selection of development plans was limited to those that were adopted or revised between 1991 and 2000. The planning department website, principal planner or the mayor’s office were contacted through e-mail, website or telephone for this information. Some of the plans included in the study were adopted earlier than 1991 but had been revised between 1991 and 2000. For such plans the most recent date of revisions was used as the date of adoption in this study.

As discussed in the literature review most development plans are created to promote sustainable urban development of community that also minimizes its environmental impact. Air pollution is one of the most visible environmental impacts and as such is expected to be an important consideration in the development of the local plans. Therefore, communities with local development plans are expected to have reduced emissions.

> *Hypothesis 1*: Communities with local development plans will show reduced emissions in comparison to communities without the plans.

3.4 Phase II: Assessing the Impact of Planning Policies

In the second phase of the research, I analyzed in detail the quality of local development plans and their influence on emissions. As the first step, the climate change management capacity of sampled local development plans was estimated. A detailed plan quality protocol was used to evaluate the planning policies contained in the plans and subsequently calculate climate change management plan quality for each plan. Thereafter, the influence of plan quality on emissions was estimated using statistical modeling. Specifically, in this phase of the research the following research questions were addressed:

> Research Question 2 (RQ2): Do the local development plans include planning policies that can influence local climate change management?
> Research Question 3 (RQ3): How does the quality of a local development plan influence a community's emissions while controlling for the socio-economic, bio-physical, and policy characteristics?

3.4.1 Dependent Variable – Change in Emissions (1990-2005)

This variable is the same dependent variable as used in the phase –I of this study. It is the measure of a community's contribution to climate change. It was measured as the change in per capita anthropogenic carbon dioxide (CO2) gas emissions in the local environment. The anthropogenic CO2 emissions data for the central cities (1990 and 2005) was derived from the Emission Database for Global Atmospheric Research (EDGAR) version 4 dataset (European Commission, 2009). The emissions for each of the sampled cities were estimated through geo-processing of the raw dataset using area based proportional allocation in a Geographic Information Systems (GIS) software environment.

3.4.2 Primary Independent Variable: Climate Change Management Plan Quality

The climate change management plan quality was conceptualized as a measure of climate change management influence of the planning policies contained in the local development plan. For example, development policies, such as higher density result in lower vehicle miles for travel that limits vehicular greenhouse gas emissions, and thus reduces a community's emissions. Other planning policies that direct development away from physically vulnerable areas or add to community resilience capacity can lower the estimated risk of climate change impacts. However, a possible secondary impact of directing development away from vulnerable areas could be higher density in other less vulnerable areas. Therefore, together these policies have the potential to significantly influence local climate change management.

Detailed policy content analysis of local development plans was carried out for analyzing the presence and the quality of the climate change management policies. Specifically, planning policies related to land use and zoning, urban design, site planning, building design, transportation, natural resource management, physical infrastructure and facilities, acquisition tools, incentive/disincentive tools, and awareness educational and technology tools were examined. The raw plan quality score for each jurisdiction in the sample was estimated as the mean of all individual policy scores received by the plan. The raw score was then weighted by plan implementation capacity scores for each plan. Plan implementation capacity scores were based on quality evaluation of the plan implementation policies included in the local development plans. Specific hypothesis that was tested with respect to this measure is listed below:

> *Hypothesis* 2: Communities with higher climate change management plan quality index will have significantly lower increase in emissions.

3.4.3 Other Independent Variables

In order to parse-out the effect of climate change management plan quality index on the dependent variables of emissions, it was necessary to control for the effects of other influencing variables. These factors were included in the study as control variables.

Human Environment: The literature review in section 2 suggested that the socio-economic characteristics of a community directly impact its contributory effect on climate change. Based on the existing research, the socio-economic characteristics of per-capita income, employment characteristics, and travel characteristics were identified as important control measures. Communities with higher income levels are expected to promote higher consumptive lifestyles that contribute towards greater greenhouse gas emissions. Greater use of private vehicles for daily travel to work is also expected to contribute to the travel emissions. In terms of employment characteristics, communities with significant number of people employed in non-profit organizations are expected to promote a more sustainable lifestyle leading to lower emissions. On the other hand, higher dependency on carbon based employment in a community is expected to result in greater carbon emissions. Specific hypotheses that were tested with respect to the dependent variable are listed below:

> *Hypothesis 3*: Communities with higher per-capita income will have significantly higher increase in emissions.

Hypothesis 4: Communities with higher usage of private vehicles to work will have significantly higher increase in emissions.

Hypothesis 5: Communities with a higher percentage of workers in non-profit employment will have significantly lower increase in emissions.

Hypothesis 6: Communities with higher percentage of workers in carbon sector employment will have significantly higher increase in emissions.

Bio-physical characteristics: The bio-physical components of the community include the natural landscape characteristics as well as developmental modifications of the local landscape. Two measures of this component included in this study are sprawl and proximity to coast. Sprawl measures the efficient of land utilization in a community. The literature review summarized in section 2.0 revealed that extensive sprawl results in increased vehicular trip lengths and as such is expected to increase vehicular emissions. On the other hand, proximity to coast is expected to result in reduced emissions as a reaction to the perception of risk from the much publicized threat of sea-level rise impact due to climate change.

Hypothesis 7: Communities with higher sprawl will have significantly higher increase in emissions.

Hypothesis 8: Communities in coastal areas will have significantly lower increase in emissions.

Policy Influences: In order to control for the influence of state planning policy, a measure of presence or absence of a state planning mandate. Presence of state mandate for local planning at the community level is expected to influence local planning capacity, access to resources, and the attitude of the local leadership that in turn is expected to yield better environmental quality benefits. Thus, it is expected that presence of state mandate for local planning will also lead to lower emissions in the community. As local development plans have long implementation periods and are updated at varying times by every community, it was important to control for the length of time the plan had been in effect. The duration for which the plan has been under implementation is expected to significantly influence the positive impact of planning policies on local emissions.

> *Hypothesis 9*: Communities in states that mandate local development plans will have significantly lower increase in emissions.
>
> *Hypothesis 10*: Communities in which the local development plan has been in effect for a longer duration will have significantly lower increase in emissions.

4. RESEARCH METHODS

This section outlines and discusses the research methods used in this study. The first sub-section identifies and discusses the study area characteristics. The second sub-section describes the research methods used in the first phase of this research study, wherein the influence of local development plans on climate change mitigation was assessed. In this sub-section, procedures of sample selection, variable formulation, and statistical analytical techniques are discussed. The third sub-section focuses on the second phase of this study wherein I analyzed in detail, the impact of local development plan quality on climate change mitigation and adaptation. Details of sample selection, variable formulation, and statistical procedures utilized are described in this sub-section.

4.1 Sample Frame

The sample-frame for this study comprises all the central cities in the contiguous U.S. Earlier research suggests that metropolitan areas, with two-thirds of the U.S. population and nearly three-quarters of its economic activities, need to be priority targets for climate change management action (Brown, Southworth, & Sarzynski, 2008). However, metropolitan areas are designated by the U.S Census Bureau, and as such lack a unified local governance or planning system. Whereas, a central city, the largest place in any metropolitan statistical area (MSA), is an incorporated jurisdiction with a local government. It is the primary population and economic center of an MSA. Thus, within a metropolitan area, the central city represents a cohesive administrative jurisdiction appropriate for policy analysis.

The Federal Register (1998) identifies a central city based on the following characteristics:

- The city with the largest population in the MSA;
- Each additional city with a population of at least 250,000 or with at least 100,000 persons working within its limits;

- Each additional city with a population of at least 25,000, an employment/residence ratio of at least 0.75, and at least 40 percent of its employed residents working in the city;
- Each city of 15,000 to 24,999 population that is at least one-third as large as the largest central city, has an employment/residence ratio of at least 0.75, and has at least 40 percent of its employed residents working in the city;
- The largest city in a secondary noncontiguous urbanized area, provided it has at least 15,000 population, an employment/residence ratio of at least 0.75, and has at least 40 percent of its employed residents working in the city; and
- Each additional city in a secondary noncontiguous urbanized area that is at least one-third as large as the largest central city of that urbanized area, that has at least 15,000 population and an employment/residence ratio of at least 0.75, and that has at least 40 percent of its employed residents working in the city.

In some cases, only part of a city qualified as central because the rest of the city was not included in the metropolitan area boundary. In order to evaluate and assess suitability for planning actions, the whole urban jurisdiction of the central city was included in the sample frame. There were 541 central cities in the contiguous U.S. identified by the Office of Management and Budget, 6/30/99, Bulletin No. 99-04, issued June 30, 1999. These 541 central cities constitute the sample frame for this study (Figure 4.1).

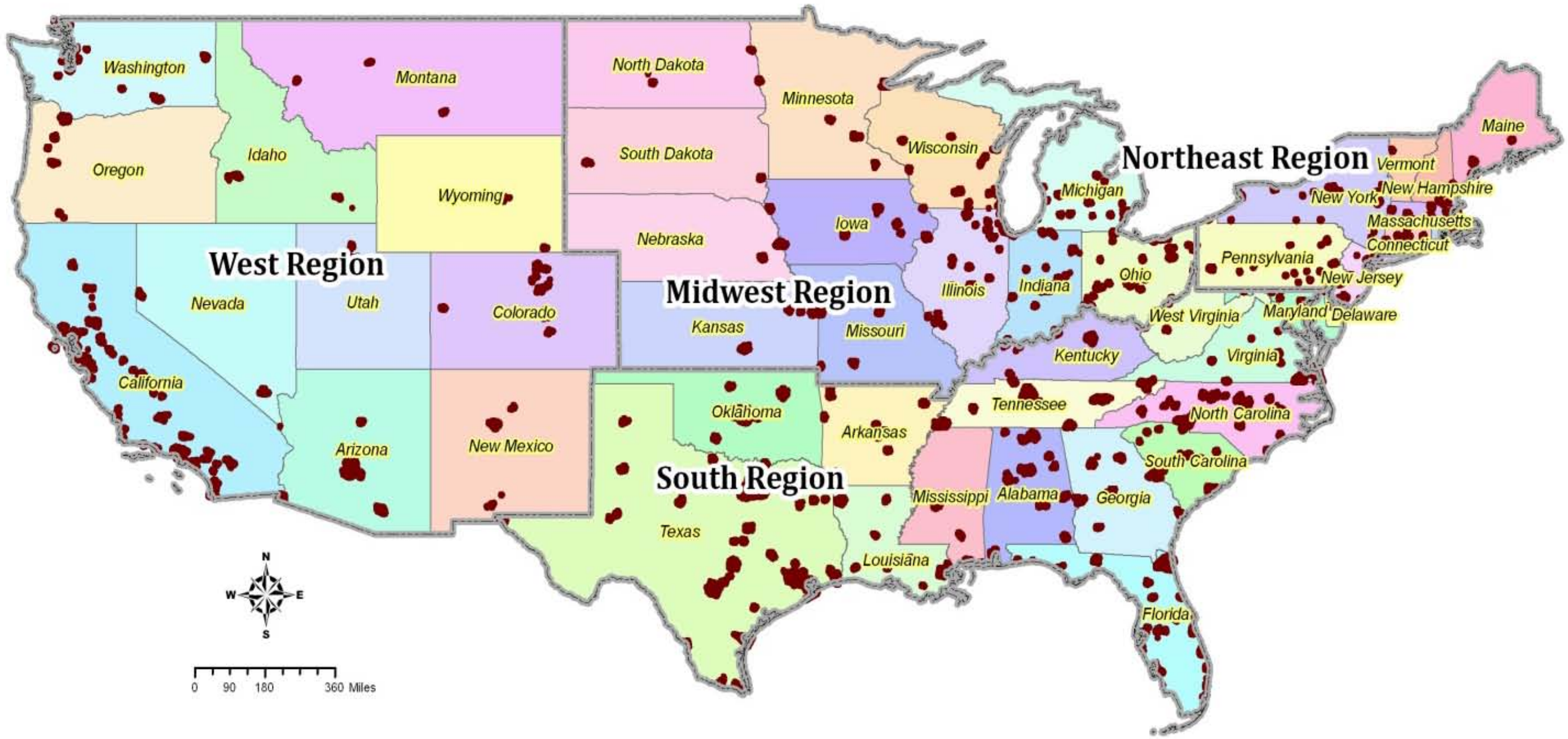


Figure 4.1. Central Cities in Contiguous United States

4.2 Phase –I: Exploratory Phase

The primary research focus of this exploratory phase was to measure the impact of local development plans on the dependent variables of emissions and estimated risk from climate change impacts.

4.2.1 Sample Selection

In the first analytical phase, all 541 central cities were included in the sample. However, 21 of the cities that were newly added in the census 2000 were excluded in this study as comparable data for the earlier census was not availble, resulting in the final sample size of 520. The U.S. Census Bureau segregates all central cities into the four census regions of Northeast, Midwest, South and West. Distribution of central cities included in the study within each of the census regions is shown in table 4.1

Table 4.1. Central Cities in Census Regions

Census Region	Total Central Cities
Northeast	87
Midwest	126
West	200
South	107
Total	520

Source: U.S Census 1990 & 2000

The total population in these central cities was 75,885,863 in 1990 and increased to 81,782,830 in 2000, showing a decadal growth rate of almost 8%. This is substantially lower than the decadal growth rate of 21.54% observed during the same period for the urban population in urbanized areas in the U.S (table 4.2).

Table 4.2. Comparison of Population Growth in Central Cities and U.S

Census Region	Inside urbanized Areas (1990)	Inside urbanized Areas (2000)
U.S urban population in urbanized areas (A)	158,258,878	192,323,824 (+21.54%)
Sample Frame (population in central cities) (B)	75,885,863	81,782,830 (+7.76%)
(B) as % age of (A)	47.95%	42.52%

Source: U.S Census 1990 & 2000

The data presented in table 4.2 shows that the sample-frame covers almost half the urban population in urbanized areas of the U.S.

4.2.2 Research Design

I used pre-test post-test non-equivalent groups quasi-experimental research design in the first phase of my study (figure 4.2). This approach is particularly useful for evaluation of public policy and community program interventions (Campbell, 1969; Shadish, Cook, & Campbell, 2002). In its simplest form, two comparable groups are identified from the sample frame; one where a program or policy was implemented and the other where it was not. Policy impact is measured by comparing the pre-program and post-program measures of variables of interest for each group. In this exploratory phase of the study, the primary goal was to determine if the development plans had any effect on emissions. Therefore, the data on emissions was collected for two time periods for each group of cities; one with local development plans and the other without.

	Dependent variables* before intervention	Intervention (Adoption of comprehensive Plans)	Dependent variables* after intervention
Central cities with comprehensive plans	O	X	O
Central cities without comprehensive plans	O		O
	1990		2005

Figure 4.2. Phase – I Research Design

4.2.3 Variable Measurements

This section describes in detail the measurement techniques used for each of the variables included in the first phase of the study.

4.2.3.1 Test Variable - Local Development Plans

Presence or absence of local development plans was measured as adoption or revision of the local development plan document between the years 1991 and 2000. The local development plan documents were found to be commonly known as comprehensive plans. Some communities used master plans or development plans as the primary local development regulatory vehicle. All local plans that identified components of land use management, circulation/ transportation, housing, economic development, and environmental management were counted in this study as local development plans. Some local development plans were organized as strategic policy documents that outlined goals and objectives with separate sectoral sub-plans with more detailed policies and actions. In such cases, if the referenced sectoral plans included land use management, circulation/ transportation, housing, economic development, and environmental management components, then all of these plans together were considered a local development plan. The test variable was measured as a dichotomous variable with presence designated as '1' and absence as '0'. Table 4.3 shows the distribution of the sampled communities with and without local development plans between 1990 and 2000.

Table 4.3. Distribution of Communities with/without Development Plans (1991-2000)

	Frequency	Percent
Communities without Development Plans	162	31.0
Communities with Development Plans	358	69.0
Total	520	100.0

Source: Primary survey

4.2.3.2 Contribution to Climate Change - Emissions

The Emission Database for Global Atmospheric Research (EDGAR) version 4 dataset (European Commission, 2009) is available at a resolution of 0.1 deg by 0.1 deg geo-grid cells. This dataset provides carbon dioxide emissions estimates for the years 1990 and 2005. The emission contribution for each community in the sample was estimated using this dataset. The geographic extent of each central city was overlaid on the geo-grids and annual emissions were attributed to each community using area-based proportional allocation in Geographic Information Systems (GIS). Only the total carbon dioxide emissions data for residential, commercial and transportation (road and non-road) uses was utilized to create this variable. Emissions for each year were converted to per-capita metric tons by dividing by the respective year's population data (estimated population for 2005) from the U.S census. Table 4.4 shows the estimated mean per-capita emission for 1990 and 2005 for the two groups of communities.

Table 4.4. Carbon dioxide Emissions in Central Cities[+] (1991, 2005)

		Per-capita Emissions* (1990)	Per-capita Emissions* (2005)	Net gain in per-capita Emissions (1990-2005)	Percent gain in per-capita Emission (1990-2005)
Central Cities without Comprehensive plans	Mean	3.65	4.48	.8277	26.59
	N	162	162	162	162
Central Cities with Comprehensive plans	Mean	4.07	4.33	.2823	14.66
	N	358	358	358	358
Sample Frame	Mean	3.94	4.38	.4522	18.38
	N	358	358	358	358
U.S. National Average		19	19.5	0.5	2.63

Source: European Commission 2009 for central cities & United Nation 2009 for national data
[+]Comparable data available for 520 central cities
*All emissions in Metric Tons of CO2/capita

4.2.4 Data Analysis

Two kinds of data analyses were used to determine the influence of local development plans in the first phase of this study. The first analysis was an independent samples t-test on the gain in estimated risk from 1990 to 2005. This is a straightforward comparison of mean change in the per-capita emissions from 1990 to 2005 for the two groups of central cities. Some methodologists recommend using ANCOVA analysis in place of t-test on gain scores as a way of exerting statistical control over the pre-existing difference amongst the two groups (Huck & McLean, 1975; Wildt & Ahtola, 1978). Therefore, the analysis of covariance (ANCOVA) was also undertaken, with 2005 per-capita emissions as the dependent variables, and the 1990 per-capita emissions as the covariate.

4.3 Phase –II: Explanatory Research

In the second phase of the research, I undertook detailed quality analysis of climate change management policies in development plans. I also examined the impact of these policies on the dependent variable while controlling for socio-economic, landscape, and policy characteristics.

4.3.1 Sample Selection

Out of the sample frame of all central cities in contiguous U.S, I used stratified proportional random sampling technique for selecting a sample of communities for detailed analysis in this phase of the study (Table 4.5). This sampling technique is particularly useful in similar situations where the distribution of communities among the census regions varies considerably (Cochran, 2009). Census regions as defined by the U.S census in 2001 were used as stratification zones to derive a proportional sample of 17% from each zone. A total of 88 central cities were identified for detailed analysis.

Table 4.5. Number of Communities Sampled for Phase- II

Census Region	Total Communities	Communities Sampled
Northeast	87	15
Midwest	126	21
West	200	34
South	107	18
Total	520	88

4.3.2 Research Design

In this phase of the study, I used a cross-sectional research design. In this type of research design, either the entire population or a subset thereof is selected, and from these individuals, data are collected to help answer research questions of interest (Babbie, 2007). It is called cross-sectional because the information about the dependent and the independent variable is gathered only at one point in time. In this phase of the study all independent variables are measured for the year 2000.

4.3.3 Variable Measurements

In this section, I describe detailed measurement techniques for each of the variables used in this phase of the research.

4.3.3.1 Dependent Variable – Change in Emissions (1990-2005)

Measurement the dependent variable, change in emissions from 1990 to 2005 is similar to the first phase of the study. Emissions for each of the years 1990 and 2005 were derived from the Emission Database for Global Atmospheric Research (EDGAR) version 4 dataset (European Commission 2009). Raw data was available at a resolution of 0.1 deg by 0.1 deg geo-grid cells. The geographic extent of each sampled city was overlaid on the geo-grids. Annual emissions were attributed to each community on the basis of proportional area allocation using Geographic Information Systems (GIS) software. Emissions data for residential, commercial and transportation (road and non-road) sectors was selected for creating this variable. Per-capita carbon dioxide emissions in metric tons were calculated by dividing the total emissions for each community by the total population estimates for the respective years. The change in emissions was measured as the difference between per-capita emissions in 2005 and 1990.

4.3.3.2 Climate Change Management Plan Quality Index

The quality of local development plans was assessed by evaluating the plan documents against the comprehensive protocol of desirable climate change management policies (Appendix I). The protocol identifies 46 planning policies that are expected to have a significant impact on local climate change management. Each policy was coded using a scale from 0-2. If the indicator was absent, a policy score of ‘0’ was assigned. A score of ‘1’ indicates that the policy was suggestive. Words such as ‘should’, ‘may’, ‘encourage’, ‘prefer’, ‘suggest’ indicated the suggestive nature of the policy. The mandatory policies were assigned a score of ‘2’. Such policies were usually indicated by use of words such as ‘mandated’, ‘shall’, ‘must’, and ‘will’. Some action-oriented mandatory policies also required identification of specific location for implementation to be given a score of ‘2’.

A raw policy score ($CCMC_{raw}$) was calculated as the overall average score estimated using the evaluation protocol:

$$CCMPQ_{raw} = \sum_{i=1}^{46} PP_{\mathrm{i}}$$

where,

$CCMPQ_{raw}$: Raw Climate Change Management Plan Quality Score
PP_i : Planning policy score.

In addition to the policy evaluation, the overall implementation potential of the plan was also assessed using the plan implementation capacity evaluation protocol consisting of ten implementation indicators (Annexurre- II). Absence of the implementation policy was coded as ‘0’. A score of ‘1’ was given if the policy was suggestive. The mandatory policies were assigned a score of ‘2.’ The overall implementation score was calculated as the ratio of the items found in the plan to the maximum possible implementation policy score for any plan (20 points). The maximum possible implementation score for any developmental plan was 1:

$$IC = IP/20$$

where,

IC: Implementation Capacity Score
IP: Implementation Policy Score

The climate change management plan quality index for each of the local development plans was calculated by weighing the raw policy score by the implementation capacity score.

$$\mathrm{CCMPQI} = CCMPQ_{raw} \times IC$$

where,

CCMCI : Climate Change Management Capacity Index
$CCMC_{raw}$: Raw Climate Change Management Plan Quality Score
IC : Implementation Capacity Score

4.3.3.3 Socio-economic Characteristics

Amongst the various socio-economic characteristics, per-capita income was used as the indicator of community wealth. Per-capita income for each sampled community was derived from the U.S census records. The next socio-economic variable, carbon employment was measured as the percentage of civilian workers above 16 yrs of age, working in the carbon based sectors. The carbon based sectors include agriculture, forestry, mining, construction, manufacturing, transportation, warehousing, and utilities. Non-profit employment was measured as the percentage of civilian workers above 16 years of age employed in non-profit organizations. Travel behavior was measured as percentage of civilian workers 16+ years of age travelling alone to work in a private vehicle.

4.3.3.4 Bio-physical Characteristics

Indicators for bio-physical landscape characteristics included measurements of sprawl, and proximity to coast. Sprawl was measured as ratio of land area in the community to the total population in 2000. Proximity to coast was measured by a dichotomous variable with presence in a coastal county indicated by ‘1’ and non-coastal county by ‘0’.

4.3.3.5 Policy Influence

In order to control for the difference in duration for which the plan had been in effect, plan years was measured as the number of years the local development plan had been in effect prior to 2005. The year the development plan was adopted was taken as the first year. Influence of state mandate was measured as a dichotomous variable. Presence of state mandate for local development plans was signified by ‘1’ and its absence was denoted by ‘0’.

Table 4.6 summarizes all the variables, variable definitions and their expected impact on the dependent variables.

Table 4.6. Variables, Definitions, and Expected Impact

Variable	Variable Definitions	Data Source	Influence on DV
Dependent Variables			
Emissions (DV1)	Per-capita Emissions in residential and transportation sectors (2005)	- Emission Database for Global Atmospheric Research (EDGAR) ver. 4 - U.S. Census Bureau, Population Division (2005 estimates)	
Estimated risk (DV2)	Estimate risk from climate change impacts (2005)	- Community Climate System Model Project NCAR-CCSM3 ensemble average for the IPCC Commit experiment - Spatial Hazard Events and Losses Database for the U.S 1991-2005 (ver. 7) - U.S. Census Bureau, Population Division (2000, and 2005 estimates	
Independent Variables			
Climate Change Management Plan Quality Index	Quality score of desirable climate change management policies in the local development plans	- Primary data collection using plan quality evaluation protocol	DV1 (-) DV2 (-)
Socio-economic			
Income	Per-capita income	- U.S Census 2000	DV1 (+) DV2 (+)
Work travel	Community work travel characteristics measured as percentage of civilian workers 16+ yrs of age, not working at home, travelling alone by private vehicle to work	- U.S Census 2000	DV1 (+) DV2 (N.A)

Table 4.6. Continued

Variable	Variable Definitions	Data Source	Influence on DV
Carbon employment	Percentage of civilian workers 16+ yrs of age working in carbon dependent industries	- U.S Census 2000	DV1 (+) DV2 (N.A)
Non-profit employment	Percentage of civilian workers 16+ yrs of age working in non-profit organizations	- U.S Census 2000	DV1 (-) DV2 (-)
Biophysical Characteristics			
Sprawl	Land area (in sqm.) per person	- U.S Census 2000	DV1 (+) DV2 (+)
Coastal proximity	Presence/ absence in a coastal watershed	- National Oceanic and Atmospheric Administration (1999)	DV1 (+) DV2 (N.A)
Policy Influence			
State mandate	Presence or absence of state mandate for local development plans	- Primary data collection	DV1 (-) DV2 (-)
Plan years	Number of years the local development plan has been in effect prior to 2005	- Primary data collection	DV1 (-) DV2 (-)

4.3.4 Data Analysis

As a first step in the second phase of the study, I used correlation analysis to ascertain the statistical relationship between the dependent and the independent variables. This procedure also allowed me to check for possible problems of multi-collinearity between the independent variables. Thereafter, I used ordinary least square (OLS) based multivariate regression analysis to test the specific hypotheses outlined in the earlier sections. In this analysis, the impact of plan quality on the dependent variable was measured while controlling for the impact of identified measures of socio-economic, bio-physical, and policy influence characteristics.

The following equation represents the regression model for the dependent variable, change in emissions (1990-2005). The coefficients $\beta_1, \beta_2, \beta_3$ and β_4 represent unique effects of the specific independent variables on the dependent variable.

$$DV1 = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \varepsilon$$

where,

DV1: Dependent variable – Change in per-capita carbon emissions (1990-2005)
α : Regression intercept
β_i : Partial Regression coefficients
X_1: Climate Change Management Plan Quality Index
X_2: Income
X_3: Work Travel Alone
X_4: Non-profit Employment
X_5: Carbon Employment
X_6: Sprawl
X_7: Coastal proximity
X_8: State mandate
X_9: Plan years
ε: error term

The regression model assesses unique influence of each independent variable on the dependent variable. This approach also permits a relative comparison of effect among the variables. To check the statistical significance of the model, (i. e., if the model accounted for a significant proportion of the variance) F-statistics were analyzed. Post –regression specification tests of normality, multicollinearity, independence and model specifications were carried out to ensure that there were no violations of the OLS regression assumptions. Spatial autocorrelation was not considered as the sample communities are not neighboring and were randomly sampled. This study analyzed both the unstandardized coefficients and standardized coefficients (Beta). The standardized coefficients are used to compare the explanatory power (relative importance) among the different independent variables.

4.4 Validity and Reliability Issues

Every research design contains inherent threats to its validity and reliability. Although every effort is made to eliminate these threats, rarely can it be achieved. Validity refers to the accuracy of the measurement in a manner that reflects the underpinning theoretical concepts appropriately. Reliability refers to the consistency or stability of the measurement.

4.4.1 Threats to Validity

Although a number of authors discuss various validity threats, I am limiting my concern to the ones mentioned in Cook and Campbell (1979). They identify four types of validity threats: statistical conclusion validity; internal validity; construct validity; and, external validity.

Statistical Conclusion Validity: This refers to the degree to which the researcher's analysis permits a correct decision regarding the truth or the approximate truth of the null hypothesis. Amongst the various threats, low statistical power, and violated assumptions of statistical tests are the possible threats to this research. In Phase I, a sample size of 520 is sufficiently large to provide adequate statistical power. In Phase II, where a stratified proportional random sample is drawn, the number of observations reduces to 88. This may be interpreted as low statistical power. However, as I have used a high sampling ratio of 17% and employed stratified proportionate random sampling technique, the threat to statistical conclusion validity is greatly minimized.

In Phase II, relatively influential data or outliers may also bias the final results. Therefore, each variable's significance and possible influential observations in the regression models are analyzed. In order to avoid any violation of assumptions for the statistical tests, care was taken to ensure appropriate distribution(s) and consistency with assumptions for the respective statistical tests. Post-test diagnostics were used to confirm the validity of regression analyses.

Internal Validity: This refers to approximate validity with which the researcher can infer a causal relationship between two variables or can infer the absence of cause in the absence of a relationship . The primary threat to internal validity in this research was that not all related variables influencing the dependent variable could be included in the statistical model. Also the independent variables probably are influenced by other regional and global ecological attributes which were not been considered in this research. In phase I of the study, in order to control for the initial differences between the two groups of communities, a covariate was included in the analysis of covariance (ANCOVA).

In Phase-II, additional socio-economic, bio-physical and policy context variables were included in the regression models to control for contextual influences. The independent variable of climate change management plan quality index is itself a complex construct influenced possibly by other independent variables. Therefore, an analysis of inter-item correlations in the independent variables was undertaken before regression modeling to identify any issues of multi-collinearity.

The history effect on the dependent variables also cannot be ruled out. However, in order to account for the historical differences, the dependent variable in phase-I was estimated as a measure of gain (in t-test) and the baseline measures of 1990 were included as covariates in ANCOVA statistical analysis. Use of change variable (1990 to 2005) in the phase –II of the study is also expected to control some of the history effect.

Another threat to the validity of this study is the time effect. Not all plans are made at the same time and thus the period of implementation is expected to have an impact on the final dependent variables. This remains a threat in the first phase of the study, but in the second phase, a time period variable of plan years was introduced into the regression model to moderate this threat.

Construct Validity: This refers to the degree of legitimacy of the inferences that can be made from the measures included in the research to the theoretical constructs on which they were based. This threat includes two components. First, theoretical relationships need to be appropriately defined based on the literature. Secondly, the measurement instrument of the concept should correspond accurately to what is desired to be measured.

The threat to construct validity on the dependent variable of emissions is due to the limitations in measuring community level carbon emissions. EDGAR dataset used in creating the measure is based on global estimations coupled with reported data from each country. The emissions attributed to each community thus may include influences of extraneous developments, and reporting bias.

The construct validity of the plan quality protocol depends on how well the protocol reflects the actual quality of the plan and the accuracy of the coders in grading the plan documents. Creation of a detailed coding protocol has helped maintain the accuracy in coding. The evaluation protocol and coding guidelines were pre-tested before actually applying to the sampled plan documents. Thus the threats to construct validity of this study are greatly reduced.

External Validity: This is related to the degree to which the outcomes of this research can be generalized to other settings. Variation is landscape, socio-economic characteristics and policy context can be threats to external validity when extending the outcomes of this study. Specifically with reference to the central cities in the U.S the research outcomes of this study are more readily applicable. When extending the results to smaller cities, impact of size and economic functions will have to be considered. Another aspect of external validity threat arises from possible weakness in implementation mechanisms of local development plans. A good plan quality may necessarily not translate into urban development as envisioned in the plan. By using an additional plan implementation quality protocol this threat to the study has been moderated.

4.4.2 Reliability Issues

Reliability is the consistency or stability of the measurement of a variable when the measurement is performed in the same manner. In this study, reliability is specifically associated with plan quality evaluation. To increase reliability, the plan coding and coding guideline was pretested. Pretesting and revision was done several times to ensure consistency before it was applied to the actual evaluation. The detailed coding guidelines for policy evaluation helped maintain reliability and prevent confusion.

5. PHASE I: DETERMINING THE INFLUENCE OF LOCAL DEVELOPMENT PLANS

The results of the exploratory analysis are presented in this section. First, the dependent variables are described, followed by the results of the statistical analysis.

5.1 Contribution to Climate Change - Emissions

Mean gain in per-capita emissions from 1990 to 2005 for the sampled communities with and without local development plans are provided in Table 5.1. Both groups of communities show an increasing trend in per-capita emissions between 1990 and 2005. However, communities with local development plans show a lower mean gain in per-capita emissions from 1990 to 2005 in comparison to the communities without the development plans. Mean gain in per-capita emissions in the communities with local development plans is less than 50% of the gain seen in communities without local development plans.

Table 5.1. Mean Gain in Per-capita Emissions 1990-2005

	N	Mean	Std. Deviation	95% Confidence Intervals	
				Lower	Upper
Communities with local development plans	358	0.28	1.73	0.10	0.46
Communities without local development plans	162	0.82	1.79	0.55	1.10

In order to test the statistical significance of this difference, an independent sample t-test analysis of gain in per-capita emissions from 1990 to 2005 was conducted. Results of the t-test between the two groups of communities reveals statistically significant differences in gain in per-capita emissions (table 5.2).

Table 5.2. T-tests Comparing Communities with Local Development Plans Versus Communities without Plans on Gain in Per-capita Emissions 1990-2005

Variable	t*	df	Sig. (1-tailed)	Mean Difference	Std. Error Difference
Gain in per capita emissions 1990-2005	- 3.291	518	0.001	- 0.54	0.16

Notes: *Equal variances assumed

Results of the t-test indicate that communities with local development plans had significantly lower gain in emissions between 1990 and 2005 in comparison to the communities without the plans. On average, this difference is estimated to be 0.54 metric tons of CO2 per-capita. These results support hypothesis 1 according to which communities with comprehensive local development plans were expected to show reduced carbon emissions.

However, this analysis does not account for the initial differences in emissions between the two groups of communities. In order to control for the pre-existing difference between the groups, a one-way analysis of covariance (ANCOVA) was also conducted with per-capita emissions in 2005 as the dependent variable. The effect of local development plans was compared while controlling for pre-existing differences by inclusion of per-capita emissions in 1990 as a covariate in the statistical model. The assumptions for ANCOVA were met. In particular, homogeneity of the regression effect for the covariate, and the linear relationship between the covariate and the dependent variable, were confirmed. The ANCOVA model is significant, where F (2, 510)=4013.905, p<0.01. Mean per-capita emissions in 2005 are significantly different between the two groups of communities while keeping the per-capita emissions in 1990 constant (Table 5.3).

Table 5.3. Adjusted Mean Per-capita Emissions 1990-2005

	Communities with Plans	Communities without Plans
Mean	0.392	0.919
Std. Error	0.051	0.076
Mean Difference (1-0)	-0.527*	
Std. Error Difference	0.092	

Notes: *$p<0.01$

Communities with local development plans show lower mean per-capita emissions by 0.527 metric tons, while controlling for the baseline per-capita emissions in 1990. The adjusted mean per-capita emissions for communities without local plans were 0.919 metric tons of CO_2 in comparison to only 0.392 metric tons of CO_2 for communities with local development plans.

5.2 Summary of Results

Thus, results from both statistical analyses provide support for hypothesis 1. The results confirm that communities with local development plans had a lower gain in per-capita emissions as compared to the communities without it. This can probably a result of sustainable development and land use management policies commonly found in most local development plans. Previous studies suggest that most comprehensive local development plans include sustainable growth and development policies, such as high density residential areas, mixed uses, and accessibility planning policies (see Berke & Conroy, 2000; Boschmann & Kwan, 2008; Tang & Brody, 2009; Wheeler, 2004). Literature review in section 2 reveled that these policies also result in secondary effect of reducing overall carbon dioxide emissions of a community. Therefore, the results of the preceding statistical analyses are indicative of the mitigation benefits of sustainable development policies.

6. CLIMATE CHANGE MANAGEMENT PLAN QUALITY

This section presents the results of climate change management plan quality evaluation. In addition to analyzing the overall plan quality, descriptive analysis of the specific policy quality scores was also carried out. Eighty-eight local development plans were selected for detailed analysis in this phase of research. The selection was based on the stratified proportional sampling from all the central cities in contiguous U.S.. To satisfy the conditions of the statistical model, only comprehensive plans adopted or amended between 1990 and 2000 were included in the sample frame. The first sub-section presents the general assessment of planning policies. Thereafter, specific policies within each policy component are examined in detail. The second sub-section evaluates plan implementation capacity by analyzing the implementation policies contained in the local development plans. The next sub-section presents the estimated climate change management plan quality index and analyzes its distribution in the sample. In the final sub-section, all results of preceding plan quality evaluation analyses are briefly summarized.

6.1 Climate Change Management Policies in Urban Development Plans

Most development plans are usually organized into two sections. The first section includes baseline data and trend analysis that provides the planning rationale and lays down the foundation for developing plan proposals. The second section in the local development plans describes the vision, planning goals, objectives and policies. Some of the plans organized planning policies and proposals into separate action plans for specific thematic areas such as transportation, economic development and housing. In evaluating these plans, planning policies contained in the main document as well as any accompanying secondary document referenced by the main plan document were considered.

As expected none of the sampled local development plans included climate change management as a planning goal or included any policy section specifically focusing on the topic. Therefore, the climate change management plan quality evaluation protocol used in this analysis includes a list of common planning policies that can potentially impact climate change mitigation. Planning policies included in the plan evaluation protocol were segregated into the following 10 categories:

i. Land use and zoning
ii. Urban design and built form
iii. Site planning
iv. Building design
v. Transportation
vi. Public facilities and infrastructure
vii. Natural resource management
viii. Acquisition tools
ix. Incentive/ disincentive tools, and
x. Awareness, educational and technology policies.

6.1.1 Raw Climate Change Management Plan Quality Assessment

Table 6.1 presents descriptive statistics for the overall raw climate change policy scores. The number of policies considered in each component of the evaluation protocol ranged from 3 to 7. Two components, site planning tools and incentive/disincentive tools included 3 planning policies each. The natural resource management component included the maximum of 7 planning policies. Each policy had a possible maximum score of 2, resulting in the maximum possible component score of 14 for natural resource management. The mean policy score for each component is a measure of the overall policy details contained in the plan for all the policies included in the planning component. The mean total raw climate change management policy score for a plan is an overall measure of the quality of all policies as evaluated using the plan evaluation protocol. The maximum possible total raw climate change management policy score for any plan was 92. This could be achieved by receiving a maximum score of 2 for each of the 46 planning policies included in the plan evaluation protocol.

Table 6.1. Raw Climate Change Management Plan Quality Scores

Component	Number of Polices	Mean score (%)	Min. score	Max. score	Standard deviation	Possible max. Score (%)
Land use and zoning	5	5.92 (59.20%)	2	9	2.07	10 (100%)
Urban design and built form	4	3.94 (49.29%)	0	7	1.51	8 (100%)
Site planning	3	4.57 (76.14%)	2	6	0.94	6 (100%)
Building design	6	5.25 (43.75%)	1	9	2.06	12 (100%)
Transportation	5	7.02 (70.23%)	2	10	1.72	10 (100%)
Public facilities and infrastructure	4	5.24 (65.48%)	2	17	1.86	8 (100%)
Natural resource management	7	8.17 (58.36%)	3	13	1.61	14 (100%)
Acquisition tools	4	4.60 (57.53%)	1	8	1.88	8 (100%)
Incentive/ disincentive tools	3	3.16 (52.65%)	1	6	1.41	6 (100%)
Awareness, educational and technology (AET) tools	5	6.72 (67.16%)	1	17	2.18	10 (100%)
Total Policy Quality	46	54.59 (59.34%)	22	85	12.69	92 (100%)

The results show that every plan included at least one climate change management planning policy within every planning component except for the component of urban design and built form. The minimum score of 0 in this component indicates that at least one of the plans did not address any of the 4 planning policies included in the urban design and built form component. The mean total raw climate change management policy score for all the sampled plans was 54.59 points. This represents only 60% of the maximum possible score. The mean scores ranged from 22 to 85 with a standard deviation of 12.69 indicating large variability in the sample. This suggests that the nature of policies and the associated details addressed in local development plans vary a great deal within the sampled communities.

Among the various components, site planning policies had the highest mean score as a percentage (76.14%) of the maximum possible component score. This indicates that the sampled communities have made relatively stronger efforts in addressing site planning policies in their development plans. Smaller standard deviation of 0.94 also suggests a greater level of consistency among the local development plans in addressing planning policies included in this component. Comparatively, the mean score for building design policy component was only 44.50% of the maximum possible, indicating lack of attention to these policies in the local development plans. Most of the policy components showed mean scores around 60% of the respective maximum possible scores. This suggests fair coverage and quality of climate change management related planning policies in the local development plans.

Histograms of each of the policy component scores show the shape of the distribution and provide information on mean component score characteristics. The histogram of the total raw policy scores shows roughly a bell-shaped distribution with a minimum score of 22 points and maximum of 85 points (Figure 6.1). Most plans received total raw plan quality scores between 50 and 60 points. There seems to be a slight negative skew to the distribution suggesting that most communities received higher scores. Histograms for each of the policy components are included in appendix III.

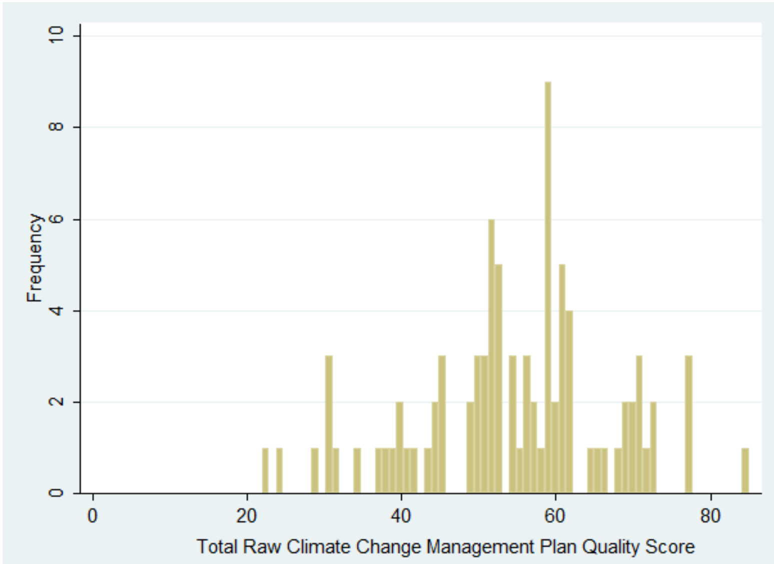


Figure 6.1. Histogram of Raw Climate Change Management Plan Quality Score

6.1.2 Detailed Policy Analysis

Each of the policies within the ten components of plan quality evaluation was further analyzed using descriptive statistics. First, relative policy preference was measured across the local development plans by determining the percentage of plans that addressed the policy. Next, the variation in the quality of the planning policy across the plans that address it was measured as the mean policy quality score. Finally, the overall policy performance score is measured as the mean of all policy quality scores for all the sampled plans (88). This score thus provides a measure of policy coverage as well as policy quality across the sample.

Table 6.2 provides the detailed summary statistics of the five policies included in the land use and zoning component. Each policy was coded 0-2, with ‘0’ signifying absence of policy and ‘2’ indicating sufficiently detailed policy. ‘1’ signifying mere inclusion of the policy without details.

Table 6.2. Land Use and Zoning Policies

Planning Policy	Policy Coverage Assessment			Policy Quality Assessment					Overall Policy Performance Score
	Policy Addressed		Relative Policy Coverage (%)	No Details		Detailed		Mean Score	
	No	Yes (a)		N	% of (a)	N	% of (a)		
Mixed use development	1	87	98.86	18	20.69	69	79.31	1.79	1.77
Brownfield / grey field redevelopment	27	61	69.32	51	83.61	10	16.39	1.16	0.81
Infill development	32	56	63.64	31	55.36	25	44.64	1.45	0.92
Limit use using Overlay zones or reduced density zones	2	86	97.73	49	56.98	37	43.02	1.43	1.40
Promote relocation of vulnerable structures out of hazard zones	19	69	78.41	48	69.57	21	30.43	1.30	1.02

Promotion of mixed use development and limiting use of hazardous areas and marginal zones through overlay zones or reduced densities is addressed in most of the sampled plans. They show a relative policy coverage of 98.86% and 97.73% respectively. Mixed use development policy with an overall mean quality score of 1.8 points is the most detailed policy in the plans addressing it. Most of the communities addressing this policy (79.31%) also invested resources to develop it in detail. Brownfield development policies are absent in 27 plans (30.68%). Only 10 plans (16.39%) addressing this policy provided sufficient details. An overall mean quality score of 1.16 points indicates that most of the communities that included this policy addressed it without much details. Of all the plans evaluated, 32 (36.36%) plans did not contain any planning policy or proposal that addressed infill development. This is an important land use tool commonly used for enhancing the sustainability of a community. It also has the potential to be effective in climate change management by increasing the density in the developed areas preventing further horizontal expansion of the city. Among the plans that addressed this policy, almost half included details (44.64%). The mean policy quality score of 1.45 points for this planning policy indicates that even though some plans did provide details, there were almost an equal number that addressed this policy without any details. Except for 2 (2.27%) of the 88 plans analyzed, all plans included planning policies addressing overlay zones or reduced densities. However, 49 of these plans (56.98%) did not provide sufficient details. Sixty-nine plans (78.41%) included planning polices to relocate structured out of hazard zones. But, only 21 (30.43%) of them provided sufficient details in regard this policy. The mean policy quality scores below 1.5 for most of the land use and zoning policies, suggests that even though majority of the plans did address these policies, they were not sufficiently detailed.

The overall policy performance score of 1.77 points for mixed development captures its high policy coverage and mean quality score. It seems to be the most addressed and the best detailed policy in this component. Even though policies promoting infill development had a high mean quality score, it received a low overall policy performance score due to low relative coverage among the plans. Four of the five policies in this component received overall policy performance scores below 1.75 points. This indicates low relative policy coverage as well as lack of details in most of these policies. Communities will need to invest more resources to develop these policies so as to be able to derive the best potential benefits.

With respect to the urban design component, the plan evaluation protocol included four planning policies. Detailed summary statistics for the planning policies included in this component are provided in table 6.3.

Table 6.3. Urban Design Policies

Planning Policy	Policy Coverage Assessment			Policy Quality Assessment					Overall Policy Performance Score
	Policy Addressed		Relative Policy Coverage (%)	No Details		Detailed		Mean Score	
	No	Yes (a)		N	% of (a)	N	% of (a)		
High density development	2	86	97.73	27	31.40	59	68.60	1.69	1.65
Promote Low-water intensive urban landscape	26	62	70.45	52	83.87	10	16.13	1.16	0.82
Building height/ orientation guidelines, street width to building height ratios	23	56	73.86	31	45.00	25	20.00	1.45	0.92
Proposals/actions for urban forests, tree lined streets, urban green spaces	43	45	51.14	45	100.0	0	0.00	1.00	0.51

Planning policies to promote high density development were found in almost all the plans (97.73%), with only 2 plans not addressing it. It also had the best mean quality score of 1.69 points, indicating that most plans paid attention to details in regards to high density development in their communities. Urban forestry and road side greening proposals were least addressed in the sampled communities. Most of the plans (48.86%) did not address these policies at all. Among those that addressed this policy none provided any details. Planning policies to create low-water intensive urban landscape were included in 62 (70.45%) of the local development plans. Of these, only 10 (16.13%) provided sufficient details. Planning policies with respect to building height, orientation or street width to building ratios were addressed in 56 (73.86%) plans. Only

25 (20%) of these plans, addressed this policy in detail. With most planning policies scoring low mean quality scores, it seems that communities need to commit more resources into developing these planning policies. At the same time high density development seems to be sufficiently detailed and popular with most communities. The mean quality score of 1.69 points, indicates that the sampled development plans laid a strong foundation for achieving higher densities during the plan period. This was expected due to the increased focus on sustainability among the local development plans during the 1990s.

High density development had the highest overall policy performance score of 1.6 points indicating good policy coverage and mean quality. All other urban design policies received overall policy performance scores below 1 point. Planning policies of urban forests, tree lined streets and urban green open spaces had the lowest overall policy performance score of 0.51 points, with a low relative policy coverage of 51.14% and mean quality score of only 1 point.

The site planning component of the plan evaluation protocol included three site planning policies. Table 6.4 summarizes the plan evaluation results for this component.

Table 6.4. Site Planning Policies

Planning Policy	Policy Coverage Assessment			Policy Quality Assessment					Overall Policy Performance Score
	Policy Addressed		Relative Policy Coverage (%)	No Details		Detailed		Mean Score	
	No	Yes (a)		N	% of (a)	N	% of (a)		
Site plan review requiring land suitability assessment/ Special study/impact assessment	0	88	100.00	23	26.14	65	73.86	1.74	1.74
Setbacks/ Buffers	4	84	95.45	60	71.43	24	28.57	1.29	1.23
Subdivision regulations	1	87	98.86	33	37.93	54	62.07	1.62	1.60

All development plans included provisions for site plan review requiring land suitability assessment or special study or impact assessments for new projects. Of these, 65 communities (73.86%) included sufficient details in the development plans. Policies for ensuring adequate setbacks and buffer for new development were also found in most of the plans (95.45%). But, only 24 (28.57%) of communities that addressed this policy provided sufficient details. Subdivision regulations were also common to most plans except for 1 plan (1.14%). Most of these plans (62.07%) that addressed subdivision regulations included sufficient details. Some plans that addressed this policy referenced sub-division regulations detailed out in another document, often prepared by a different local or county agency. This is probably because in some jurisdictions, sub-division regulations are prepared by the county planning authorities. Inclusion of planning directive in the local development plan that mandates consideration of these principles made them mandatory for all new development.

High overall policy performance scores for two of the three planning policies considered in this component indicates good policy coverage as well as mean quality of site planning policies in the local development plans. Setbacks/ buffer received high relative policy score of 95.45% but a low overall policy performance score of 1.23 points. This indicates lack of attention to details regarding this policy in the development plans.

Plan quality evaluation protocol focused on six specific policies within the building design component. These are summarized in table 6.5.

Table 6.5. Building Design Policies

Planning Policy	Policy Coverage Assessment			Policy Quality Assessment					Overall Policy Performance Score
	Policy Addressed		Relative Policy Coverage (%)	No Details		Detailed		Mean Score	
	No	Yes (a)		N	% of (a)	N	% of (a)		
Storage/ collection/ recycling of waste	4	84	95.45	23	27.38	61	72.62	1.73	1.65
Water-efficient construction	39	49	55.68	44	89.80	5	10.20	1.10	0.61
Recycling of grey-water	36	52	59.09	41	78.85	11	21.15	1.21	0.72
Rainwater harvesting	63	25	28.41	25	100.0	0	0.00	1.00	0.28
On-site water treatment	31	57	64.77	57	100.0	0	0.00	1.00	0.65
Building standards/Building code for enhanced protection from natural hazards	6	82	93.18	46	56.10	36	43.90	1.44	1.34

Among the various policies evaluated within this component, storage, collection and recycling of wastes was the most commonly addressed policy in the local development plans. This policy received a relative policy coverage score of 95.45%. Sixty one (72.62%) of the plans addressing this policy mandated storage, collection or recycling of solid waste and provided sufficient policy details. Building codes for enhanced protection from natural hazards such as tropical storms, tornadoes and flooding also figured in most of the plans (93.18%). Thirty six (43.90%) of these plans mandated adherence to these codes in the risk zones as identified by the plans. In some of these plans reference was made to building codes created as a separate document. A few of them mandated the referenced building code but mostly left it is as a suggested planning action. Recycling of wastewaters and on-site water treatment were also found in majority of the plans. All plans that included on-site water treatment policies did not include them as a mandatory requirement or provide sufficient details. Out of the 49 (55.68%) plans that addressed water-efficient construction, only 5 (10.20%) included it as a mandatory requirement for specific types of buildings. Some of these also provided details in terms of options and ways to realize water conservation during construction or referred to separate manuals that included these details. Rainwater harvesting was not addressed in most of the plans (71.59%). All plans that addressed this policy limited it to a suggestive guideline without much details.

Low overall policy performance scores for four out the six policies considered in this planning component suggests lack of policy coverage and low quality of detailing of this component in the development plans. Rainwater harvesting with the lowest relative policy performance score of 0.28 points also had the lowest relative policy coverage of 28.41% and mean quality score of 1 point. On-site water treatment had a relatively better coverage policy coverage of 64.77% but a low overall policy performance scores of 0.65 points due to low mean quality of 1 point. Highest overall policy performance score in this component was 1.65 points for storage, collection, and recycling of wastes.

Transportation component of the local development plans was evaluated with respect to five specific planning policies. Evaluation results of these polices are summarized in table 6.6.

Table 6.6. Transportation Policies

Planning Policy	Policy Coverage Assessment			Policy Quality Assessment					Overall Policy Performance Score
	Policy Addressed		Relative Policy Coverage (%)	No Details		Detailed		Mean Score	
	No	Yes (a)		N	% of (a)	N	% of (a)		
Creating/ implementing/ enhancing public transportation systems	0	88	100.00	19	21.59	69	78.41	1.78	1.78
Increased public transportation stops/nodes	4	84	95.45	37	44.05	47	55.95	1.56	1.49
Management of no traffic zones	6	82	93.18	56	68.29	26	31.71	1.32	1.23
Creation/ upgrading of bicycle paths	5	83	94.32	51	61.45	32	38.55	1.39	1.31
Creation/ upgrading of pedestrian facilities	5	83	94.32	59	71.08	24	28.92	1.29	1.22

All plans included policies related to enhancing local public transportation systems. Out of these, 69 (78.41%) plans also included specific public transportation related projects and interventions. Increased public transportation nodes received a relative policy coverage score of 95.45%. This indicates that the policy was addressed in most of the plans . Of these 47 (55.95%) plans included sufficiently detailed policies. Traffic zone management was addressed in 82 (93,18%) plans, but only 26 (31.71%) of them included sufficient details. Planning policies related to bicycle paths and pedestrian facilities were addressed in 83 (94.32%) plans. Only 32 (38.55%) plans addressing planning policies related to bicycle path also included sufficient details. Among the plans addressing pedestrian facilities, only 24 (28.92%) included sufficient details .

Enhancing public transportation system received the highest overall policy performance score of 1.78 points. This policy also had the highest relative policy coverage and the highest mean quality score. Creating/ upgrading of pedestrian facilities received a high relative policy score of 94.32% but a low overall policy performance score of 1.22 points indicating lack of policy details in plans addressing this policy. Most of the policies in this component received overall policy performance scores between 1.25 and 1.5 points, with high relative policy coverage. This suggests inclusion of these policies in most plans with some not providing adequate details. These scores reflect the underlying focus of sustainable development in majority of the development plans. Sustainable development advocates emphasize attention to public transportation system as an important constituent of good planning. It seems most communities have addressed this issue in sufficient detail.

Evaluation of the natural resource management component of the plans addressed seven planning policies. Table 6.7 provides the summary results of the policy evaluation.

Table 6.7. Natural Resource Management Policies

Planning Policy	Policy Coverage Assessment			Policy Quality Assessment					Overall Policy Performance Score
	Policy Addressed		Relative Policy Coverage (%)	No Details		Detailed		Mean Score	
	No	Yes (a)		N	% of (a)	N	% of (a)		
Natural Hazard Management guidelines for Emergencies and Disasters	1	87	98.86	9	10.34	78	89.66	1.90	1.88
Environmentally sensitive area protection (national/state parks, coastal barriers, breeding areas)	0	88	100.00	37	42.05	51	57.95	1.58	1.58
Conservation of forests, vegetation, and riparian areas	0	88	100.00	30	34.09	58	65.91	1.66	1.66
Preventing habitat fragmentation	50	38	43.18	37	97.37	1	2.63	1.03	0.44
Sediment and erosion control regulation	15	73	82.95	68	93.15	5	6.85	1.07	0.89
Stream dumping/ prevention regulations	19	69	78.41	43	62.32	26	37.68	1.38	1.08
Wetlands restoration regulations	37	51	57.95	45	88.24	6	11.76	1.12	0.65

Analysis of the natural resource management guidelines reveals that planning policies related to environmentally sensitive area protection, conservation of forests, vegetation, and riparian areas, and general emergency/ disaster/hazard management guidelines were addressed in most of the local development plans. Of the 87 plans that addresses general hazard management guidelines, 78 (89.66%) included sufficiently detailed action policies. All plans addressed policies related to environmentally sensitive area protection, and conservation of forests, vegetation, and riparian areas. Of these, 51 (57.95%) included sufficiently detailed environmentally sensitive area related planning policies. Policies related to conservation of forests were included with sufficient details in 58 (65.91%) plans. Prevention of habitat fragmentation was not addressed in most of the plan (56.82%). Among those that addressed these planning policies, only 1 (2.63%) included sufficient details. A number of plans also addressed sediment and erosion control regulations (82.95%), and stream dumping regulations (78.41%). Among the plans that addressed sediment and erosion control, only 5 (6.85%) included related policies in sufficient details.

Three of the seven policies included in this component received high overall policy performance scores above 1.5 points. Natural hazard management guidelines received the highest overall policy performance scores of 1.88, due to high policy coverage accompanied with a high mean quality score. Habitat fragmentation received the lowest overall policy performance score as a result of the lowest relative policy score of 43.18% and also the lowest mean quality score of 1.03 points. Low overall policy performance scores of habitat fragmentation, sedimentation and erosion control regulations, and wetland restoration regulations indicate lack of attention to specific environmental management activities. Communities seem to be more focused towards managing natural hazard threats and traditional activities such as forest conservation.

The next component of plan evaluation included policies related to physical infrastructure and facilities. Four specific planning policies were evaluated within this component. Table 6.8 summarizes the results of plan evaluation within component.

Table 6.8. Policies Related to Physical Infrastructure and Facilities

Planning Policy	Policy Coverage Assessment			Policy Quality Assessment					Overall Policy Performance Score
	Policy Addressed		Relative Policy Coverage (%)	No Details		Detailed		Mean Score	
	No	Yes (a)		N	% of (a)	N	% of (a)		
Structural tools for controlling hazard losses (dams, dykes, flood gates etc)	0	88	100.00	23	26.14	65	73.86	1.74	1.74
Capital Improvements for phased development	0	88	100.00	13	14.77	75	85.23	1.85	1.85
Redevelopment /Retrofitting/ Maintenance of public structure	31	57	64.77	48	84.21	9	15.79	1.16	0.75
Locating critical facilities in non-hazardous areas	24	64	72.73	59	92.19	5	7.81	1.08	0.78

Analysis of the sampled plans revealed that all plans addressed policies related to structural tools for prevention of hazard losses. Majority of these plans (73.86%) also provided location specific details and guidelines for constructing dams, dykes and embankments. All evaluated plans also included provisions for capital improvement projects through phased development. Most of these plans (85.23%) contained detailed policies for capital improvement projects. Among all the plans evaluated, 57 (64.77%) addressed retrofitting and redevelopment of public structure. Only 9 (15.27%) of these plans included sufficient details. Only 64 (72.73%) of the plans evaluated, addressed policies for locating critical facilities in non-hazardous areas. Only 5 (7.81%) of these plans included any details. Planning policies addressing structural tools and capital improvements scored above 1.5 points in the mean quality indicating that most communities gave better attention to these policies in comparison to the other policies in this component.

Two of the four policies include in this component received overall policy performance scores of almost 1.75 points or above. Structural tools and capital improvement policies were the most common and best addressed in the sampled local development plans. Redevelopment, retrofitting or maintenance of structures were addressed in least of the development plans with a relative policy coverage of 64.77%. They also had the lowest overall policy performance score of 0.75 points due to a low mean quality score. Planning policy of locating critical facilities in non-hazardous areas received a marginally higher (but low) overall policy performance score of 0.78 points as they showed a better relative policy coverage even though the mean quality score was the lowest among the all the policies in this component.

The next component included four planning policies related to acquisition tools. The results of this component analysis are summarized in table 6.9.

Table 6.9. Acquisition Tools

Planning Policy	Policy Coverage Assessment			Policy Quality Assessment					Overall Policy Performance Score
	Policy Addressed		Relative Policy Coverage (%)	No Details		Detailed		Mean Score	
	No	Yes (a)		N	% of (a)	N	% of (a)		
Land and property acquisition (fee simple purchase/eminent domain)	1	87	98.86	52	59.77	35	40.23	1.40	1.39
Dedication of hazardous open space (conservation easement)	1	87	98.86	70	48.28	17	19.54	1.52	1.18
Transfer of development rights	22	66	75.00	46	69.70	20	30.30	1.30	0.98
Purchase of development rights	22	66	75.00	39	59.09	27	40.91	1.41	1.06

Most plans included a variety of land acquisition tools for planning projects. Fee simple purchase, acquisition through eminent domain and conservation easements were commonly addressed in all the plans except for one. Among the plans that addresses land and property acquisition through fee simple purchase and eminent domain, 35 (40.23%) included sufficient details. Among the plans that addressed dedication of hazardous open space through conservation easements, only 17 (19.54%) included policy details. Innovative instruments like transfer of development rights and purchase of development rights were addressed by 75% of the plans evaluated. Among the plans that addressed transfer of development rights, 20 (30.30%) included detailed guidelines. Among the plans addressing purchase of development rights, only 27 (40.91%) included detailed policies.

None of the policies in this component received an overall policy performance score above 1.5 points. Policies related to land and property acquisition, and dedication of hazardous open space had high relative policy coverage (98.86%) but lower mean quality scores of 1.40 points and 1.52 points. This suggests that communities need to invest resources in detailing out these policies if they expect to derive the intended benefits of these planning proposals. Transfer of development rights and purchase of development rights had comparable overall policy performance scores around 1 point. As these were relatively new tools during the study period, most likely the jurisdictions addressing these innovative acquisition tools were still in the process of evolving detailed guidelines and procedures for implementation.

In the next component of incentive/disincentive planning policies, three policies were evaluated using the plan evaluation protocol. The results of this component analysis are presented in table 6.10.

Table 6.10. Incentive/disincentive Tools

Planning Policy	Policy Coverage Assessment			Policy Quality Assessment					Overall Policy Performance Score
	Policy Addressed		Relative Policy Coverage (%)	No Details		Detailed		Mean Score	
	No	Yes (a)		N	% of (a)	N	% of (a)		
Subsidized mass transit	45	43	48.86	19	44.19	24	55.81	1.56	0.76
Density Bonuses	4	84	95.45	66	78.57	18	21.43	1.21	1.16
Impact fees	5	83	94.32	57	68.67	26	31.33	1.31	1.24

Use of density bonuses and impact fees was seen as a common incentive/ disincentive tool in most of the sampled plans. Only about half (51.14%) of the plans analyzed included provision of subsidies for mass transit. Some of the common examples are tax incentives for companies that provide discounted passes to employees for using mass transit, incentives to developers for developing real estate near transit points and subsidized mass transit costs to increase ridership. Of the 88 plans that included provisions for levying impact fees for new development, only 26 (31.33%) included specific recommendations. Density bonuses, though common to many plans were the least detailed of the incentive/disincentive provisions. Only 26 (31.335%) plans that addressed this tool also included sufficient details. Some of the best detailed policies specifically identified new development projects wherein this policy was mandated.

None of the policies in this component received an overall policy performance score above 1.25 points. Subsidized mass transit received the best mean quality score of 1.56 points but had a low relative policy coverage of only 48.86%, resulting in a low overall policy performance score of 0.76 points. Impact fees had the highest overall policy performance score among the three policies in this component but received the lowest mean quality score, resulting in a low overall policy performance score of 1.24

points. Planning policies evaluated in this component showed lack of coverage and detailing in the sampled local development plans.

Proposals and policies related to use of awareness, educational and technology tools were also evaluated using the climate change management plan quality evaluation protocol for each of the sampled plans. This component included five specific policies. The results of this analysis are provided in table 6.11.

Table 6.11. Policies Related to Awareness, Educational and Technology (AET) Tools

Planning Policy	Policy Coverage Assessment			Policy Quality Assessment					Overall Policy Performance Score
	Policy Addressed		Relative Policy Coverage (%)	No Details		Detailed		Mean Score	
	No	Yes (a)		N	% of (a)	N	% of (a)		
Education and outreach program during plan implementation	0	88	100.00	17	19.32	71	80.68	1.81	1.81
Information dissemination regarding location of hazardous areas (including posting of signs, information booklets etc)	1	86	98.86	55	63.95	31	36.05	1.36	1.33
Disaster warning and response awareness program	17	71	80.68	13	18.31	58	81.69	1.82	1.47
Training/ Technical assistance to developers or property owners	3	85	96.59	56	65.88	29	34.12	1.34	1.30

Table 6.11. Continued

Planning Policy	Policy Coverage Assessment			Policy Quality Assessment					Overall Policy Performance Score
	Policy Addressed		Relative Policy Coverage (%)	No Details		Detailed		Mean Score	
	No	Yes (a)		N	% of (a)	N	% of (a)		
Computer models/ evacuation systems/ transportation models/ GIS (ex. HEC, web-based modeling system)	31	57	64.77	56	98.25	1	1.75	1.02	0.66

Among the plans analyzed all addressed proposals or policies for education and outreach programs during various stages of plan implementation. Most of these plans (80.68%) also included detailed policies. Equally common were proposals for information dissemination on hazardous and vulnerable areas (98.90%). Among all the plans that addressed this policy only 31 (36.05%) provided sufficient details. Majority of the plans (80.68%) also addressed disaster warning and response awareness programs. Of all the plans that addressed this policy, 58 (81.69%) included sufficient details. A large number of plans (96.59%) also included proposals for training and technical assistance programs for developers or property owners. However, only 29 (34.12%) of these were sufficiently detailed. Among all the AET tools, GIS, evacuation systems and transportation modeling, were addressed only in 57 (64.77%) plans. Of the plans that addressed it, sufficient policy details were included only in 1 (1.75%) development plan.

Only one policy in this component received an overall policy performance score above 1.5 points. Education and outreach programs during plan implementation had 100% policy coverage and a high mean quality score of 1.81 points, resulting in a high overall policy performance score of 1.81 points. Lowest overall policy performance score of 0.66 points was given to high technology policy including computer models/evacuation systems/transportation models/ GIS. It suggests that sampled communities did not address new technology tools effectively.

6.2 Analysis of Plan Implementation Capacity

In order achieve the desired impact of the proposed planning policies, it is important to have an enabling implementation framework. Allocation of funds for planning proposal, designation of responsibilities, identification of coordination mechanisms, implementation time-line and monitoring of the implementation process are important aspects that ultimately impact the overall success of the plan. Evaluation of plan implementation capacity by analyzing the overall implementation related policies in the plan document specifically addressed this aspect of local development plan quality.

All plans had separate guidelines for overall plan implementation. They were often included in a separate section of implementation and coordination. A few of the plans also included these guidelines as a separate sub-section for each component. It is highlighted that these implementation guidelines are not for a particular policy but rather for overall plan implementation or at minimum the whole planning component such as transportation or natural resource management. Therefore, it is envisaged that assessment of implementation capacity of a development plan reflects a realistic assessment of the overall implementation potential of the planning proposals. Table 6.12 displays the evaluation results of the implementation capacity. Ten policies were evaluated in each plan with possible scores ranging from 0-2.

Table 6.12. Plan Implementation Score

Planning Policy	Policy Coverage Assessment			Policy Quality Assessment				
	Policy Addressed		Relative Policy Coverage (%)	No Details		Detailed		Mean Score
	No	Yes (a)		N	% of (a)	N	% of (a)	
History of Planning	0	88	96.70	6	6.82	82	93.18	1.93
Identification of costs/ funding for implementation	2	86	94.51	49	56.98	37	43.02	1.43
Designation of responsibility for implementation	0	88	96.70	31	35.23	57	64.77	1.65
Timetable for implementation	1	87	95.60	73	83.91	14	16.09	1.16
Sanctions for failure to implement	40	48	52.75	46	95.83	2	4.17	1.04
Regular update procedures	9	79	86.81	44	55.70	35	44.30	1.44
Provisions for technical assistance	7	81	89.01	43	53.09	38	46.91	1.47
Monitoring of environmental and human impacts	21	67	73.63	37	55.22	30	44.78	1.45
Public participation process in monitoring and review	1	87	95.60	46	52.87	41	47.13	1.47
Provision of plan response to new information/ data	17	71	78.02	64	90.14	7	9.86	1.10

Among all the implementation proposals and policies evaluated with respect to plan implementation, planning history and designation of responsibility for implementation were addressed in all the plans. With regards to history of planning most plans (93.18%) referenced earlier plans and provided assessments of past planning initiatives within their community. With respect to designation of responsibility for implementation, majority (64.77%) designated specific departments and agencies for implementing specific programs and schemes. Except for 1 plan, time table for implementation and proposal for public participation in monitoring and review of planned activities was included in all sampled plans. Among the plans addressing time line for implementation, 14 (16.09%) provided details for specific programs and programs.

Among plans addressing public participation, 41 (47.135) provided sufficient details. Most of the plans (94.51%) also addressed cost identification and funding for implementation of various planning proposals. Among all plans addressing this, 37 (43.02%) provided guidelines for cost estimation and identified funding for the proposed actions. Among the sampled plans 81(89.01%) also included specific provisions for technical assistance during plan implementation. Among these, 38 (46.91%) plans provided detailed guidelines or identified specific agencies that could be approached for technical assistance. Most of the plans (86.81%) addressed policies related to regular updating of the plan and planning policies. Only 35 (44.30%) of these plans, included detailed guidelines and procedures.

Surprisingly, 71 (78.02%) plans had policies addressing planning response to new information and data. Most of these provisions related to adapting local policies in response to funding changes in the state and federal policies. Only 7 (9.86%) plans that addressed this issue included detailed provisions. Among the 88 plans evaluated, 67 (73.63%) addressed policies and proposals related to monitoring of environmental and human impacts of planning proposals and actions. Among these 30 (44.78%) plans included detailed guidelines and proposals. Most of the proposals were related to monitoring of state or federally funded transportation projects that affected the communities directly. Among all the plan implementation policies, sanctions for failure to implement were the least commonly found among the sampled plans. Only 48 (52.75%) plans addressed policies related to sanctions for failure to implement. Most (95.83%) of these plans that addressed these policies did not provide any details or specific guidelines for planning action.

Implementation capacity score was calculated for each plan as the ratio of total implementation policy score received by the plan to the maximum possible total score of 20. Table 6.13 provides descriptive statistics for the implementation capacity score for the sampled plans. The maximum possible implementation capacity score for any plan is 1 signifying the highest potential for implementation of planning proposals.

Table 6.13. Results of Implementation Policy Assessment

Descriptive Statistics	Implementation Capacity Score
Mean	0.57
Median	0.55
Min.	0.35
Max.	0.80
Standard deviation	0.13
Possible max. Score	1

The mean implementation capacity score for the 88 plans evaluated in this research was 0.57 points which is 57% of the maximum possible score. Most plans received a score of 0.55 points (median score) indicating that the planning policies included in these plans had at best, 55% chance of being implemented. The highest implementation capacity score received by any plan was 0.8 points suggesting a healthy 80% chance of implementation of the proposed planning policies included in the plan document.

6.3 Climate Change Management Plan Quality Index

In order to assess the effective climate change management capacity of the sampled local development plans, raw climate change management policy scores for each local development plan is weighed by the respective implementation capacity scores. The resulting weighted score is a climate change management plan quality index for each local development plan. Table 6.14 provides descriptive statistics for this index.

Table 6.14. Descriptive Statistics of Climate Change Management Plan Quality Index

Descriptive Statistics	Implementation Capacity Score
Mean	31.12 (33.83%)
Min.	9.6
Max.	63.75
Standard deviation	12.89
Possible max. Score	92 (100%)

The mean climate change management plan quality index for the sampled local development plan was 32.61 points, which is only 33.83% of the maximum possible score. This is much lower than the mean raw climate change management policy score of 54.59 (table 6.1). These results indicate that even though the sampled plans included at least 50% of the desired climate change management related policies, their mean climate change management impact is expected to be less than 35% of the maximum possible.

The frequency distribution for overall effective climate change management plan quality scores was roughly bell shaped with a minimum score of 9.6 points and maximum of 63.75 points (Figure 6.2). There was a slight positive skew in the distribution implying that majority of the jurisdictions achieved lower scores. There did appear to be a possible issue of outliers with the 3 communities scoring above 55 points in the climate change management plan quality index. Most of the climate change management plan quality index scores were clustered between 25 and 35.

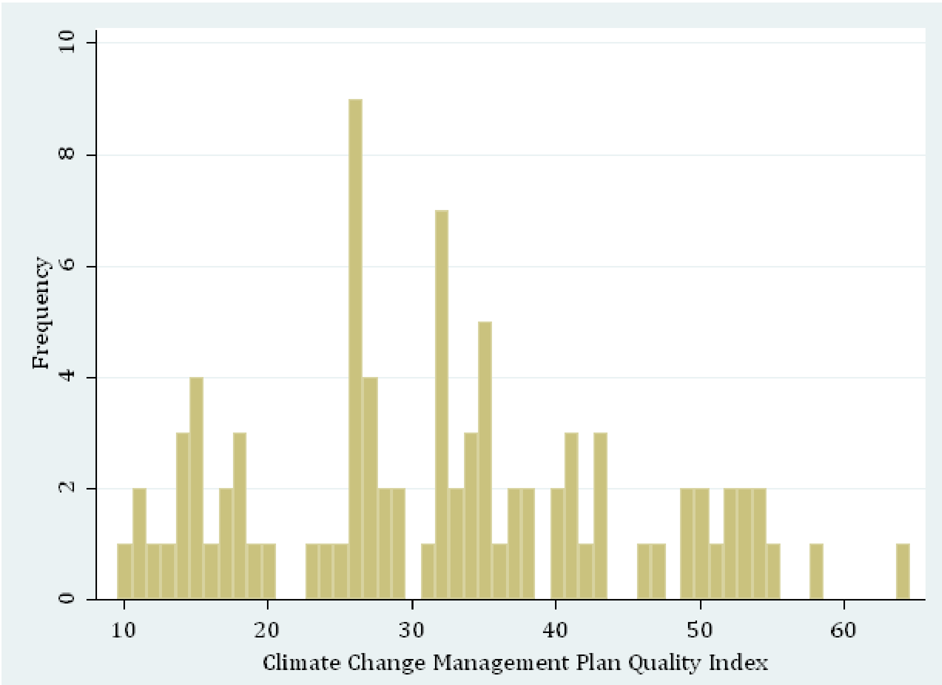


Figure 6.2. Histogram of Climate Change Management Plan Quality Index

6.4 Summary of the Results

Plan quality analysis revealed that at least one desirable climate change management planning policy was present in all local development plans for each evaluation components, except for the component of urban design and built form. Raw climate change plan quality scores showed good coverage of the desired policies. Eight of the ten evaluation components had raw mean quality scores above 50% of the maximum possible component score. This indicates that climate change management related policies are commonly addressed in most development plans. Even though there seems to be a good coverage of desired climate change management policies in the local development plans, the quality is at best fair. Based on the nature of measurement and mathematical estimations used in plan quality analysis, a mean raw climate change management policy score above 75% of the maximum possible for any component indicates extensive coverage across the plans along with sufficient details. The results presented in table 6.1 indicate that the site planning component received the score above

75% of maximum possible. This is encouraging for climate change management as land suitability analysis, setbacks, buffers and subdivision regulations have the potential to be used as viable tools for directing development away from areas threatened by the anticipated impacts of climate change.

Transportation policies received a mean policy score of 7.02 points, which was 70.23% of the maximum possible for this component. This is potentially encouraging as vehicular emissions are a major contributor to climate change. Transportation policies promoting public transportation, providing better facilities for walking and cycling will help reduce the total vehicle miles travelled in the community resulting in climate change mitigation benefits. Awareness, education and technology tools had raw component quality score of 6.72 points which is 67.16% of the maximum possible. If the quality of these policies can be further improved, it will provide the infrastructure necessary to create awareness and educate community members, businesses, and organizations on the various aspects of climate change management.

However, except for these three components all other policy components received mean policy scores much below the desirable level of 75%. Lowest mean raw component score (49.29% of maximum possible) is for urban design and built form. This is specially discouraging because many climate change researchers believe that substantial residential and transportation emissions can be managed by urban and building design interventions.

Within the land use and zoning component, mixed use development policy had the highest maximum overall policy performance score of 1.77 points. This result indicates that this policy was covered in good detail across the sampled plans. This was expected as mixed use development is a common planning and development strategy in sustainable development approach to planning. Planning policies related to promoting brown field/ grey field redevelopment scored the lowest (0.81 points) suggesting that it was not adequately addressed across the sampled plans. This policy was absent in 30.68% of the plans and among the plans that addressed it, only 16.39% provided sufficient details. This is probably due to the specific nature of the policy. It is focused towards brown field and grey field areas that may not be present in communities that did not address this policy.

With regards the urban design policy component, high density development scored the highest overall policy performance score of 1.65 points. This indicates good coverage of the policy across the sampled plans along with good quality. All other overall policy performance scores in this component were below 1 point. Proposals for urban forestry and tree lined streets to decrease urban heat island effect scored the minimum. They were not addressed in almost 50% of the plans, and where addressed, were not accompanied with any details.

Within the site planning component, site planning review requiring land suitability analysis or special study or impact assessment was found in all development plans. It also had the highest overall policy performance score of 1.74 points indicating adequately detailed policies across most of the plans. Lowest overall policy performance score was 1.23 points for policies related to setbacks and buffers. Even though this policy was addressed by 71.43% of the communities only 28.57% of these provided adequate details.

With respect to the planning policies related to the building design component, large variation was seen in policy coverage across the plans. While 95.45% of the plans addressed policies related to storage, collection, recycling of wastes, 71.59% of the plans did not address any policy related to rainwater harvesting. Building standards and codes for enhanced protection from natural hazards were addressed in 93.18% of the plans but included sufficient details only in 43.90% of these. The overall performance policy score for this policy was only 1.34 points, much below the minimum desired performance level of atleast1.5 points.

Within the transportation component of plan quality analysis, planning policies addressing creating, implementing or enhancing of public transportation systems had the highest overall policy performance score of 1.78 points. This policy was addressed in all the sampled local development plans. It was accompanied with sufficient details in 78.41% of the plans evaluated. Policies addressing creating or upgrading of pedestrian facilities had the lowest overall performance score of 1.22 points. Even though this policy was addressed in 94.32% of the plans, only 28.92% of these included any details.

In the natural resource management component of plan evaluation, hazard management guidelines received the highest overall policy performance score of 1.88 points. They were addressed in 98.86% of the sampled plans and were accompanied with details in 89.66% of these. Planning policy related to prevention of habitat fragmentation received the lowest overall policy evaluation score. They were addressed only in 38 plans and detailed only in 1 plan. This was somewhat expected because habitat fragmentation is not a major concern in the central cities. These are large communities that have already converted most of their land area for urban uses. Therefore, there is a low chance of any viable natural habitats being present within the city. It was expected that this policy would capture the planning attitude towards future expansion of the city with policies that would avoid growth into the non-urbanized with existing natural habitats around the city. However, very few plans addressed such issues of future expansion.

Among the policies related to physical infrastructure and facilities capital improvement projects for phased development received the highest overall policy performance score of 1.85 points. This policy was addressed in all the sampled plans. Detailed phasing guidelines and identification of projects were included in 85.23% of the plans. This is probably explained by the need to include phase-wise capital improvement projects within the local development plans for generating funds for implementation. It may also be due to federal and state funding guidelines that require inclusion of capital improvement works in the local development plan document before considering them for support grants. Planning policy for maintenance or retrofitting or redevelopment of public structures received the lowest overall policy performance score of 0.75 points. It was not addressed in 35.23% of the plans. Among the plans that addressed his policy, only 15.79% included details or identified any specific projects.

In the policy evaluation component of acquisition tools, overall policy performance scores for all the polices were below the minimum desirable level of 1.5

points. Even though planning policy for land and property acquisition through fee simple purchase and eminent domain was addressed in most of the plans (98.86%), it lacked sufficient details in 59.77% of these plans. Policy instruments for transfer or purchase of development rights were not addressed in 25% of the local development plans. Lack of attention and resource commitment to acquisition tools reflects the reluctance of communities to interfere with an individual's development rights. It is suspected that planning policies that impact an individual's property rights are least preferred for fear of litigation and associated compensatory damages.

All planning polices included in the incentive/disincentive tools component received low overall policy performance scores. Amongst these impact fees received the highest overall policy score of 1.24 points. It was addressed in 94.32% of the plans, but only 31.33% plans included details. It is suspected that this policy is often included as a general planning policy without details so as to facilitate customized assessments based on individual cases. Some plans (48.86%) also included direct fare subsidies to increase ridership in mass transit. Limited use of incentive/disincentive polices in local development plans indicates reluctance of local administration to use innovative tools for achieving planning goals. This will be challenge for climate change management as communities will need to implement a range of incentive/disincentive actions to promote lifestyle changes among the citizens and organizations for mitigation and adaptation benefits. Reluctance to adopt such policies will impede climate change management initiatives in the community.

Among the policies related to awareness, educational and technology tools, educational and outreach programs had the highest overall policy performance score (1.81 points), followed by awareness programs for disaster warning and response (1.33 points). These results are encouraging as climate change management at the community level would require effective outreach and education activities. On the other hand, a low overall policy performance score for technology tools such as computer modeling, and GIS may prove to be a challenge for climate change management due to the need of computing and scientific analysis usually associated with climate change data.

The mean plan implementation capacity of the sampled plans is quite low. This indicates low probability of successful implementation of the planning policies proposed in the local development plans. The mean policy implementation capacity score of 0.57 points suggests only a 57% chance of implementation of planning policies. The results of implementation policy assessment indicate that most implementation aspects that are critical for successful implementation of planning policies are not addressed in sufficient detail in the local development plans.

Consequently, the climate change management plan quality index that weights the raw plan quality scores by respective implementation capacity score of the development plan, had a mean index value of only 31.12 points. This was only 33.83% of the maximum possible index value. These results indicate that even though communities did address a range of desired climate change management planning policies, more needed to be done to improve their quality and chances of implementation.

7. MITIGATION INFLUENCE OF CLIMATE CHANGE MANAGEMENT PLAN QUALITY

The mitigation influence of planning is ascribed to planning impacts that result in reduced carbon emissions into the local environment. In this study, emissions related to residential uses, and transportation (excluding air transportation) were included in the measurement of the dependent variable. The dependent variable, emissions was measured as the change in per capita metric tons of CO2 emissions from 1990 to 2005. This study employed correlation analysis and ordinary least squares (OLS) regression models to test various research hypotheses as outlined in section 4. Influence of climate change management plan quality index was analyzed using statistical analyses while controlling for the effects of socio-economic, landscape and other policy influence. Detailed analysis of the direction and strength of the influence of plan quality index on the dependent variable provided valuable insights into developing appropriate local development policies for achieving climate change mitigation benefits.

The first sub-section summarizes the descriptive statistics of all variables included in the statistical analysis. This discussion is followed by the results of the correlation analysis that identifies statistically significant relationships between the variables. The next sub-section presents the results of the regression model. Final sub-section summarizes the results of the preceding statistical analyses.

7.1 Descriptive Statistics

Descriptive statistics for dependent and the independent variables included in this analysis are presented in Table 7.1. Top five and the lowest five communities for each of the variables are listed in appendix IV. The mean change in per-capita carbon dioxide emissions from 1990 to 2005 in the sampled communities is estimated to be 0.48 metric tons per capita with a wide range from a minimum of -3.13 metric tons to 5.50 metric tons per capita.

Table 7.1. Descriptive Statistics of Variables (Mitigation Effect)

Variables	N	Mean	Standard Deviation	Min.	Max.
Dependent Variables					
Per-capita Emissions (2005)	88	0.48	1.07	-3.12	5.50
Independent Variables					
Climate Change Management Plan Quality Index	88	31.12	12.89	9.60	63.75
Socio-economic					
Income (in '000$)	88	20.327	5.00	13.01	45.63
Work Travel (in %)	88	87.70	7.15	61.29	95.80
Non-profit Employment (in %)	88	7.78	2.79	3.58	16.24
Carbon Employment (in%)	88	38.21	11.33	14.89	64.26
Landscape Characteristics					
Sprawl (in sqm. per person)	88	1372.48	694.66	126.11	3885.49
Coastal Proximity	88	0.52	0.50	0	1
Policy Influence					
State Mandate	88	0.64	0.48	0	1
Plan Years	88	9.02	1.48	6	12

A histogram of the dependent variable is shown in figure 7.1. Most of the communities had emissions below 7.5 tons per-capita. The mean emissions for the sampled communities was 4.58 metric tons per-capita. The shape of the histogram resembles the bell shaped normal distribution. There are a couple of communities at the either ends of the extreme range.

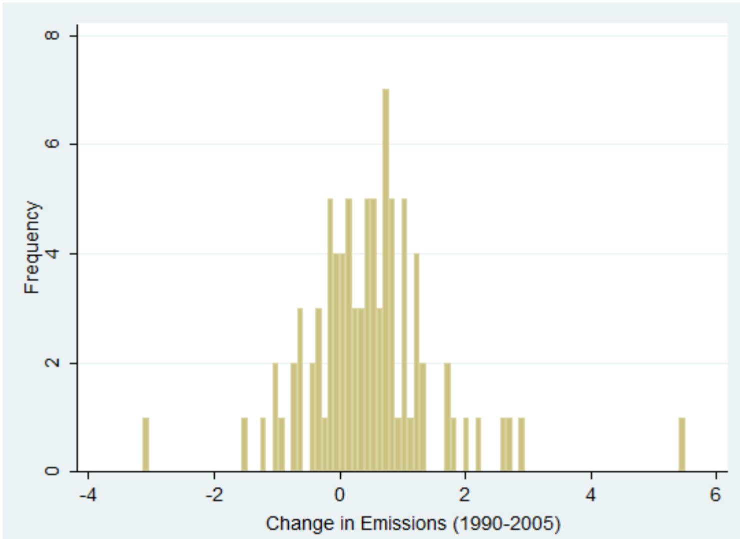


Figure 7.1. Histogram of Change in Emissions (1990-2005)

Climate change management plan quality index scores were calculated using the detailed plan quality evaluation protocol. The mean index value for all the sampled plans is 31.18 points with a wide range from 9.60 to 63.75 points. Frequency distribution of the variable shows that data is more or less normally distributed with possible issues of outliers towards the higher extreme of range (figure 7.2).

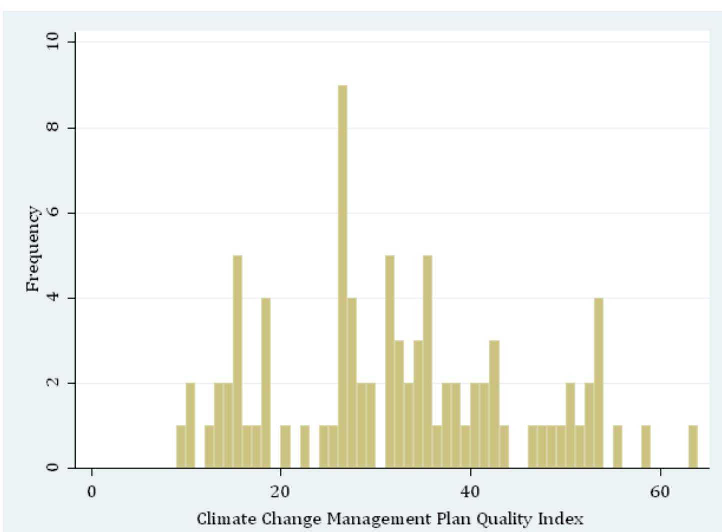


Figure 7.2. Frequency Distribution of Climate Change Management Plan Quality Index

The mean annual per-capita income (2000) in the sampled cities was $20327.07, ranging from a minimum of $13009.00 to a maximum of $45628.00. Figure 7.3 shows the histogram of the distribution.

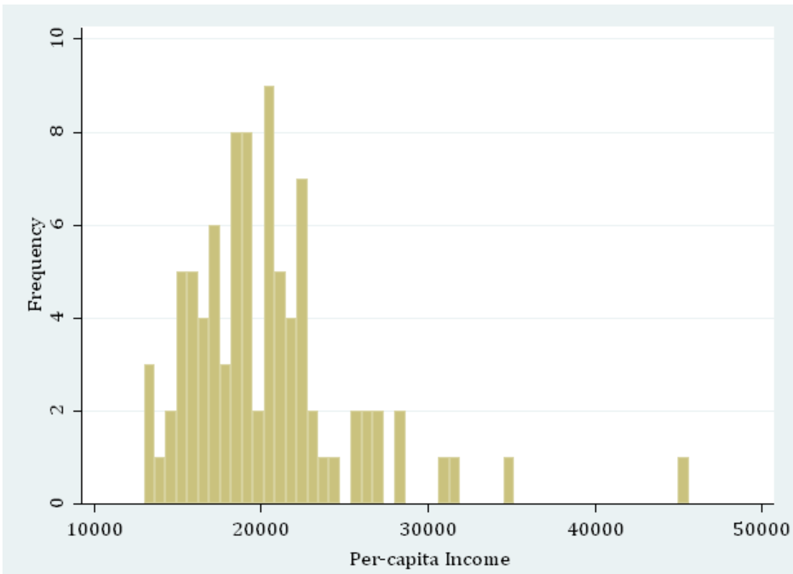


Figure 7.3. Histogram of Income Distribution

Distribution of the data shows that most of the communities (more than 75%) had average per-capita income below $25000. This indicates a positively skewed distribution with possible issues related to outlier communities with per-capita incomes above $30,000.

Among the sampled communities, percentage of workers above 16 years of age, travelling alone to work by a private vehicle ranged from 61.29% to 95.80%. Histogram of the variable shows that more than three-fourths of the communities had more than 85% of the workers travelling alone to work in a private vehicle (Figure 7.4). More than half of the sampled communities had more than 90% of the workers travelling alone by private vehicles. The histogram shows a negatively skewed distribution with extreme values towards the lower end of the range.

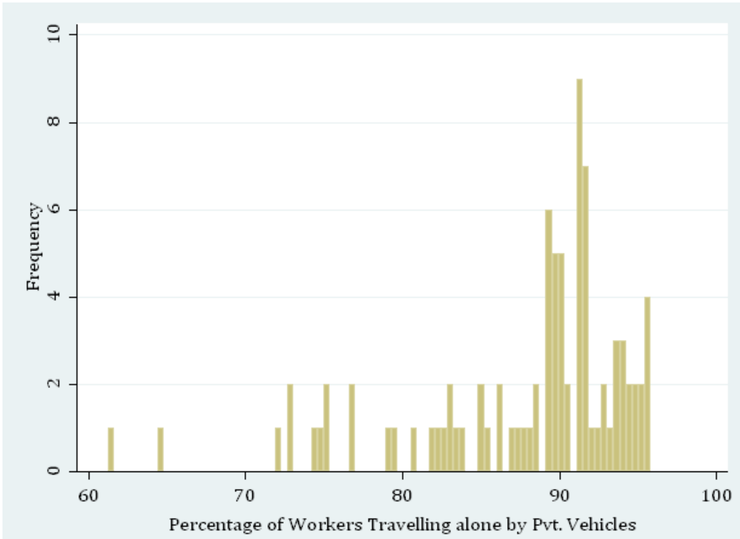


Figure 7.4. Histogram of Work Travel

In regards the non-profit employment variable, the sampled communities showed an overall low percentage of workers 16+ yrs of age working in non-profit organizations. Figure 7.5 shows the histogram of the variable. More than three-fourths of the communities had less than 10% of the workforce in the non-profit sector. Only a few of communities showed more than 15% of the workforce employment in the non-profit organizations.

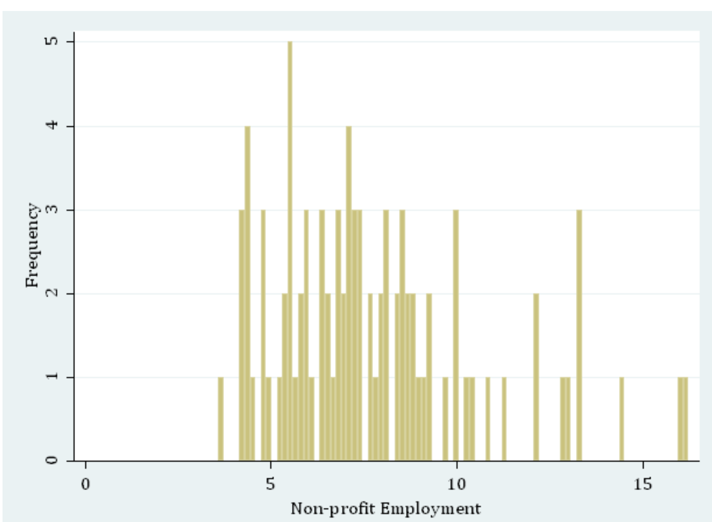


Figure 7.5. Histogram of Non-profit Employment

The variable sprawl measured the extent of land developed for urban uses within the community. Sampled communities on an average have allocated 1372.48 sqm. of land area per person. Minimum value of the sprawl measured was 694.66 sqm./person and the maximum land area used per person was estimated to be about 3885.49 sqm./ person. More than 75% of the sampled communities used less than 2000 sqm./ person (figure 7.6).

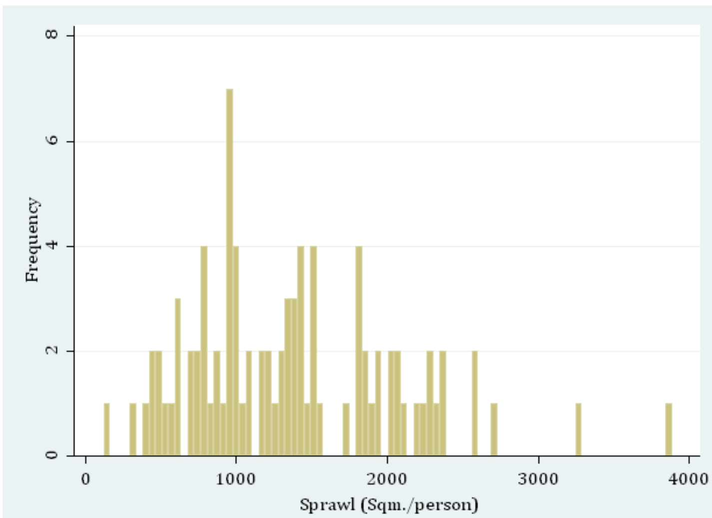


Figure 7.6. Histogram of Sprawl

Coastal proximity was a dichotomous measure with ‘1’ signifying location of the community within a coastal watershed, and ‘0’ signifying presence in a non-coastal watershed. Approximately 47% of the sampled cities were in non-coastal watersheds (table 7.2).

Table 7.2. Coastal Proximity Data Distribution

Coastal Proximity	No. of Cities	Percent
0 (No)	42	47.73%
1 (Yes)	46	52.27%

State local planning mandate was also measured as a dichotomous variable based on the presence (1) and absence (0) of state mandate for local planning. Some of the states such as Florida and Washington had state legislation mandating local development plans whereas states such as Texas ,did not mandate development plans . Most of the communities (64%) included in the sample had local development plans mandated by the state policies (Table 7.3).

Table 7.3. State-mandated Local Planning Data Distribution

State policy mandate	No. of Cities	Percent
0 (No)	31	36.05%
1 (Yes)	55	63.95%

Plan years was measured as the number of years prior to 2005 for which the plan has been in effect. Communities included in the study had at a minimum 6 plan years and a maximum of 12 plan years (table 7.4). Thus, the most current plan evaluated was adopted/modified/updated in the year 1999 and the oldest was in 1993. Most of the plans evaluated were from the year 1996.

Table 7.4. Distribution of Plan Years

Year plan was adopted/modified/updated	No. of Sampled Development Plans	Percent
6	1	1.15%
7	14	16.09%
8	17	19.54%
9	24	27.59%
10	16	18.39%
11	9	10.34%
12	6	6.90%

7.2 Correlation Analysis

As the first step, statistical relationships between the variables is identified using correlation matrix (Table 7.5). This analysis reveals the level of association between the dependent and independent variables.

The dependent variable, change in emissions, is found to be correlated with five independent variables. Four of the independent variables were correlated at a significance level of 0.10 and one was correlated at the significance level of 0.05. Climate change management plan quality index was negatively correlated with dependent variable ($r=-.2044$, $p<0.10$). This indicates that communities with better plan quality index were likely to have lower per-capita emissions. Among the socio-economic variables, carbon employment was positively associated with the dependent variable ($r=0.2621$, $p<0.05$), suggesting that communities with higher percentage of workers in the carbon based employment shad higher increase in emissions. Coastal proximity was also positively correlated with the dependent variable ($r=0.1726$, $p<0.10$) suggesting that coastal communities had higher gain in per-capita emissions between 1990 and 2005. State mandate variable was negatively correlated with the dependent variable ($r=-0.1779$, $r<0.1$) indicating that communities in states that mandated local development plans had lower gain in emissions. Plan years also showed a similar negative correlation with teh dependent variable ($r=-.1805$, $p<0.1$). This suggests that communities in which the local development plan had been in effect for a longer duration, experienced lower gain emissions.

In addition to the significant relationships between the dependent and the independent variables, the correlation analysis also revealed some noteworthy relationships between the various independent variables. Plan quality index was correlated with sprawl, and state local planning mandate. There was a negative relationship between plan quality and sprawl ($r=-0.2302$, $p<0.05$), indicating that communities with higher plan quality were likely to have lower sprawl. This is expected as most sustainable development policies commonly found in local development plans, focus on controlling the urban footprint of a community. Presence of state guidelines mandating local development plans showed a positive effect on the plan quality ($r=0.2895$, $p>0.05$). This suggests that state policy mandate for local planning is related to high quality of local development plans.

Other statistically significant relationships among the independent variables were seen between per-capita income and carbon employment ($r=-0.3134$, $p<0.05$), per-capita income and plan years ($r=-0.2173$,$p<0.05$), work travel and carbon employment ($r=-0.1892$, $p<0.1$), non-profit employment and carbon employment ($r=-0.2430$, $p<0.05$), non-profit employment and state local planning mandate ($r=-0.1736$, <0.1), and coastal proximity and state planning mandate ($r=0.2709$, $p<0.05$). In spite of numerous statistically significant correlations among a number of independent variables, multi-collinearity was not an important issue in the subsequent OLS regression modeling as the identified relationships were statistically weak ($r<0.6$).

Table 7.5. Correlation Matrix (Mitigation Effect)

	Change in Emissions	CCMPQI	Income	Work Travel	Non-profit Employment	Carbon employment	Sprawl	Coastal Proximity	State Mandate
<u>Dependent variable</u>									
Change in Emissions	1								
<u>Independent Variables</u>									
Climate Change Management Plan Quality Index (CCMPQI)	-0.2044*	1							
Income	0.1188	0.1238	1						
Work travel	0.1532	-0.0522	0.0564	1					
Non-profit Employment	0.0113	-0.0657	0.1036	0.1162	1				
Carbon Employment	0.2621**	-0.0981	-0.3134**	-0.1892*	-0.2430**	1			
Sprawl	0.0079	-0.2302**	0.0803	-0.0332	-0.0527	-0.0231	1		
Coastal Proximity	0.1726*	0.1693	0.1545	0.0505	-0.0048	-0.0151	-0.1520	1	
State Mandate	-0.1779*	0.2566**	0.1179	0.0059	-0.1736*	-0.0032	-0.0794	0.2709**	1
Plan Years	-0.1805*	-0.1337	-0.2173**	-0.0373	0.0850	0.0687	-0.0291	-0.0161	0.0436

$^{**}p<0.055$ $^{*}p<0.1$(two-tailed)

7.3 Examining the Impact on Emissions

I used OLS regression analysis to analyze the mitigation impact of climate change management plan quality index. The dependent variable, change in per-capita emissions is regressed against the independent variables of plan quality index, socio-economic characteristics, bio-physical/landscape characteristics and policy influence.

I tested normality, multi-collinearity, heteroskedasticity, independence and model specifications to ensure the OLS assumptions were met. As heteroskedasticity was infered, regression analysis was done using robust standard errors. Spatial autocorrelation was not considered in this study as the communities were randomly selected and are not adjacent. The regression model tested the impact of plan quality index while controlling for other factors on the dependent variable. Table 7.6 presents the results of the OLS regression analysis.

Table 7.6. Mitigation Model - Regression Analysis on Per-capita Emissions

Variable	Coefficient	Robust Std. Err.	p-value (one-tailed)	Beta Coefficients
ECCM Plan Quality	-0.0164	0.0082	0.03	-0.20
Income	0.0422	0.0272	0.06	0.20
Work travel alone	0.0270	0.0170	0.06	0.18
Non-profit Employment	0.0091	0.0586	0.44	0.02
Carbon employment	0.0340	0.0125	0.00	0.36
Sprawl	<0.0001	0.0001	0.39	-0.03
Coastal Proximity	0.4682	0.2249	0.02	0.22
State Mandate	-0.4434	0.2597	0.05	-0.20
Plan Years	-0.1243	0.0717	0.04	-0.17
Constant	-2.3744	1.7561	0.09	
N	*88*	*F(9,78)*	*2.76*	
Prob>F	*0.0010*	*R-squared*	*0.29*	

The primary independent variable of interest, climate change management plan quality index showed statistically significant negative relationship ($p<0.05$) with the dependent variable, change in emissions. This result is consistent with the correlation analysis in the previous section. These results provide support for hypothesis 2, wherein it was hypothesized that communities with better plan quality would have significantly lower increase in emissions.

Per-capita income shows statistically significant ($p<0.10$) and positive relationship with the dependent variable. The positive direction of the statistical relationship indicates that wealthy communities (higher per-capita income) had higher increase in emissions. This result provides support for hypothesis 3. Work travel also showed statistically significant ($p<0.10$) positive relationship with the change in emissions. This indicates that communities with higher percentage of workers travelling alone to work in private vehicles experienced a higher increase in per-capita emissions. Thus, this result provides support for hypothesis 4.

The results of the mitigation model do not show statistically significant ($p>0.1$) relationship between non-profit employment and the change in emissions. It seems that percentage of population working in the non-profit organizations did not have any statistically significant impact on the change in emissions in the sampled communities. Thus, the regression model results do not provide support for the hypothesis 5 wherein it was expected that expected communities with higher non-profit employment would have lower increase in emissions.

Carbon employment shows statistically significant ($p<0.05$) positive relationship with the dependent variable. This indicates that communities with higher percentage of workforce engaged in carbon based employment had higher increase in per-capita emissions. These results support mitigation hypothesis 6 that expected higher carbon employment in the sampled communities to result in higher increase in emissions.

The measure of sprawl does not show any statistically significant ($p<0.1$) relationship with change in emissions. This indicates that sprawl did not have any significant impact on the change in emissions in the sampled plans. Thus, these results do not provide support for the hypothesis 7, wherein higher sprawl was expected to be associated with higher increase in emissions.

Coastal proximity shows statistically significant ($p<0.05$) positive relationship with the change in emissions. This suggests that communities closer to the coast experienced a higher gain in emissions. This contradicts hypothesis 8, wherein coastal communities were expected to have lower increase in emissions.

State guidelines mandating local development plans show a statistically significant ($p<0.1$) negative relationship with the dependent variable. This indicates that communities in states that mandated local planning has a lower increase in emissions. Therefore, the results of the regression analysis provide support for hypothesis 9.

Finally, plan years also showed a statistically significant ($p<0.5$) negative effect on emissions in the sampled communities. This indicates that the communities in which the local development plan has been in effect for a longer a period, had lower increase in per-capita emissions. Thus, the results support mitigation hypothesis 10 wherein longer plan years were expected to result in lower increase in emissions.

Results of the regression analysis showed that carbon employment had the strongest effect on the dependent variable (comparing beta coefficients). The values of the unstandardized coefficient suggests that a 1% increase in carbon employment resulted in an additional increase of 0.034 metric tons of carbon dioxide emissions per person. Coastal proximity shows the next strongest effect in the regression model. The results indicate that communities in coastal counties had an additional increase of 0.468 metric tons in per capita emissions compared to the communities outside the coastal counties.

Climate change plan quality index, income, and state mandate show equally strong effect on the dependent variable. The effect of plan quality and state mandate is negative whereas the effect of income variable is positive. From the unstandardized coefficient of plan quality index it can be interpreted that an increase in the plan quality index by 1 point resulted in lower change in per-capita emissions by 0.16 metric tons. On the other hand, an increase of $1000 in the per capita income resulted in an increase of 0.042 metric tons of per capita emissions. Communities in states that mandate local planning showed a lower increase in per-capita emissions by 0.44 metric tons.

Work travel variable had a comparatively lower strength of effect on the dependent variable. Communities with 1% more of workers travelling alone in a private vehicle to work had a higher increase in per-capita emissions by 0.027 metric tons. Comparatively, communities with an additional (1) year of plan enforcement, had lower increase in per-capita emissions by 0.124 metric tons.

7.4 Summary of the Results

One of the research objectives of this study was to evaluate the influence of climate change management plan quality of the local development plans on emissions. The results of the preceding analyses support the contention that local development plans significantly influence carbon dioxide emissions. The results of the OLS regression analysis showed that climate change management plan quality index had a statistically significant negative impact on the change in emissions from 1990 to 2005 in the sampled communities.

The results of the statistical analyses supported most of the initial hypotheses. Six out of the nine mitigation hypotheses were supported by the results of the OLS regression. The hypothesized effects of plan quality, income, work travel, carbon employment, state mandate and plan years on the dependent variable of change in emissions were validated. The results support the initial hypotheses that higher climate change management plan quality index, state mandate and plan years resulted in lower increase emissions, whereas higher income, work travel, and carbon employment resulted in increased emissions. The relative effect of these statistically significant variables was in the order of carbon employment, income, climate change management plan quality index, state mandate, work travel, and plan years.

Results of this analysis contradicted the hypothesized effect of coastal proximity. Contrary to the expectation, coastal communities showed higher increase in emissions. This may be due to higher energy demands and economic activity in the coastal cities.

The anticipated effect of risk perception due to sea level rise is probably not strong enough to translate into reduced emissions. The results of the regression analysis do not provide support for hypothesized effects of non-profit employment and sprawl on the dependent variable.

8. DISCUSSIONS AND POLICY RECOMMENDATIONS

Results from the preceding statistical analyses are summarized and expanded upon in this section. Results of phase –I analysis, plan quality evaluation, and the explanatory phase are collectively discussed in the context of the overall theme of this study. Thereafter, policy implications of these research findings are discussed and synthesized into recommendations.

8.1 Influence of Local Development Plans on Climate Change Management

The first phase of this study compared the change in per-capita carbon dioxide emissions from1990 to 2005 between groups of communities with and without local development plans. Data on all central cities in contiguous U.S was analyzed using t-test and analysis of covariance (ancova) models. The results showed statistically significant differences in emissions between the two groups of communities. Specifically, the results supported hypothesis 1, wherein communities with local development plans were expected to have lower emissions. The mean per-capita emissions in 2005 for communities without local development plans were 0.52 metric tons more than the emissions for communities with plans. The adjusted mean per-capita emissions (2005) in communities without local development were estimated to be 0.92 metric tons. In comparison communities with plans had 0.39 metric tons per-capita emissions, which is lower by more than 50%. These results support the rationale for community based climate change management. Other researchers have also argued for greater role for local communities as urban areas are considered the hot spots and drivers of climate change (Grimm, et al., 2008; Hunt, 2004). The preliminary results of this study are encouraging as they suggest that the emissions from urban areas can be managed through local development plans.

8.2 Climate Change Management Plan Quality

The first phase of the study was followed by detailed policy analysis of a random sample of 88 local development plans. Detailed plan quality evaluation protocol was used to evaluate the quality of planning policies contained in these plans. The climate change management plan quality evaluation protocol included 46 planning policies that are expected to significantly influence local climate change management. These policies were grouped into 10 planning components and were analyzed using descriptive statistics. The raw climate change management plan quality index was calculated as the mean of all individual policy evaluation scores for each development plan. Additionally, the implementation capacity of each local development plans was also measured using the plan implementation capacity evaluation protocol consisting of 10 policies. Plan implementation capacity was calculated for each plan using this protocol. The raw climate change management policy score was weighted by the implementation capacity score of the respective plan, to create the final climate change management plan quality index.

The mean raw climate change management policy score for the development plans was 54.59 points, which is approximately 60% of the maximum possible score. This indicates good quality of climate change management policies across the selected plans. The results also showed that the quality of the planning policies varied greatly across the sampled plans. Overall, these results were encouraging primarily because they highlighted the potential for use of local development plans as viable instruments for climate change management. If climate change management can be incorporated as a legitimate planning goal then the existing planning policies can be used to achieve desired climate change management results. These results supports the recommendation of other researchers to involve cities and local governments for effective management of greenhouse gases (Betsill & Bulkeley, 2007; Betsill & Bulkeley, 2004b; Kates, Wilbanks, & Abler, 2003; Smit & Wandel, 2006; White, 1994; Wilbanks & Kates, 1999).

Distribution of policy quality scores across the various policy groups indicated emphasis on site planning and transportation planning policies in the local development plans. Site planning policies such as site plan review, setbacks and subdivision regulations are important planning tools with potential for directing development away from physically vulnerable areas (Berke, et al., 1996; Brody, 2003a). Therefore, extensive coverage of these planning polices in the development plans is encouraging as they can be effective in local climate change management. As part of local climate change management, site suitability analysis studies can be mandated to include physical vulnerability assessments with respect to the anticipated impacts of climate change. Setbacks and subdivision regulations can be used to direct growth and development away from vulnerable areas and increase density of development in safe locations. Similarly, transportation policies too have the potential to provide enhanced mitigation benefits. Transportation sector is an important target for mitigation interventions as widespread use of fossil fuels in private vehicles makes it one of the few sectors where emissions continue to grow (Potter, 2003; Sperling & Clausen, 2002). Significant gains in controlling vehicular emissions are possible by promoting planning policies that create opportunities to reduce the use of private vehicles and increase alternative means of transportation. Local transportation polices promoting public transportation, bicycle paths, pedestrian facilities and traffic management can thus help significantly lower local emissions.

Planning policies related to awareness, educational and technology tools received a mean score of 6.72 points that was almost 70% of the maximum possible. This is particularly important in the context of risk communication and policy support for climate change management. Previous research suggests that enhancement of civic capacity through education and awareness activities can be effective in implementing climate change mitigation and adaptation policies (Brody, Zahran, Grover, & Vedlitz, 2008; Brody, Zahran, Vedlitz, et al., 2008; Zahran, et al., 2006; Zahran, Grover, et al., 2008). As local developments showed adequate coverage of planning policies for education and awareness, there is potential to integrate climate change communication and knowledge into the existing planning outreach framework. It is envisaged that increased community engagement and education on issues of climate change management will promote community support for appropriate policy action.

In the plan quality evaluation, building design polices scored the lowest mean policy score. Previous research on climate change response suggests that building design guidelines such as design standards for protection from natural hazards , water-efficient construction and rainwater harvesting, are important tools for local climate change (Belzer, Scott, & Sands, 1996; Steemers, 2003). Therefore, lack of attention to these tools in the local development plans is concerning. Communities will have to address these policies in more detail to facilitate effective climate change management at the local level. Low mean policy score for incentive/disincentive tools indicated lack of attention to these planning tools in local development plans. This is expected to hamper local climate change management efforts as these policies are important for motivating community members to adopt and support initiatives that may have associated personal costs.

Thus the results of climate change management plan quality evaluation suggest that there exists a ready framework of policies and tools in local development plans that can be used to incorporate enhanced climate change management considerations. Significant benefits can be achieved by communities with better detailing of these selected planning policies in the local development plans.

However, the results of implementation capacity evaluation were discouraging. The results indicate lack of attention to the overall implementation strategy. The low mean implementation capacity score suggests deficiencies in the implementation policies addressed in the local development plans. Due to this low plan implementation capacity score, the weighted mean climate change management plan quality index was less than 35% of the maximum possible score. that the analysis revealed that most local development plans did not have the desired combination of policies and implementation capacities necessary for effective climate change management. Therefore, even though the local development plans showed significant climate change management potential, they lacked adequate implementation capacity, thereby limiting the final benefits. Thus, the analysis of the climate change management policies it is evident that communities will need to better address their implementation policies in local development plans to derive maximum climate change management benefits.

8.3 Mitigation Effect

The effect of climate change management plan quality on the change in carbon dioxide emissions (1990-2005) was analyzed using regression analysis. Results of the OLS regression model support the hypothesis that climate change management plan quality index has a statistically significant effect on emissions. Communities with higher climate change management plan quality index were found to have lower increase in emissions. This is significant as it endorses earlier research claims that the choice of development path by a community has significant implications for greenhouse gas emissions (see Agyeman, et al., 1998; Collier, 1997; Rayner & Malone, 1997; Tol, 2001). Most climate change mitigation policies such as reducing vehicular emissions and lower energy emissions require changes in lifestyle and activities at the household and the community level. These community characteristics and household opportunities are, to a large extent, influenced the local development pattern. Thus, appropriate planning policies can potentially result in decreased emissions by adopting appropriate development strategy. If the quality of these planning policies contained in the local development plans enhanced further, the resulting mitigation effects can be significantly increased.

Related variable of plan years also showed statistically significant effect on the change in emissions. Local development plans that had been in effect for longer duration were found to result in lower increase in emissions. Most local development plans are framed with a long time perspective, often ranging from 10-20 years ahead. The results of this study suggest that given sufficient time for implementation, good planning policies have the potential to realize significant reductions in emissions. It is critical that planning policies and actions be provided sufficient time for implementation to show measurable impact. The communities will therefore have to ensure sustained support for climate change management policies, often beyond the electoral time-frame, to achieve noticeable reductions in local emissions.

Communities with high percentage of the workers employed in the carbon based sectors also showed higher increase in emissions. This had the strongest effect on the increase in emissions. Carbon intensive industries are direct emitters of emissions into the local environment. These results were as hypothesized. Other studies analyzing the impact of economic activities on emissions have also found similar results (Chang & Lin, 1999; Glaeser & Kahn, 2008; Holtz-Eakin & Selden, 1995). It is evident that if the communities continue to rely on carbon intensive sectors for economic growth, it will pose challenges for local climate change mitigation efforts. Thus, it will be prudent for communities to diversify their economic base to achieve an optimal mix of economic opportunities. The results of the study also suggest that the communities have the opportunity to offset some of these emissions through better land use planning, building design, transportation and other aspects of community development.

The per-capita income also showed significant positive effect on the increase in emissions. Communities with higher per-capita income showed higher increase emissions. This relationship was expected as a consequence of higher standard of living and a relatively more consumptive lifestyle associated with wealthier income groups. Similar relationships are seen in earlier studies analyzing the links between income and carbon emissions (Holtz-Eakin & Selden, 1995; Martinez-Zarzoso & Bengochea-Morancho, 2004; Shafik, 1994). On the other hand, these results seem to contradict the hypothesis based on Environmental Kuznets Curves (EKC) (Torras & Boyce, 1998). These researchers hypothesize an inverted U-shape relationship between income and emissions, suggesting that as the community income increases, the environmental pollution levels off in the middle-income range and then falls down along the inverted ‘U’ in wealthy societies (Dasgupta, Laplante, Wang, & Wheeler, 2002). With carbon dioxide emissions recognized as an atmospheric pollutant, researchers have hypothesized similar relationship between income and per capita emissions (Holtz-Eakin

& Selden, 1995; Panayotou, 1993). Whereas some studies found evidence supporting this hypothesis, others have also found contradictory results leading the researchers to conclude that the turning point in the U-curve of the EKC may be beyond the largest value for income range (Richmond & Kaufmann, 2006). The results of this study may also be explained by the same logic. It is possible that the sampled communities included in this study were in the upward phase of the inverted-U, with income levels yet to reach the turning point of the curve. Therefore, this observed relationship between income and emissions needs to be interpreted with caution.

The communities that had a higher percentage of workers travelling alone in private vehicles to work also showed greater increase per-capita emissions. Vehicular exhaust from private vehicles is known to be one of the primary sources of transportation related emissions in any urban area (Kahn, 1996). Thus, the results were as hypothesized. In such communities, with majority of the workers travelling alone to work in private vehicles, reduction in community emissions will be a daunting task. These communities will need to create and promote planning policies such as car pools or incentives for increasing vehicular occupancy in order to reduce their emissions.

Coastal communities also showed significantly higher increase in per capita emissions. This may be explained by greater energy consumption in coastal areas for internal climate control and increased economic activity in these cities. These results contradict outcomes of climate change risk perception research. Studies on perception of risk suggest that the much publicized impact of sea level rise prompts coastal communities and residents to undertake emission control initiatives (Zahran, Brody, et al., 2008; Zahran, Grover, et al., 2008). As most of the plans included in this study were formulated in the 1990’s, prior the increased focus on climate change, it is possible that the reaction to climate change risk perception is not captured in this study.

8.4 Policy Implications and Recommendations

The results from the statistical analyses conducted in this study and discussed in the preceding sub-sections have substantial policy implications. Overall, the findings of this study support the imperative need to include local development planning as an important tool in global climate change management. In recent years, many researchers have recommended community based climate change management programs for achieving climate change mitigation and adaptation goals (Bulkeley, et al., 2005; Satterthwaite, 2006; Wilbanks, 2003). However, research rhetoric has yet not translated into local action (Betsill & Bulkeley, 2007) . Lack of initiatives at the community level have been primarily hindered due to apprehensions about the capacity and ability of the existing local policy framework for undertaking climate change mitigation and adaptation actions (Betsill & Bulkeley, 2007; Granberg & Elander, 2007; Holgate, 2007). The results of this study emphasize the ability of local development plans as a viable tool for local climate change management.

Policy implications discussed in this sub-section are primarily focused towards local climate change management policy. Effective local climate change management requires planning and action at various scales and across all levels of governance. Therefore, these implications and recommendations will prove useful for all researchers and policy makers as guidelines for undertaking climate change management actions.

First, the present piece-meal approach to climate change management through state plans and sectoral initiatives needs to give way to integrated local decision making and developmental planning. Local development plans can be the ideal conduit for implementing federal and state level commitments of climate change mitigation. An effective response to climate change requires cross-cutting approach with complimentary policies across various thematic areas, such as transportation, land use, and zoning. Local development plans impact all these aspects of community growth and therefore should be the logical choice for local action.

Most local development plans contain a number of planning policies that impact climate change. In order to realize the full potential of these policies, it is necessary to allocate resources for improving the general quality of these planning policies. Without adequate detailing of the policies in the development plans, the potential benefits of these policies may never be realized. The planning policies as identified in the climate change management policy evaluation protocol can provide climate change management benefits and as such should be the first target for local action.

Communities also need to address the issue of poor quality of implementation policies in the local development plans. Lack of adequate implementation procedures and directions in the development plans limits the potential implementation benefits. This poses a challenge for achieving local climate change management objectives as well as the desired planning and development benefits that were envisaged during policy formulation. Strengthening of the public participation process, clear designation of responsibilities, phased timetable for monitoring and regular update procedures are some of the planning actions that can help effective implementation of the policies included in local development plans. Appropriate allocation of funds and an enabling institutional framework will go a long way in creating a successful plan implementation framework.

Another important policy implication of this research study is the need to initiate better place based climate change management strategies. Research assumptions based on global and national level analyses, commonly accepted in climate change management, cannot be necessarily implanted as is at the local level. Community level analyses are required to adapt these assumptions in the context of local community characteristics. For example, the outputs of this study do not support the commonly accepted inverted U-shape relationship between the income and carbon emissions as predicted by Environmental Kuznets Curve (EKC) hypothesis. This makes local policy regime inconsistent with the notion that climate change management can be achieved as a byproduct of increased community wealth. Instead, the results of this analysis highlight the concerns that increasing income and wealth may lead to ever increasing emissions and adaptation challenges. This reflects similar concerns of some researchers who worry that the plateau and the downward curve in the inverted U may never materialize in the context of climate change management (Liu, 2005). Consequently, increased income would not necessarily induce better attempts to control emissions. Instead, some communities may be forced to sacrifice economic growth opportunities in favor of achieving climate change management gains. Policy makers and decision makers will have to be mindful of this when formulating local climate change management strategies.

Another major implication of this study is the possible opportunity to create integrated mitigation and adaptation strategies that provide balanced climate change management benefits. The results of this study revealed that change management plan quality index had a significant impact on local emissions. This stands in stark contrast to the commonly accepted views. Many researchers and policy makers have traditionally viewed adaptation as the local priority, and mitigation as more of a regional or national issue (see Adger, 2001; Smit, et al., 2000). But the results of this research study suggest that local development plans have a significant impact on emissions. Therefore, it is possible to evolve an integrated approach to climate change management that will optimize resource utilization at the community level.

The results of this study also highlight the need to recognize possible conflicts between climate change management goals and local developmental priorities. Cities are preferred production sites for many industries as they provide a large pool of skilled manpower as well as a market for the finished goods (Sassen, 1991). However, the results of this study show that reliance on carbon intensive industries in a community will lead to increased emissions. Thus, from the climate change management perspective, growth of these industries in a community needs to be regulated. Even though the new industries will boost the local economy, they will also most likely result in increased emissions. Given this scenario where climate change management policies may compete with local socio-economic opportunities, new innovative means to limit emission will have to be explored. One of the possible ways may be to create regional emissions control and development partnerships, wherein group of communities can share developmental benefits while keeping regional emissions under control. Another option can be that of a national or regional carbon credit exchange allowing communities to trade emissions. Communities with higher carbon emissions can negotiate agreements with other communities with lower emissions to together maintain a fair share of emissions.

The final recommendation based on the results of this study is to focus on creating an integrated policy framework at the community level that combines the goals of climate change management with the local developmental aspirations. If the local development policies are sensitized to climate change issues and implications, it is expected that the resulting development would be truly sustainable. Presently, the resources available to communities for pursuing their goals of sustainable growth and development are limited. At the same time there is increasing pressure from the higher levels of governance and the world community to allocate more resources for climate change management. In this situation, there is a unique opportunity at the community level to evolve an integrated planning strategy wherein local development plans can also be used as vehicles for implementing climate change management actions. For example, increasing availability and accessibility to public transportation is often recognized as a local economic necessity. This study has shown that the same policy can result in climate change mitigation benefits too. Use of such policies that serve the dual purpose of local development as well as climate change management will most likely enable local communities to access climate change management funds that will add to the local resources available for community development. Convergence of planning policies for pursuing the dual objectives of sustainable growth and climate change mitigation will help achieve efficient utilization of resources and create synergistic opportunities for sustainable development.

9. CONCLUSIONS

Results of this research study provide empirical evidence supporting the important and significant role of local development plans in climate change management. Other researchers have recommended community based approaches to climate change mitigation and adaptation primarily on the basis of theoretical analysis of the jurisdictional scope and control (see Angel et al., 1998; Collier, 1997; Gupta, Van Der Leeuw, & De Moel, 2007; Kates, Mayfield, Torrie, & Witcher, 1998). The results of this study support their claims and arguments. This study fills in the ‘gap’ between academic prescription and professional practice in climate change management research, by corroborating the key role of local development plans in climate change management.

The outcomes of this study complement earlier research on the role of local development plans in ecological and environmental conservation. Earlier research by Godschalk et al. (1998) and Burby (1999) provides evidence that local planning can be an effective tool for limiting disaster losses and creating disaster resilient communities. Brody’s (2003c) analysis of comprehensive plan in Florida shows that jurisdictions with higher quality comprehensive plans are more successful in achieving the sustainability and conservation objectives of ecosystem management. Other research studies have shown the importance of good quality of local development plans in managing issues related to natural hazards (Berke & Beatley, 1992; Brody, 2003a; Nelson & Steven), land use pattern (Kent & Jones, 1990), ecosystem management (Brody, 2003c; Brody, Carrasco, et al., 2003; Brody, Highfield, & Carrasco, 2004; Brody & Highfield, 2005), and sustainability (Berke, 1995; Berke & Conroy, 2000; Berke, et al., 1999; Conroy & Berke, 2004; Laurian, et al., 2004). This study builds on this rich literature on the diverse role of local development plans by providing empirical evidence supporting the role of local development plans as a viable and appropriate policy instrument for climate change management.

The results of this study highlight the need to seek opportunities for synergistic growth, development, and climate change management at the community level. At present most cities and states are pursuing climate change actions unilaterally (Engel, 2005). Consequently, there is increasing competition for allocation of resources for competing demands of climate change management and development priorities. The results of this study indicate that climate change management objectives and development goals can be achieved by using the existing planning framework of local development plans. Integration of multiple policy goals will open up opportunities for efficient and optimal utilization of resources. Local development plans offer a unique opportunity to create such an integrated local policy action framework that can meet the dual objectives of climate change management and sustainable development.

9.1 Research Summary

Various components of this research provided significant and interesting results. Some of results supported the initial hypotheses, especially in relation to the mitigation effect of local development plans, while others contradicted the initial hypotheses and therefore, necessitated alternative explanations for the observed effect. Overall, this research endorses the role of local development plans as a viable tool in climate change management. Even though climate change management goals are yet to be included in planning practice, strong linkages between them are evident. This research highlights the links between climate change management objectives, and common planning policies contained in local development plans.

The first phase of this research study identified significant differences with respect to per-capita emissions between communities with and without local development plans. Communities with development plans had significantly lower gain in per-capita emissions in comparison to the communities without plans. Climate change management plan quality analysis revealed opportunities and challenges in using local development plans as tools for climate change management. Results of the overall plan quality analysis were mixed. It was observed that even though local development plans included numerous planning policies with potential to influence climate change management, the ultimate impact on the community was limited due to the wide variations in quality of details and a weak implementation strategy. Descriptive analyses of planning policies exposed wide variation in policy quality across the development plans. Implementation analysis of the development plans showed low quality of implementation capacity that limits the impact of planning policies.

In the explanatory phase, statistical analyses showed that climate change management plan quality index had a positive mitigation impact. Communities with higher plan quality index showed lower increase in per-capita emissions. The results also highlighted the importance of having a sufficient period of policy enforcement to significantly influence community emissions. Communities that had longer periods of plan enforcement showed relatively lower increase per-capita emissions. Importance of state mandate for local planning was also found to be significantly associated with lower increase in emissions. Socio-economic characteristics of income, work travel, and carbon employment were also found to significantly influence emissions. Communities with higher per–capita income and carbon employment base showed higher emissions. These results suggest that wealthy communities contribute more to the problem of climate change. The effect of carbon employment on emissions suggests that communities need to diversify their economic base and move away from carbon intensive sectors in order to control their emissions.

The primary policy recommendation is to include climate change management considerations in mainstream urban planning. The results of this study support the use of local development plans as a viable tool for climate change management. The outcomes of the various empirical analyses undertaken in this study highlight the key role of local development plans in influencing climate change mitigation outcomes. Overall the results support increasing demands for adopting place based approach for climate change management. The empirical results of this study suggest that substantial climate change management gains can be made by enhancing the quality of local development plans.

Possible contradictions in development goals and climate change management objectives were also discovered in this study. Some communities may need to be comprise developmental aspirations to decrease their contribution to climate change . This study recommends formulating climate change management policies through regional partnerships and place based actions that are responsive to the natural landscape.

Even though the results of this research study were based on the data collected for the central cities in the U.S, the methodology, the analytical approach, and the implications can be extended to other similar communities. It is envisaged that inclusion of climate change sensitivity in planning will provide impetus to community based mitigation initiatives. Planning actions focusing on achieving the dual aims of climate change management and sustainable development will help achieve balanced community development.

9.2 Study Limitations

Although this study provides a better understanding of the role of local development plans in climate change management, the results need to be interpreted within the limitations of this study.

Firstly, the measure of climate change mitigation used in this study is the best available and not the ideal. As discussed earlier, there is lack of reliable data on emissions at the community level. This study used the best available data on emissions that included residential, transportation (road and non-road), and commercial sectors. Emission from the other sectors such as industrial uses, and land use change were not included in this study due to reliability issues. However, in order to derive a better understanding of emissions in a community all sectoral emissions will need to be included. Also, lack of fine resolution data necessitated use of geo-processing techniques for estimating community level emissions. This may have introduced some degree of processing error in the estimates. Increasing understanding of the science behind climate change will possibly lead to finer resolution data at the community level that will help create better and more reliable measures. Therefore, the outcomes and implications of this study need to be understood within the limitations of the measurement techniques used for estimating emissions.

This study included only 88 central cities in the explanatory phase of the analysis. This is not a big sample size and therefore the statistical analysis may have low statistical power. Also, as the sample frame was limited only to the central cities, the results of this study may be extendable only to communities with similar socio-economic profile.

Another limitation of the study is the use of a simple coding technique for plan evaluation. The climate change management plan quality evaluation protocol coded planning policies on a scale of 0 to 2 based on the presence and the details included in the development plan. However, the specifics of proposals were not evaluated. For example, proposals for high density development ranged from 25-60 units/acre. Even if the actual outcomes of the varying densities in this range may be very different, all high density policies within this range were coded and graded at the same level of detail. The evaluation protocol used in this study did not evaluate or grade such policy targets which may have influenced the observed results.

While the results of this study provide significant empirical evidence supporting the relationship between local development plan policies and climate change management, this study did not investigate the intermediate step of plan implementation. The plan implementation capacity assessment used in the study did try to measure it to some extent but is certainly not a substitute for implementation process evaluation. Therefore, this study does lack efficient measures of variation in implementation processes that may have been present in the sampled communities.

Finally, this study suffers from the known limitations of cross-sectional research. Even though statistical analyses show statistically significant relationships, causality cannot be inferred. In order to minimize the history effect, independent variables were measured for the time period preceding the dependent variables. However, as local planning and plan making is a complex evolutionary process, history and feedback effects cannot be ruled out.

9.3 Future Research

This study is only the first step towards understanding the role of local development plans in climate change management. Further research is necessary to enable a more detailed understanding of the relationship between local development plans and climate change management.

In order to overcome the limitations of this study more communities need to be included in future research. Representative communities from each state and diverse bio-physical environments need to included to facilitative comparative analysis. The climate change management plan quality evaluation protocol used in this study can be applied to other communities as an evaluation criteria for existing policies and planning proposals. The protocol can also serve a guiding document for formulating climate change sensitive planning policies in local development plans.

Future research also needs to focus on creating rigorous datasets for measuring urban emissions. Climate change science is still in early stages of research and may need more time to develop instruments for generating fine resolution data. In the meantime, future data collection initiatives should look at creating better and stronger indirect measures of climate change.

This study focused on assessing the impact of climate change management plan quality on emissions. However it is also important to evaluate the adaptation impact of local development plans. The primary reason for not addressing the adaptation side of climate change was lack of efficient measure of climate change risk at the community level. While the results of this study indicate that planning policies in local development plan do influence climate change mitigation, the adaptation influence also needs to be analyzed. This would help communities better evaluate and measure the overall benefits of local development policies.

Detailed analysis of the plan implementation process is another important aspect not addressed in this study but should be included in future research. This study used policy evaluation of implementation polices included in the development plans as a proxy measure for actual implementation assessment. Local climate change policy formulation would benefit by thorough investigation of the variation in implementation strategies within communities. Examination of the factors that influence various levels of implementation would help evolve better and more effective policy guidelines in local development plans.

In this study, I focused on evaluating the impact of the aggregated index of climate change management plan quality. Future studies can improve upon the results through disaggregated analysis of planning policies. Further investigation of each planning component and planning policy will provide greater assessment of the strength and weaknesses of each policy with respect to climate change management.

Finally, future studies should also look at detailed case study analysis. Focused case studies would help identify the best practices and challenges for effective climate change management at the community level. Inclusion of data on planning capacity, community leadership, residents and business attitude in case study analysis would help identify barriers and opportunities to integrating climate change management goals in the local planning process. These studies would also provide valuable insights that can be used to evolve an integrated framework for climate change sensitive sustainable development.

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APPENDIX I

Climate Change Management Plan Quality Evaluation Protocol Items

Plan Component	Desired Environmental Change Management Policies/Actions
Land use and zoning	Promote mixed use development
	Promote Brownfield / Grey-field redevelopment
	Promote Infill development
	Use of overlay zones or reduced density zones
	Promote relocation of vulnerable structures out of hazard zones
Urban Design/Built form	Promote high density development
	Promote low-water intensive urban landscape
	Building height/ orientation guidelines, street width to building height ratios
	Proposals/actions for increasing urban green space, urban forests, tree lined streets
Site Planning	Site plan review requiring land suitability assessment/ Special study/impact assessment
	Setbacks/Buffers
	Subdivision regulations
Building design	Storage, collection and recycling of wastes
	Water-efficient construction
	Recycling of grey-water
	Rainwater harvesting
	On-site water treatment
	Building standards/Building code for enhanced protection from natural hazards
Transportation	Creating/implementing/enhancing public transportation systems
	Increasing public transportation stops/nodes
	Management of no traffic zones
	Creation/ upgrading of bicycle paths
	Creation/ upgrading of pedestrian facilities
Natural resource management	Emergency/ Disaster/Hazard Management guidelines
	Environmentally sensitive area protection (national/state parks, coastal barriers, breeding areas)
	Conservation of forests, vegetation, and riparian areas

Plan Component	Desired Environmental Change Management Policies/Actions
	Policies to prevent habitat fragmentation
	Sediment and erosion control regulations
	Stream dumping regulations/ prevention regulations
	Wetlands restoration regulations
Public facilities and Infrastructure	Proposals/ policies for Structural tools for controlling hazard losses (dams, dykes, flood gates etc)
	Capital Improvement projects for phased development
	Proposals/ policies for redevelopment /retrofitting/ maintenance of public structure
	Proposals for locating critical facilities in non-hazardous areas
Acquisition tools	Land and property acquisition (fee simple purchase/eminent domain)
	Dedication of hazardous open space (conservation easement)
	Transfer of development rights
	Purchase of development rights
Incentive/disincentive tools	Subsidized mass transit / incentives for car pooling
	Density bonuses
	Impact fees
Awareness/Educational Tools	Education and outreach program during plan implementation
	Information dissemination regarding location of hazardous areas (including posting of signs, information booklets etc)
	Disaster warning and response awareness program
	Training/Technical assistance to developers or property owners
	Computer models/evacuation systems/transportation models/ GIS (e.q. HEC, web-based modeling system)

Coding Conditions:

0	**Not mentioned in plan**
1	**Mentioned but no detail** - Stated as recommendation for future development, a general policy reference or a suggestion to look for opportunities to implement the policy Key words - “should”, “may”, “encourage”, “prefer”, or “suggest”.
2	**Mentioned in Detail** - Identifies at least 1 location for implementing this during the plan period. - Answers the questions – ‘when’, ‘where’, ‘what’ and ‘how’ Key words - “mandate,” “shall,” “must” or “will”

APPENDIX II

Climate Change Management Plan Quality Evaluation Protocol

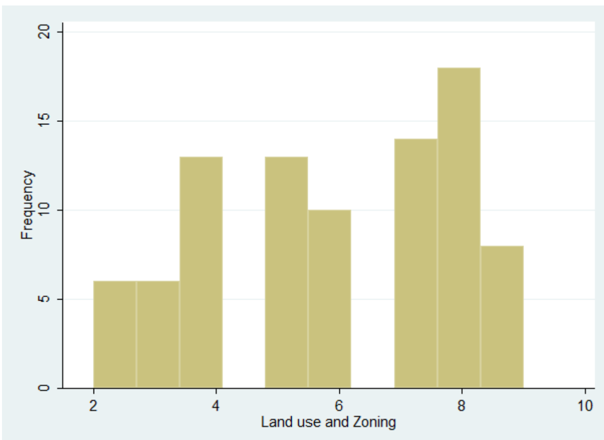
Implementation Policy
History of Planning (Past planning initiatives)
Identification of costs/ funding for implementation
Designation of responsibility for implementation
Timetable for implementation
Sanctions for failure to implement
Regular update procedures
Provisions for technical assistance
Monitoring of environmental and human impacts
Public participation process in monitoring and review
Provision of plan response to new information/ data

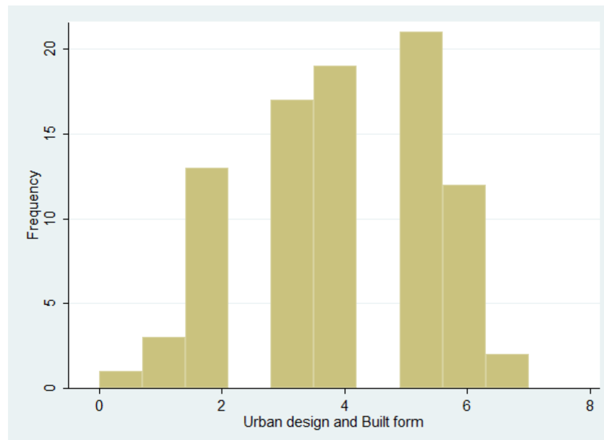
Coding Conditions:

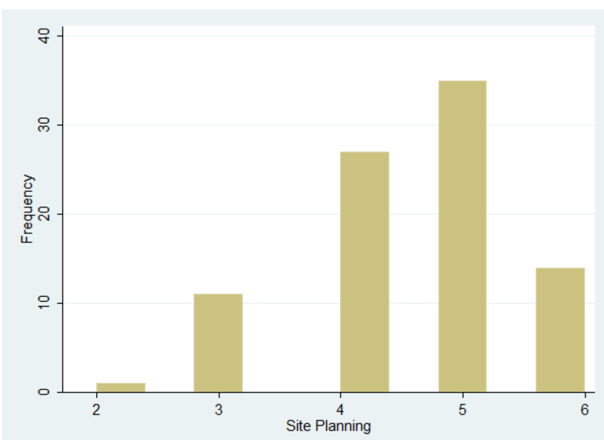
0	Not mentioned in plan
1	Mentioned but not detailed
2	Mentioned in Detail

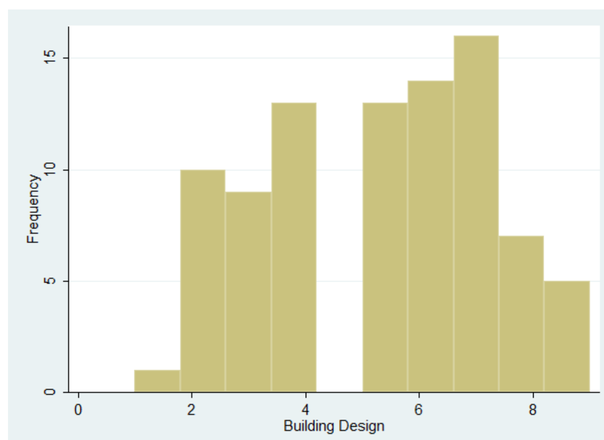
APPENDIX III

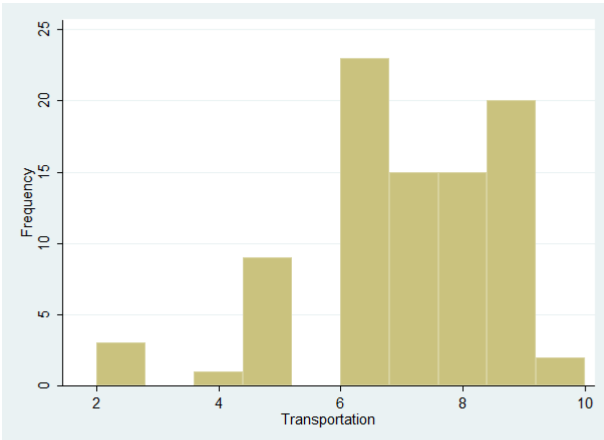
Histograms







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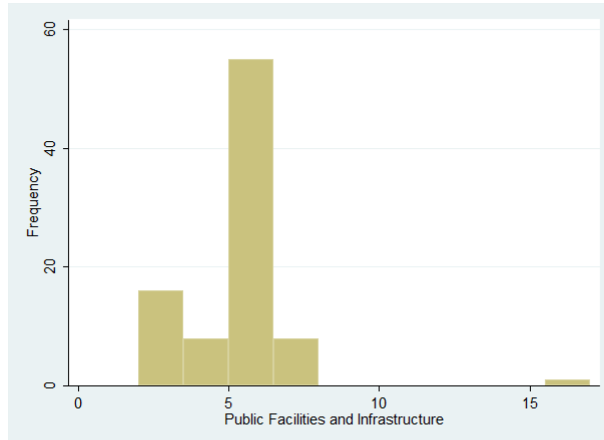
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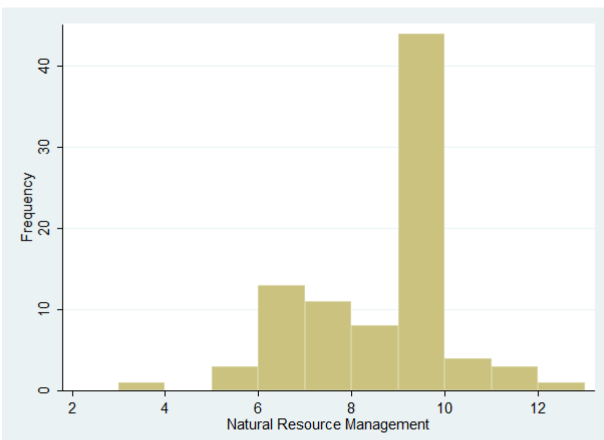
Public Facilities and Infrastructure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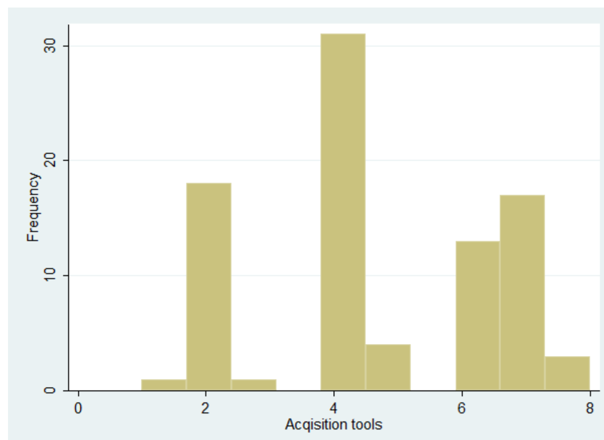
Natural Resource Management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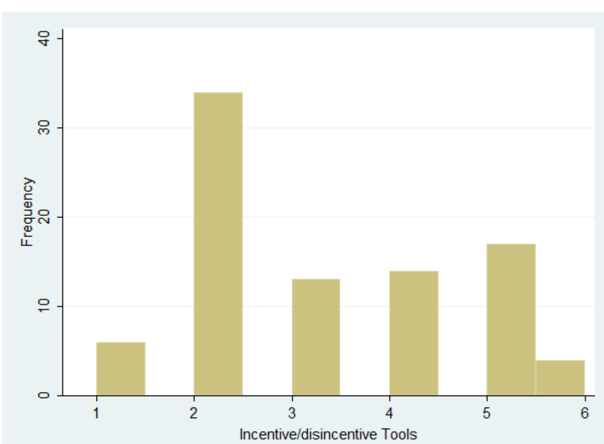
8
Acqisition tools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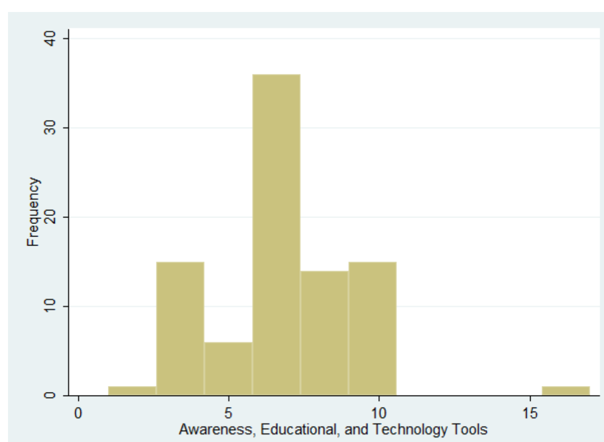
Incentive/disincentive Tools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Awareness, Educational, and Technology Tools

APPENDIX IV

Communities with highest and lowest increase in per-capita emissions in metric tons/person (1990-2005)

Lowest 5		Top 5	
-3.13	FL, Port St. Lucie	5.50	NJ, Camden
-1.56	ID, Nampa	2.90	NC, Gastonia
-1.17	NC, Concord	2.68	DC, Washington
-1.05	CA, Chico	2.64	CA, San Francisco
-1.02	NC, Durham	2.19	KS, Wichita

Communities with lowest and highest Climate Change Management Plan Quality Index

Lowest 5		Top 5	
9.6	FL, Fort Myers	63.75	CA, Long Beach
10.85	AL, Decatur	58.4	CA, Alameda
10.85	NC, Winston-Salem	55.2	MD, Hagerstown
12.1	KY, Ashland	53.9	NC, Greenville
13.3	TN, Johnson City	53.9	KS, Wichita

Communities with lowest and highest Per-capita Income in US$ (2000)

Lowest 5		Top 5	
13009	NJ, Newark	45628	FL, Boca Raton
13115	CA, Merced	34556	CA, San Francisco
13428	CT, Hartford	31755	CA, Santa Clara
14283	MI, Muskegon	30982	CA, Alameda
14491	ID, Nampa	28659	DC, Washington

Communities with lowest and highest Work Travel in % (2000)

Lowest 5		Top 5	
61.29	CA, San Francisco	95.80	NJ, Camden
64.57	NY, Poughkeepsie	95.73	NJ, Bayonne
72.20	NC, Concord	95.62	CT, Hartford
72.74	FL, Palm Bay	95.52	MI, Battle Creek
72.97	NJ, Newark	95.33	KY, Ashland

Communities with lowest and highest Nonprofit Employment in % (2000)

Lowest 5		Top 5	
3.58	CA, Anaheim	16.24	VT, Burlington
4.18	VA, Suffolk	16.05	DC, Washington
4.19	NC, Hickory	14.49	MN, Duluth
4.21	CA, Gilroy	13.32	KS, Wichita
4.30	NC, Morganton	13.25	NC, Durham

Communities with lowest and highest Carbon Employment in % (2000)

Lowest 5		Top 5	
14.89	FL, Boca Raton	64.26	MI, Muskegon
15.27	DC, Washington	60.97	MA, New Bedford
18.70	AL, Auburn	60.05	VA, Danville
20.85	CA, Pasadena	59.22	CA, San Francisco
21.83	SC, Charleston	58.36	NJ, Camden

Communities with lowest and highest Sprawl in sqm/person (2000)

Lowest 5		Top 5	
126.11	CO, Denver	3885.49	AL, Dothan
317.80	CA, Long Beach	3251.56	MA, Barnstable Town
396.99	CT, Bridgeport	2717.63	NC, Morganton
446.08	NY, Poughkeepsie	2599.15	SC, Charleston
459.43	NY, Buffalo	2565.00	AL, Decatur

VITA

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Zahran, S., Grover, H., Brody S.D., and Vedlitz, A. 2008. Risk, Stress, and Capacity: Explaining Metropolitan Commitment to Climate Protection. Urban Affairs Review, 43:447-474.
Brody, S.D., Zahran, S., Maghelal, P., Grover, H., and Highfield, W. 2007. The rising costs of floods: Examining the impact of planning and development decisions on property damage in Florida. Journal of the American Planning Association 73(3): 330-345.
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Zahran, S., Brody, S.D., Grover, H., and Vedlitz, A. 2006. Climate Change Vulnerability and Policy Support. Society and Natural Resources 19(9):771-789.

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Regents Fellowship, TAMU, 2004-05