CLIMATE CHANGE AND THE LAW, ECONOMICS AND POLICY OF CALIFORNIA LAND USE CHANGE: COASTAL MANAGEMENT RISK AND VULNERABILITIES

Margaret Caldwell, Stanford University Law
Judith Kildow, Monterey Bay Aquarium Research Institute
Michael Reilly, Woods Institute for the Environment, Stanford University
Michael Mastrandrea, Woods Institute for the Environment, Stanford University

The following represents a strategic research approach to the climate change issues in California offered by a small research group anticipating such an undertaking in the near future.

Problem: In California's coastal areas, current development patterns, policies, and legal frameworks may be on a collision course with projected climate change impacts.

Goals: Compile historical information to forecast future growth patterns in California's coastal and coastal adjacent areas for use in a coupled systems model that allows users to visualize development patterns, current policies and legal frameworks, and their interaction with projected climate change impacts to identify critical risks and vulnerabilities and analyze a range of policy choices.

Purpose: To collect baseline information on key land use indicators for California's coastal and coastal adjacent areas over the last 50 years: e.g. residential, commercial/industrial, agricultural, estuarine, forests, dune systems, coastal watersheds, recreational areas, open space. To create a decision support tool (systems analysis model) for state and local managers to understand the implications of decisions under a range of climate change and policy scenarios. To identify the conflicts and gaps in the state's legal and regulatory system that affect coastal and coastal adjacent areas, as pressures build from climate change, urbanization, and other stressors.

Importance and Justification: California will experience major impacts in its coastal and coastal adjacent communities as climate changes unfold, areas that are crucial to California's vitality. As of 2005, California's coastal counties accounted for 83% of the state economy, 79% of its jobs, and 75% of the population on only 25% of its land area. The coastal areas host a major part of the state's public infrastructure, are out-migration destinations, major workforce sources for coastal industries, food supply sources, and encompass essential components of the state's unique ecosystems. They are also critically vulnerable to climate change impacts such as sea level rise, continued increases in air and water temperatures, water and food supply shortages, wildfires, precipitation and coastal storm changes causing changes in river and stream flow inputs, flooding, and erosion, loss of near-shore habitat and wetlands, changes in species

composition and distribution, ocean acidification, and air quality and public health problems (Snover et al., 2005; Luers and Moser, 2006; Cayan et al., 2006; Caldeira and Wickett, 2003; Sallenger et al., 2002; Sagarin et al., 1999; Hollbrook et al., 1997).

To plan for a sustainable future, Californians must understand the potential interactions between projected climate change and forecasted trends in land use and population growth along the coast and coastal adjacent areas. While individual studies have been done to project urban growth patterns and demographic changes, no one has evaluated these future trends together in the context of potential climate change scenarios, nor analyzed the specific risks and vulnerabilities these areas face. The compilation of decades of historical data documenting changes in land use, and economic and population growth can be used as a basis for forecasting future trajectories, and can be coupled with existing detailed scenarios of climate change and their impacts on California. An assessment of the current legal and regulatory system combined with the power of this information can reveal where policies and laws may not be adequate to manage the pressures from likely changes in the next decades, and where policy changes are needed to avoid or at least ameliorate damage and destruction of the quality of life in these areas of California.

Vulnerability of coastal California to climate and demographic changes: Vulnerability analysis is a conceptual framework to understand the potential damages to social and natural systems from stresses such as climate change, and to highlight key areas for management capacity-building and policymaking to address and mitigate or prevent those damages (Luers and Moser, 2006). Vulnerability is a function of exposure to a stress, sensitivity to that stress, and the adaptive capacity to deal with that stress, which may differ due to ranges in awareness, analytic capacity, and action (Turner et al., 2003; Metzger, 2005). Scientists and policymakers increasingly recognize that climate change should be viewed in the context of multiple, interacting stresses (Luers and Moser, 2006). Climate change can both exacerbate existing stresses (e.g., increase the frequency of droughts where droughts were previously experienced) and create new ones (e.g., sea level rise. There is increased agreement among scientists and policymakers that both adaptation (dealing with climate change impacts) and mitigation (reducing further impacts) are important response strategies to climate change.

Tasks:
I. Historical land use patterns: development, economic and population changes within the target geography as far back as adequate data allows: We will use a combination of existing datasets, land use maps, satellite imagery, aerial photographs, and archival resources, both published and unpublished, to map historical land use patterns in coastal California. Two types of data on socioeconomic activity are required: population data and economic data.

II. Analyze the information and develop projections for future growth patterns: With an assembled historical time-series of economic, socio-demographic, and land use data, it is necessary to build statistical and rule-based models to predict potential urban futures for the coastal region. Existing efforts have demonstrated the feasibility of this approach for California (Landis and Reilly, 2003) but have lacked the time span, geographic specificity, and climate change focus of the current work.

While predicting future growth patterns is an inherently difficult task, the use of a scenario-based approach greatly improves the ability to intelligently plan for the future (Landis and Reilly, 2006). There is a need to devise multiple scenarios for the coast's future by varying various growth rates, spatial interrelationships, and land consumption demands. The first scenario represents a baseline where the rates and spatial logic of growth is assumed to remain very similar to observed historical patterns of change. Other scenarios should examine policy modifications or economic changes.

III. Develop a multi-criteria decision-making model using the compiled historic land use information, economic indicators, current policies and legal frameworks, and climate change scenarios to forecast trends and evaluate policy choices: Some existing efforts have aimed to provide coastal managers with support tools to aid in decision-making in the context of climate change. For example, Snover et al. (2007) have compiled a comprehensive resource for governments at the state, regional, and local levels to prepare for climate change, including a checklist and detailed directions on setting and achieving scientific, institutional, and political goals to respond appropriately to climate change. They highlight motivations for governments to address climate change, including the fact that climate change is already underway, that we are committed to substantial changes in the next few decades regardless of climate policy choices, that losses from climate change in the absence of action may be irreversible, and that climate change creates economic opportunities (Snover et al., 2007).

IV. Evaluate data projections under climate change scenarios already developed for the state, using an economic and policy multi-criteria decision making analysis model, considering varying time and scale changes: Climate scientists have developed a range of potential climate change scenarios based on different assumptions about future greenhouse gas emissions and different assumptions about how the climate will respond to rising concentrations of greenhouse gases in the atmosphere. California is likely to face is the potential for more intense and/or more frequent extreme events (heat waves, heavy precipitation, etc.) than those seen historically, since extreme events can change substantially with small average changes.California has experienced sea-level rise of about 10-20cm over the past 100 years in the southern and central open ocean sections and San Francisco Bay. Sea level in California is projected to increase by 11-54cm

(under a lower emissions scenario), 14-61 cm (medium emissions) and 17-72cm (highest emissions)over the coming century (Cayan et al., 2006).
V. Analyze the current legal and policy frameworks' readiness, capacity and direction for managing natural and human land use changes: Moser and Tribbia (2006) surveyed 135 coastal managers in California, who represented 89% of coastal cities and counties in the state. They identified their top management problems as inland and near-shore water quality, inland flooding, species and habitat protection, and coastal erosion and flooding. More than 80% of managers reported facing development pressure in coastal areas that was moderate, significant, or extreme. Moser and Tribbia (2006) conclude that coastal managers in California are inadequately prepared for the impacts of climate change on coastal areas. A study of 17 coastal managers in California (Moser and Luers, 2006) examined their attitudes and knowledge about global warming, agency efforts to prepare for coastal climate change impacts, and climate change – related information needs to account for climate change in their management efforts. Information will be gathered based on the findings of Moser and Luers, 2006.

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Judith Kildow
Monterey Bay Aquarium Research Institute
7700 Sandholdt Rd
Moss Landing, California, 95039, USA
Ph (831) 775-2075
Fax (831) 775-1620
Email address: jtk@mbari.org