UNDERSTANDING FLOOD RESILIENCE STRATEGIES IN VENTURA AND SAN LUIS OBISPO COUNTY: USING A SOCIAL-ECOLOGICAL-TECHNOLOGICAL-SYSTEMS FRAMEWORK

By

Nikki Maraviglia

A Thesis

Submitted in Partial Fulfillment

of the Requirements for the Degree of

Master of Science

in Applied Geospatial Science

Northern Arizona University

May 2024

Approved:

Jessica R. Barnes, Ph.D. Chair

R. Dawn Hawley, Ph.D.

Steven Gehrke, Ph.D.

ABSTRACT

UNDERSTANDING FLOOD RESILIENCE STRATEGIES IN VENTURA AND SAN LUIS OBISPO COUNTY: USING A SOCIAL-ECOLOGICAL-TECHNOLOGICAL-SYSTEMS FRAMEWORK

NIKKI MARAVIGLIA

Climate change poses a long-term risk to communities, increasing chronic and shock stresses to infrastructure and the environment. Flood risk has increased with climate change, with more frequent and worsening flooding events are already occurring. Historically, regional planners have focused on resisting chronic and shock stresses like flooding. In recent years the mindset of planners has shifted from resistance to resilience theories in planning strategies. Emerging research suggests flood risk management strategies balancing Social-Ecological-Technological-Systems (SETS) approaches to FRM are more effective. Using a SETS framework two California counties General Plans were assessed to understand the existing Flood Risk Management (FRM) strategies utilized in both counties. The SETS strategies differ by county, implying opportunities for learning from the two counties' experiences. San Luis Obispo County, situated in southern California, has been experiencing increased flooding events and loss of life, yet their approach to FRM has not been updated in recent decades. Ventura County, also situated in southern California, has also been experiencing increased flooding events. Recently Ventura County adopted a new General Plan to account for the chronic and shock stresses to existing systems from flooding. Both Counties have differing flood risk management strategies, with Ventura

County having a more balanced SETS approach, and a greater focus on resilience than San Luis Obispo County.

Acknowledgements

I would like to express my gratitude to Northern Arizona University Department of Geography, Planning & Recreation Professors for accommodating me through my graduate studies. To my advisor Dr. Barnes, for supporting me through topic changes, pivots, and adjustments during my writing process. I am grateful for Dr. Barnes' support throughout the program, from my cancer diagnosis immediately after starting the program, I have had her support from the beginning. To Dr. Hawley, for the amazing planning courses, I would not have focused so much on planning had it not been for her amazing classes. Thanks to my entire committee for supporting me through this process and providing support and helpful edits to my paper. I would also like to extend gratitude to my family and friends in supporting me through long nights and busy schedules of this program.

Table of Contents

List of Figures

List of Tables

List of Acronyms

ALERT	Automated Local Evaluation in Real Time
CRS	Community Rating System
FEMA	Federal Emergency Management Agency
FRM	Flood Risk Management
LUC	Land Use Circulation
LUCE	Land Use and Circulation Elements
NFIP	National Flood Insurance Program
RRT	Resistance Resilience Transformation
SE	Social Ecological
SET	Social Ecological Systems
SETS	Social Ecological Technological Systems
SFHA	Special Flood Hazard Area
SLO	San Luis Obispo
SLOF C&WCD	The San Luis Obispo Flood Control and Water Conservation District
ST	Social Technological
STF	Safe to Fail
TE	Technological Ecological
VCRMA	Ventura County Resource Management Agency

Chapter 1: Introduction

Flood risk management strategies of the 20th century typically focused on resisting flooding events, often by building technological solutions to block flood waters from damaging cities. Resistance based strategies once thought of as ideal for flood risk management (FRM) are now being questioned and rethought with an emerging body of research on climate resilience (McPhearson et al., 2022). Resiliency based approaches expand beyond technological solutions which typically physically block flood waters, and now shift into a combination of approaches, including social, and ecological solutions. A Social, Ecological, and Technological Systems (SETS) based approach to FRM is being accepted and encouraged by scholars who focus on resilience in a planning setting. A SETS based approach provides a more holistic strategy for communities to improve their flood resilience capacity (Chang et al., 2022). Climate change and land use changes have contributed to increased flooding across the globe. California is susceptible to all types of flooding, including coastal flooding and flash flooding. How floods are managed and prevented varies across the state. Each county is required to outline their strategies for hazards including flooding in their General Plan. Flood management and mitigation is a concern for planners and stakeholders alike. The strategies for management and mitigation are diverse and complicated. Two coastal counties with very different flood management strategies are San Luis Obispo County and Ventura County. Ventura utilizes more of a SETS based approach to include FRM strategies that are Social, Ecological, and Technological in nature, as well as approaches that blend different elements of SETS. San Luis Obispo's FRM strategies are consistent with strategies that were the norm in the 20th century, focusing primarily

on resistance and technological approaches. The differences in these counties highlight the need for more uniform flood management strategies in the state, as well as more clarity in communicating FRM strategies. The goal of this research is to examine the existing and planned FRM strategies in Ventura County and San Luis Obispo County, by evaluating their General Plans using a SETS framework to assess how resilient each county is to the chronic and shock stresses of flooding.

Ventura and San Luis Obispo counties have a history of flooding, mudflows, related disasters, and loss of property and life. The floods of 1969 in Ventura County resulted in a high volume of water rushing through the Ventura River Watershed, loss of life and changes to flood management in the county. Ventura County has a robust system of assessing and reassessing plans that mitigate and manage flooding. A series of interactive maps, risk resources, and data can be found on Ventura county's websites providing a plethora of information on floods, resources, current projects and the status of water levels. San Luis Obispo County has considerably fewer resources provided online at the county level. In January 2023 in San Luis Obispo County floods resulted in a mother and child washing away at a creek crossing, which are common in the county (see Figure 1 for example of the creek crossing in San Luis Obispo County). The mother was rescued but the child still has not been found as of April 2024. This event has resulted in the family of this child filing a wrongful death lawsuit against San Luis Obispo County among others. Kyle Doan washed away with his mother Lindsay in January of 2023 the Doan family's lawsuit alleges:

“As a direct and proximate result of defendants’ negligence, a breach of duty and failure to take steps to either make the risky conditions safe or warn drivers of the dangerous conditions, all caused, Kyle to be swept away by raging floodwaters at the crossing of San Marcos Road and Wellsona Road. Although his body has not yet been located, Kyle is tragically presumed deceased.”

Despite this tragic disaster no mention of it is made on any county website. Nor are there any apparent changes to how floods are managed in San Luis Obispo County if one were to pursue their sites. The flooding and water management of San Luis Obispo County is focused on the area surrounding their largest city, the City of San Luis Obispo, and there is less information and resources for the smaller communities and rural areas of the county. Their resources are also focused on property owners, primarily highlighting permitting, and ordinances for building.

The National Flood Insurance Program (NFIP) sets a standard for how flood information is conveyed across the United States in regions that wish to participate in the program – establishing a standard for mapping, requirements of impacted areas, and outlining thresholds. The National Flood Insurance Program is not compulsory, however both San Luis Obispo and Ventura County participate in the National Flood Insurance Program, to different degrees. A large part of how Ventura County differs from San Luis Obispo County in their approach to flooding is to what degree they choose to participate in the National Flood Insurance Program (it is a tiered system), as well as how they communicate the information around flooding in the region. The General Plans of each county and FRM strategies therein echo the differences in how each county ranks on the NFIP ranking system.

Figure 1: Creek Crossing San Luis Obispo County

1.1 Regional Setting

San Luis Obispo County and Ventura County employ different strategies for FRM, both participate in the National Flood Insurance Program, and utilize the mapping within the program to inform decisions and the public. San Luis Obispo does not participate in the Community Ranking System at a county level, a system that offers additional incentives to participating communities in the National Flood Insurance Program. However, Ventura County does participate in the CRS at a county level, offering a more regional strategy to FRM that is evident in their General Plans, see figures 3 and 4 which show the CRS distribution in each county. This information is important when considering the differing results that were collected from each General Plan.

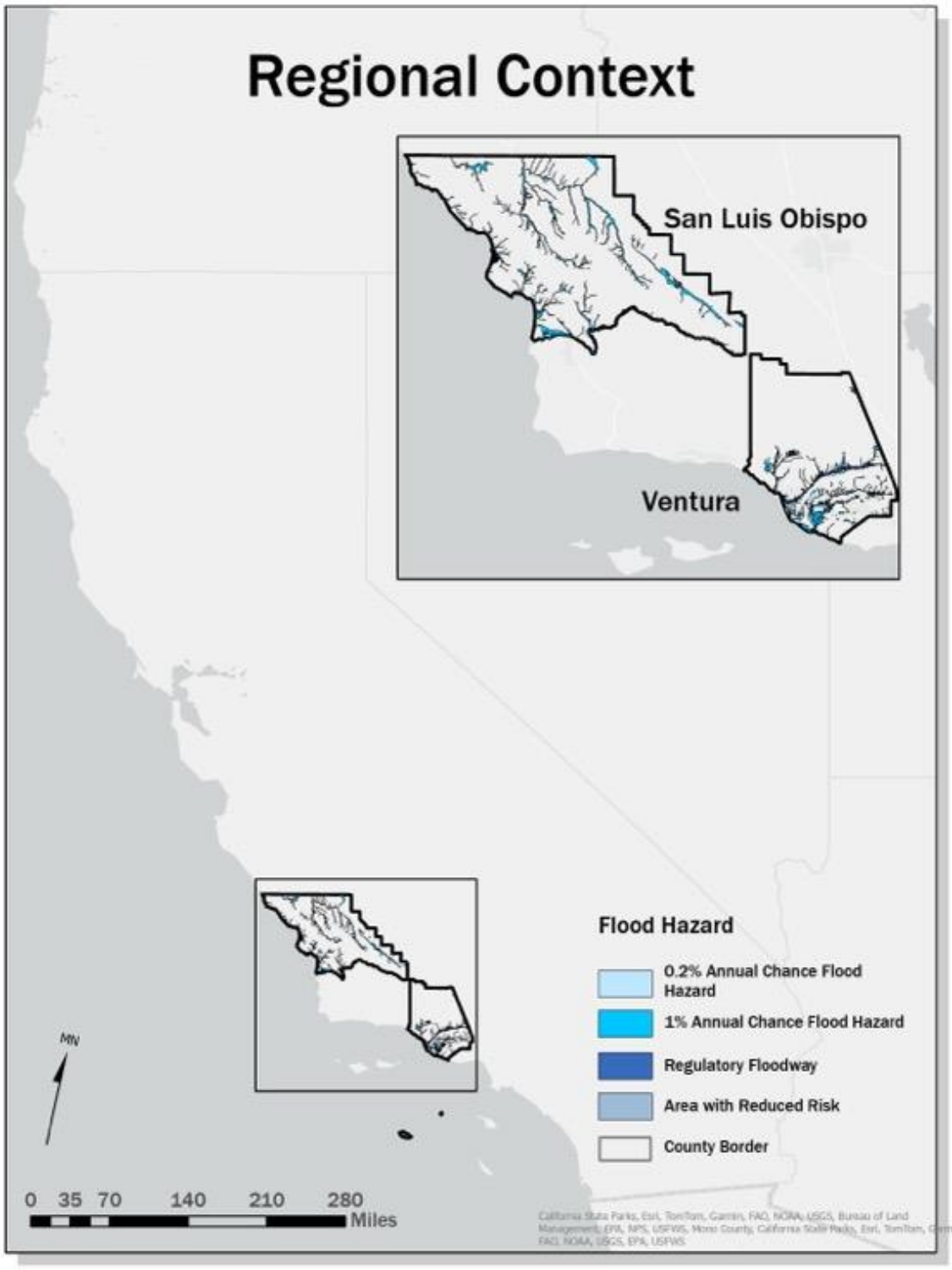


Figure 2: Regional Context

1.2 Ventura County

Ventura County is nestled in Southern California, north of Los Angeles and south of Santa Barbara, along the coastline (see Figure 2). The region is home to 42 miles of coastline and is a leading agricultural producer in the state. A large portion of the county is part of Los Padres National Forest. Agricultural land occupies half the county's acreage (About Us, 2022). Of the county's 1.413 million acres, 326,447 acres are Chaparral, the seventh largest acreage in the state (Chaparral, 2024). Much of Ventura County is Los Padres National Forest, which includes a range of ecosystems: seacoast, marine, mixed forests, chaparral, and semi-desert areas (Los Padres National Forest - Nature & Science). Much of this region has a Mediterranean climate along the coast to semi-desert in the inland regions (Los Padres National Forest - Nature & Science, 2024).

Ventura County sits in a unique position in California, where it is heavily impacted by numerous factors that can increase the risk and severity of flood events. A large portion of Ventura County is forests and chaparral, which are prone to more extreme fire events and increased risk of post-fire flash floods and mudslides. This region also is along the coastline, making it more susceptible to tidal flooding and storm surge related flooding. The region has had a history of flooding and landslide events, making them more at risk for future events. Ventura County has had a history of flooding and landslides due to large-scale rain events, flooding following wildfires, and the severe slope-influenced flooding common in Chaparral ecosystems. Several landslides have caused loss of life in La Conchita over the last 50 years, an area that will continue to experience landslides as they have been occurring there at a regular rate for thousands of years (*Flooding*

History, 2020). Despite frequent landslides that have caused loss of life and damaged property, homes remain there, and areas previously buried during mass wasting events continue to be re-developed (*Landslide/debris flow,* 2022).

Ventura's flood history has also influenced and changed the management of the county's water systems. Following flooding along the Sespe River in 1978, the Fillmore levee was constructed. This flood event also led to the installation of the first Automated Local Evaluation in Real Time (ALERT) rain gauge, which is now part of the Flood Warning System (Flood Warning System, 2020). The Ventura County Public Works Agency-Watershed Protection operates 90 self-reporting rain gauges and 30 self-reporting stream gages (Flooding History, 2020). The ALERT network expanded through additional funding from the US Navy after the 1980 Calleguas Creek flood (Flood Warning System, 2020). Improvements in technology have allowed computer software to display water levels so they can be monitored in real-time, much like rainfall. The network continued to grow since its implementation in the 1970s. There have been multiple fires and flood events which resulted in increased funding being pushed to the project.

1.3 San Luis Obispo

San Luis Obispo County is located on the California coast north of Santa Barbara County and south of Monterey County. San Luis Obispo County has 100 miles of coastline divided into five districts (See Appendix A) (*About The County*, 2024). San Luis Obispo is not in a major metropolitan area and consists of several cities under forty thousand residents. One of the main industries of San Luis Obispo is agriculture,

boasting wine grape production, avocados, and other agricultural products. Another significant draw to the county is the academic institutions, namely Cal Poly San Luis Obispo, a polytechnic university and first polytechnic in the California State University (CSU) system, as well as Cuesta College, a junior college. The county is home to chaparral and oak woodlands, as well as a large section of Los Padres National Forest (*About The County*, 2024).

San Luis Obispo County has a history of flooding – creeks and streams jumping banks and flooding urban areas – numerous times to various degrees of severity during the twentieth century. Wave action is an additional concern in the region along the coastline. Winter storms and El Niño years historically bring the worst flooding in the region. The San Luis Obispo County creeks - Stenner Creek, Brizziolari Creek, Prefumo Creek, and See Canyon Creek - have all jumped their banks during storm events causing loss of life, property damage, or both (Flooding History, 2024).

The San Luis Obispo Flood Control and Water Conservation District (SLOF C&WCD) is a resource intended to help individuals and communities in San Luis Obispo County. The goal is to identify and address flooding problems with the purpose "to provide for control, disposition and distribution of the flood and storm waters of the district and of streams flowing into the district..." (*Public works,* 2024). The district is divided into three zones: Lopez Water Project, San Luis Obispo Creek Watershed, and Arroyo Grande Creek Channel. The county website provides resources for flood management primarily focused on property owners and the steps they can take to manage and mitigate floods on their properties. They also provide emergency information in the case of active flooding events. Flooding events have had some

impact on San Luis Obispo's flood management practices, primarily focusing on the San Luis Obispo Creek watershed (*Public works,* 2024). Flooding events that have resulted in loss of life have occurred beyond this primary focus area.

San Luis Obispo County is in a position where it is impacted by all flood types, with the primary concern riverine flooding where streams, rivers and creeks jump their banks. Localized flooding is also a concern and results in riverine flooding when storms settle over the region for an extended period.

1.4 Hazard Mapping

The hazard mapping for both regions is through the National Flood Insurance Program (NFIP) which was created in 1968 by Congress to protect property and lives by providing disaster assistance (*Floodplain management,* 2023). The NFIP is an agreement between the Federal Government, local governments, and communities required to adopt and enforce floodplain management regulations that help mitigate flooding effects. Flood hazard maps are generated through partnerships with water management districts, local, and state governments in accordance with Federal Emergency Management Agency (FEMA) standards (Shively, 2017). The maps themselves are used by insurance agencies, home buyers, real estate agencies, and officials for decision-making purposes. In many cases these are the only maps that are easily accessible for community residents, for their own needs (Shively, 2017). Everything is contextualized in risk zones on the flood risk maps.

Communities participating in the NFIP allow property owners within the participating communities to insure their properties and contents through the program (*About Us* Flood Smart). Flood resilience strategies recognized by the NFIP can include preservation of open space, enforcing higher standards for development and zoning, appropriate monitoring of flood conditions, and adequate ways of informing residents of hazards, programs, and how to reduce their individual risk (*Community rating system,* 2024*).* The primary goals of the NFIP are as follows:

1. Providing affordable flood insurance to property owners,
2. Reducing the cost of federal disaster assistance to taxpayers, and
3. Encouraging communities and individuals to take actions that result in flood loss reduction.

Comprehensive floodplain management as a goal of the CRS is a key difference between the two programs (*Community rating system,* 2024).

The purpose of the NFIP is reducing cost and financial loss while also encouraging communities to take preventative action. The NFIP's focus is financial – their resources emphasize financial loss and insurance. Joining the NFIP does encourage more flood resilience strategies to be implemented, but it does not require it. This is where the Community Ranking System goes beyond the NFIP in requiring comprehensive plans (Community rating system, 2024).

Communities can choose to go above the level of preparedness to qualify for the NFIP by being ranked under the Community Ranking System (CRS) also operated by

FEMA. The incentive for going beyond the NFIP requirements is multifaceted. CRS ranking provides a tiered discount for insurance through the NFIP (Community rating system, 2024). Communities also have the benefit of their strategies providing more protection and mitigation of flooding in their communities. Ventura County is a participant in the CRS, San Luis Obispo County is not.

The CRS uses a class ranking system that reflects the level of protocols in place and the subsequent discount. The scale ranges from 1 to 9, with 1 offering the highest discounts and 9 offering the least discount. As the community includes more flood mitigation strategies the ranking can be improved to improve flood insurance discounts. There are numerous activities that are considered for credit under the program (Community rating system, 2024). A common way of earning a credit for the CRS is providing information to the public. Much of this information is already required as part of the NFIP. Information communication that earns communities additional credit includes publishing construction permits, NFIP maps, and maintaining a community library website with flood information. Another goal is developing maps for areas not managed by FEMA, a key difference between communities that join just the NFIP and those that are participants in both NFIP and CRS. The insurance discounts of joining the CRS range from 5 - 45 percent. The goals of the CRS are as follows:

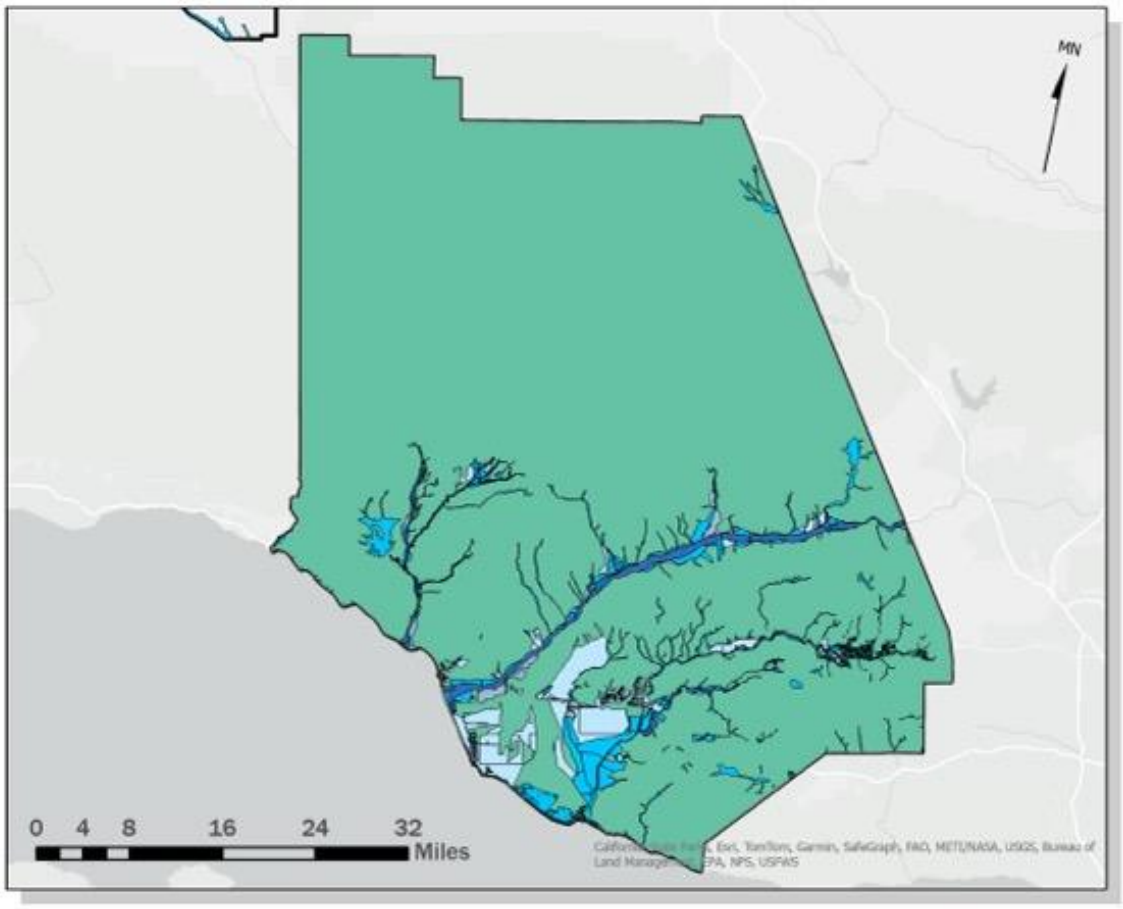
1. Reduce and avoid flood damage to insurable property,
2. Strengthen and support the insurance aspects of the NFIP, and
3. Foster comprehensive floodplain management.

Comprehensive floodplain management as a goal of the CRS is a key difference between the two programs (*Community rating system,* 2024).

San Luis Obispo as a county does not participate in the CRS however some cities and towns (see figure 4) within the county participate, as these cities have comprehensive floodplain management plans and more information available about each region's risk (Community rating system, 2024). These communities also have more educational community events and risk mapping beyond the maps required by FEMA for participation in the NFIP. However, this does not represent all of San Luis Obispo County. Much of the county does not participate in the CRS unlike Ventura County which participates in the CRS on a county-level. San Luis Obispo County not participating in the CRS leaves a patchwork of protection, mitigation, and information available to the public. This fosters inequity in the county, making some communities more vulnerable and resulting in gaps in information available to the public. Ventura, however, participates in the CRS on a county level, allowing for unincorporated areas and smaller communities to not only have more of a NFIP discount, but additionally more information and mitigation methods for these regions (Community rating system, 2024).

There are two cities in San Luis Obispo County that participate in the CRS at a 7 on the scale: San Luis Obispo and Morro Bay. As of the 2020 Census, San Luis Obispo had just over 47,000 residents and Morro Bay had nearly 11,000 residents. Of the 282,000 residents in San Luis Obispo County this represents just under 20.5% of the population (State Profile, 2023). Ventura participates on a county level meaning all of their 843,843 residents have information, resources, and mitigation methods in place for

them (as of the 2020 census) (State Profile, 2023). The two San Luis Obispo cities that participate in the program are ranked as 7s representing a 15 percent discount. Ventura county is ranked at a 5 on the CRS scale (See Appendix B for full discount breakdown)(Community rating system, 2024). The importance of participating at a county level is that unincorporated areas, villages, and towns that are governed by the county rather than a city government, are included and have additional FRM strategies in place.



Ventura County
NFIP: Flood Hazard and CRS Map

Nikki Maraviglia

Legend

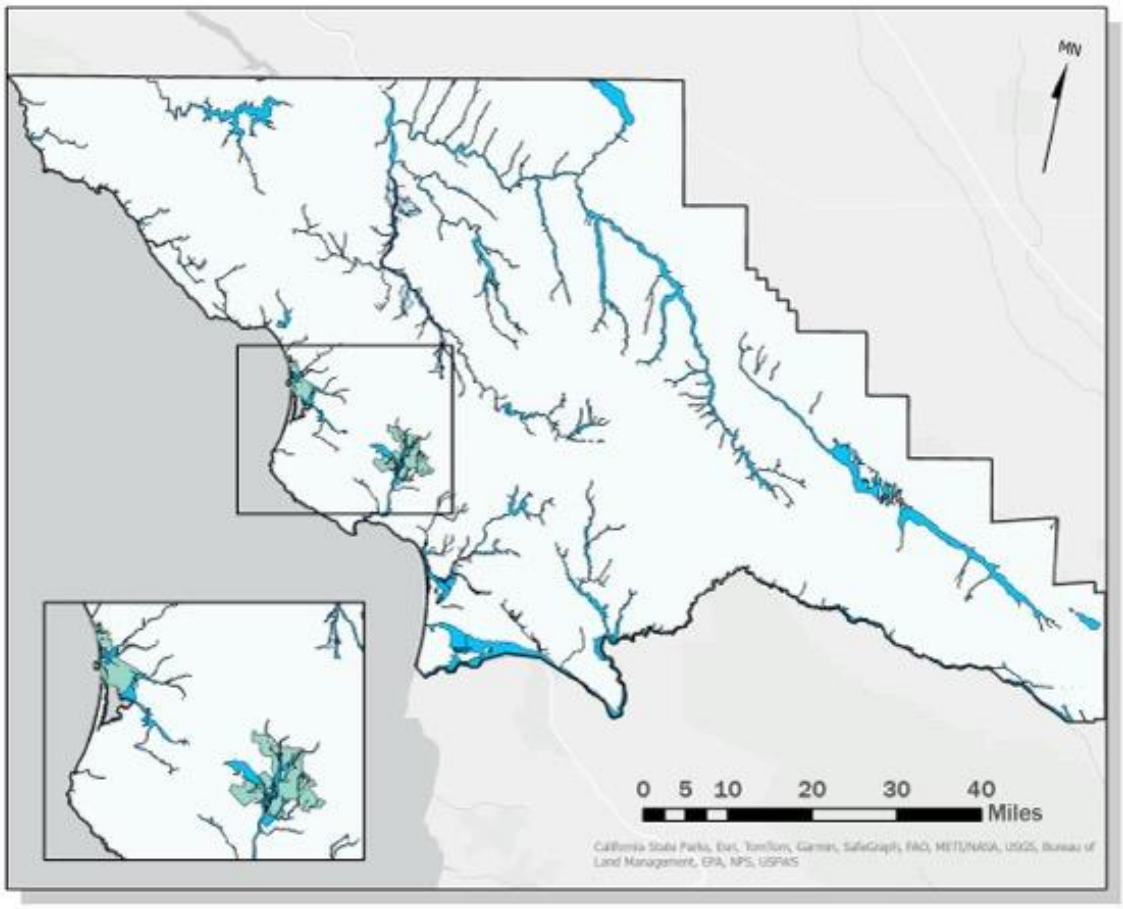
Flood Hazard

- 0.2% Annual Chance Flood Hazard
- 1% Annual Chance Flood Hazard
- Regulatory Floodway
- Area with Reduced Risk
- County Border

CRS Ranking

1 2 3 4 5 6 7 8 9 10

Figure 3: Flood risk and CRS in Ventura County



San Luis Obispo County
NFIP: Flood Hazard and CRS Map

Nikki Maraviglia

Legend

Flood Hazard

- 0.2% Annual Chance Flood Hazard
- 1% Annual Chance Flood Hazard
- Regulatory Floodway
- Area with Reduced Risk
- County Border

CRS Ranking

1 2 3 4 5 6 7 8 9 10

Figure 4: Flood Risk and CRS in San Luis Obispo County

Chapter 2: Literature Review

Flood risk management has multiple approaches and practices utilized by different communities across the globe. Strategies that community planners use for FRM are dynamic, often incorporating new theories that inform decision makers. Flood Risk Management strategies in the U.S. have experienced three major paradigm shifts over the last 60 years. In the 20th century, the dominant approach was Technological and resistance based. In the last 21st century, the approach has shifted to include Social-Ecological interactions. The paradigm shifts from Technological to Social-Ecological FRM strategies often neglected the technological approaches of years past, separating them as not influenced or a part of Social-Ecological interactions. New research has indicated that these two approaches do not exist in a vacuum but are interwoven and impact one another. Thus, a third approach has emerged that combines Technological and Social-Ecological to create Social-Ecological Technological Systems (SETS) as a more resilient and balanced FRM strategy, where each system within SETS is acknowledged by planners. The shift to a SETS FRM approach seeks to acknowledge the interactions between the different elements of SETS, seeing them as a complex system not independent variable. This section will examine the historical and contemporary approaches to FRM that are being utilized, which is crucial to understanding flooding in San Luis Obispo and Ventura counties. I will introduce and explore the existing research around the key topics, including: benefits of resistance planning strategies, paradigm shifts in approaches, SETS definitions, and RRT strategies in conservation approaches. As SETS resilience is the foundation of this research, this section will also explore the foundations of SETS resilience. These topics

are complex and have implications beyond FRM strategies and Ventura and San Luis Obispo County. In the following section I examine these topics in turn then bridge them together to provide context for the specific issue of flooding in the regions of interest.

2.1 Resilience Planning

The American Planning Association (APA) provides several resources for resilience planning – defining resilience as “the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kind of chronic stresses and acute shocks they experience” (*What is urban resilience?* 2022). Planning strategies are complex and interdisciplinary. Resilience planning has become the focus of planners around the world, instead of planning purely for control of shock events, such as flooding. The APA stresses that planners must plan for communities to bounce back after acute and chronic stress. Resilience planning is becoming more widely utilized and accepted across the world (*Planning for resilience* 2022). Much of the literature on resilience planning is within academic textbooks, planning pages on government websites, and is a limited body of research, due to it being a newer concept only in the last two decades the need emerged for acknowledging the interconnected nature of planning systems (Fisher et al., 2018) Much of the research around resilience planning has taken place within the last decade, testing the longevity of these strategies as adequate FRM solutions is ongoing.

Climate change is another factor impacting planning. The changes to regional planning for climate change center around shifting from focusing only on mitigation to both mitigation and adaptation (Sharifi & Yamagata, 2014). Mitigation as defined by

FEMA is an action to reduce the loss of life and property by lessening the impact of natural disasters (*Mitigation for homeowners* 2023). Resilience planning accommodates acute and chronic stresses caused by climate change, among other root causes, allowing for resilience to long term economic stress and a wide range of other threats. Adaptation and mitigation are important for resilience strategies according to a toolkit developed by Sacramento State for resilience planning (*Resilience planning: Tools and resources for Communities* 2020). Adaptation involves adjusting to current or expected conditions and reducing impacts. Mitigation involves attempting to prevent or reduce the likelihood or severity of a hazard. The resilience planning process involves understanding risks and hazards, identifying vulnerabilities to assets, identifying, and evaluating recovery actions, and developing plans to implement solutions (*Resilience planning: Tools and resources for Communities* 2020). Some resilience research is centered around planning for reducing risks to “assets", this does not necessarily highlight all elements of planning for resilience in my research, but stresses the importance of resilience planning (*Resilience planning: Tools and resources for Communities* 2020).. It is important to contextualize this as seen through an asset lens, as most resilience planning is focused on communities’ resilience not asset resilience. Resilience planning can have a positive impact on both assets and communities.

2.2 Shifting Paradigms

The SETS framework’s is foundational to this research, representing a modern approach to planning, recognizing Social, Ecological, and Technological Systems as connected and nested within each other. Historically FRM strategies have been focused on resisting flood events and technological approaches were the primary way this was

achieved for planners. Flood risk management has historically been rooted in Technological approaches in the 20th century Chang et al. examined the FRM strategies in Portland, Oregon; Seoul, South Korea; South Korea; and Tokyo, Japan, finding each city had a history of technological approaches to FRM (2021). The previous model of resistance to flooding can result in more devastating flood events. The resilience-based approach is becoming more accepted by planners as a effective strategy for navigating shock and chronic stresses due to climate change, including flood events (Chang et al., 2021).

Technological approaches used in the 20th century were primarily focused on resisting flood events. The primarily technological and resistance-based approaches can be effective for a time, however these strategies can be subject to extreme failure events (Markolf et al., 2018). Infrastructure is more than just technological artifacts, consisting of constructed projects, infrastructure is linked to social-ecological systems (Markolf et al., 2018). According to Markolf et al., “SETS perspective integrates socio-technical and socio-ecological perspectives and expands upon them to also consider ecological-technological interactions”(2021, p. 1642). Utilizing this perspective authors identify lock-in processes and where infrastructure systems can adapt (Markolf et al., 2018). Vulnerabilities can develop over time in infrastructure systems, communities can move beyond technological resistance strategies to improve their long-term resilience to chronic stresses and shock events due to flooding (Markolf et al., 2018). McPherson et al. stress the importance of defining cities via a SETS framework as a tool to understanding the challenges and areas for improvement within cities (2022).

Utilizing only resistance and technological approaches have led to major failures of FRM in years past, some research suggests a safe-to-fail approach is more effective for long chronic and acute stresses. Kim et al., define a safe-to-fail (STF) approach as a challenge to the isolated technological approaches of years past, and recognize SETS approaches as interconnected and interdependent in infrastructure systems (2022). Kim et al. examine the importance of managing these systems cohesively exploring the in-depth background of existing infrastructure systems, and the need for STF planning and design, to manage unpredictability of multiple shock events associated with climate change (2022). Many communities that focused primarily on technological approaches shifted to Social-Ecological approaches for FRM. Social and ecological systems are interconnected with technological systems, impact and change each other, and improve the capacity of a community's resiliency to flooding events.

The SETS lens expands on Social-Ecological Systems (SES) research, which focuses on framing resilience in terms of sustainability of human-environment interactions. Where the SETS lens differs is it expands on SES research by considering the built environment (Technological Systems). Kim et al. 2022, explain that the limitation of only an SES lens is it often does not consider the built environment, which the authors cite is vital to resilience. The authors stress the importance of considering SES alongside Technological Systems as a means of improving community resilience, highlighting the failures of a SES perspective without incorporating Technological strategies. The authors point to the aftermath and recovery from Hurricane Maria as a specific example where SES focused strategies failed, due to not considering Technological strategies, specifically citing a lack of ecological monitoring and

administrative capacities. There is a need for considering the interaction between the three systems within SETS. Kim et al., highlight the fact that the SETS lens accounts for the Social and Ecological systems where previous perspective have not. Technological approaches to FRM were previously established in a large body of engineering resilience literature, focused on withstanding hazards (Kim et al, 2022). The SETS framework provides long-term solutions to increases in frequency of shock events due to climate change (Kim et al., 2022). Operational frameworks of planners need to account for climate change as these events will become more frequent. The need for a SETS understanding when shifting from a technological focus on infrastructure to nature-based solutions is crucial to resilience of a community to stresses (McPherson et al., 2022). SETS strategies are more resilient to chronic and shock stresses, and are more equipped for stresses due to climate change.

2.3 Defining SETS and Resistance Resilience Transformation

Defining FRM strategies a community uses as components of SETS helps contextualize a community's preparedness for flooding events. Utilizing city governance documents Chang et al. identified the changing flood risk management strategies of the cities, coding the documents for the SETS variables used in the respective cities historically, and presently. Each city's approach provides insight into how they respond to historic flood events, providing opportunities for comparison between the two cities. Chang et al.'s research identifies policy changes as collective choices, made by broader stakeholders within the regions. This approach can be utilized to assess and compare the trajectory of FRM systems in other regions, by identifying SETS variables and data

where these variables can be found (formal government documents) (Chang et al., 2022).

Once the flood events were understood, government documents from before and after major flood events were compared for a perspective on how strategies changed between them (Chang et al., 2022). Their research provides a valuable model that can be used to compare FRM strategies between different communities. Chang et al. and Markolf et al.'s research highlight the importance of SETS and viewing communities as complex systems, as critical to resilience to stresses and shock events. Chang et al. offers a model that can be replicated in full or in part for other regions – identifying FRM strategies, defining them, and categorizing them according to the SETS framework.

When observing FRM and defining them as SETS components, they can be defined as Social strategies, Ecological strategies, and Technological strategies. SETS also represents the cross-cutting strategies as Social Ecological, Social Technological, and Ecological Technological. For example, social strategies can be for example, disaster aid and limiting basement dwellings in flood prone areas. Ecological strategies can include maintaining or improving the capacity of waterways to manage flood waters. Technological strategies can encompass improving existing infrastructure or repairing it after a disaster or, introducing an automatic flood warning system. There are many examples that combine different strategies: Social Technological solutions can include, improving and supporting disaster prevention awareness and education; Ecological Social solutions can include preventing development of infrastructure in flood plains; Technological Ecological solutions can include, green infrastructure like bioswales

(Chang et al., 2021). Each of these defined variables can also fall on a scale of resistance, resilience, and transformation see Table 1 (Chang et al., 2022).

Table 1: Characteristics of social–ecological–technological systems social learning framework Chang et al., 2022

	Resistant (single-loop)	Resilient (double-loop)	Transformative (triple-loop)
Social	Offer socioeconomic aid after disaster (e.g., disaster relief fund)	Change in practice or organization (e.g., collaborate among different departments)	Change in norms, principles, and value systems (e.g., radical change in sociopolitical system)
Ecological	Maintain the existing environment (e.g., waterway, vegetation maintenance)	Modify the current environment to reduce flood (e.g., small-scale restoration, installation of green infrastructure)	Change in the whole landscape for different uses (e.g., major floodplain restoration, designation of new protected area)
Technological	Focus on repairing damaged infrastructure (e.g., increase levee heights, construct pump stations)	Improve or change existing technologies (e.g., introduce automatic flood warning system)	Reform technological paradigm (e.g., large-scale system-wide technical reconfiguration)

Resistance, Resilience, Transformation (RRT) typology reveals differential conservation approaches and the shift from maintaining current conditions to resilient strategies all the way through transformative action. Cross et al. developed a RRT scale improving on existing concepts of Resistance, Resilience, and Transformation to define the RRT scale see (Figure 5) for an example of this scale outlined in the research (Peterson St-Laurent et al., 2021). Figure 5 describes the transition from active resistance to accelerated transformation, and steps between the two sides of the spectrum, briefly defining each. The research applies the RRT scale to a case study of 104 adaptation projects, finding a trend towards transformation. They define the scale in clear terms, from active resistance to accelerated transformation, defining what types of practices by planners fall on the scale (and where). This delineation is important for the research methods, which need the planning actions to be categorized as SETS and where they fall on a simplified version of the RRT scale (see Figure 5) (Peterson St-

Laurent et al., 2021). SETS FRM strategies can fall anywhere on the RRT scale. For example dams and levees can be seen as technological resistance-based strategies as they act to stop flood waters and are part of the built environment (Chang et al., 2022). While having more balance to FRM strategies utilizing all SETS components, these individual strategies can still represent resistance focused strategies used in the 20th century (Chang et al., 2022). Figure 5 provides a deeper understanding of where SETS variables can fall on the RRT scale. Understanding where FRM strategies fall on the RRT scale, and what components of SETS were used is important to understanding how resilient a county is to flood events. The more balanced FRM strategies are (even distributions to S, E, T) the more resilient a community is to climate related stresses (Chang et al., 2022).

As a relatively new field of study, there is a lack of research on SETS, and resilience. There is a vastly smaller body of research dedicated to resilience planning and thus it will be more difficult to assess each county's resiliency strategies. There is even less research on SETS specifically, and SETS research is typically focused on broader climate resilience strategies beyond just FRM (Sauer et al., 2022). in a The volume of government documents, and ease of access to these documents are an additional challenge for this research.

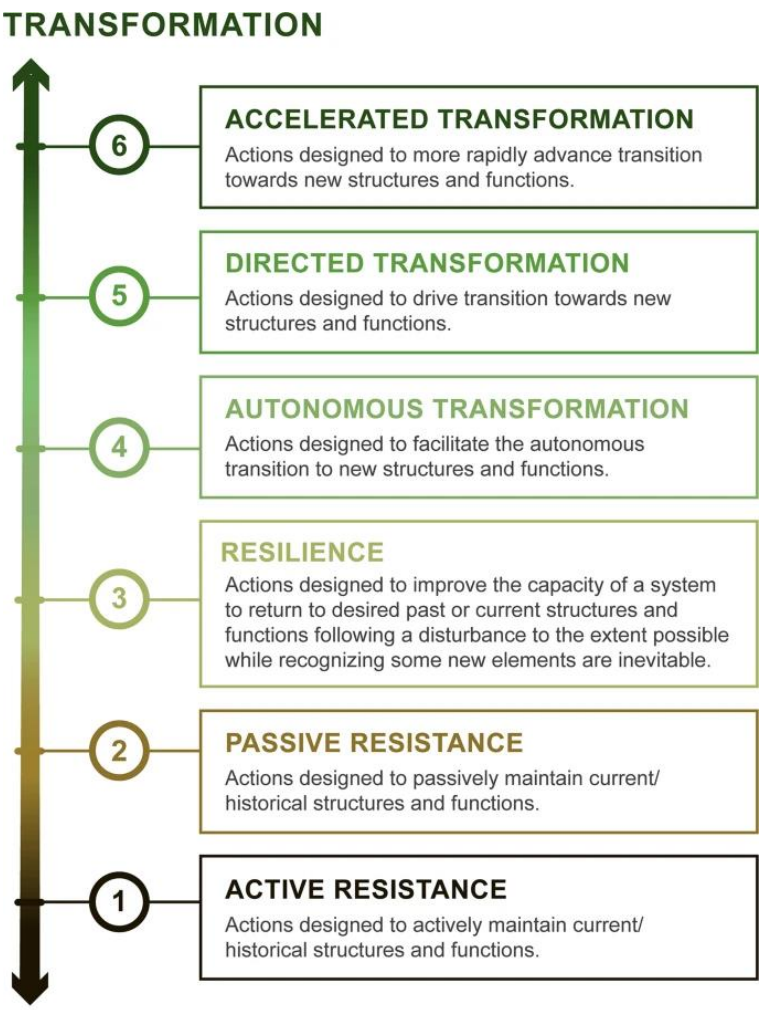


Figure 5: Resistance- Resilience- Transformation Scale (Peterson St-Laurent et al., 2021)

Chapter 3: Methodology

3.1 Introduction

I carried out a content analysis of both counties' General Plans to categorize their FRM projects and approaches. Searching the two counties' General Plans using the: keywords flood, and flooding, the surrounding text near these key words (paragraphs, and sections) were extracted then coded into variables. This approach was adapted from Chang et al., 2022 where a principal data source was identified - here I am using each county's General Plan. The principal data source is then coded using SETS Framework to identify the common variables in the General Plans. Once identified these variables were then coded. The General Plans were viewed through Social-Ecological-Technological Systems lens (SETS). FRMs occur at all scales, local, regional, state, and national. My research assesses the FRM strategies of two counties at the county scale, as such the General Plan was used as the document that was coded. The county scale is useful in this context as unincorporated areas, such as rural areas, villages and smaller towns in each region, are managed at a county level. The SETS Framework analysis is used to identify shortcomings in each county, highlighting the dominate strategies in each County. The goal of highlighting the dominate strategies is to understand how resilient the counties are, as a more balanced approach to SETS results in a more resilient community (Chang et al., 2022). This methodology has some challenges including the differing organization of the two counties plans and the possibility for error in coding the documents.

3.2 Coding General Plans Overview

Planning perspectives are shifting, many regions are moving away from a technocentric approach, instead opting for more Social, Ecological, and Technological approaches (Markolf et al., 2018). Planning strategies fall on a scale of resistant-resilient-transformative. In addition to coding the General Plans in Ventura and San Luis

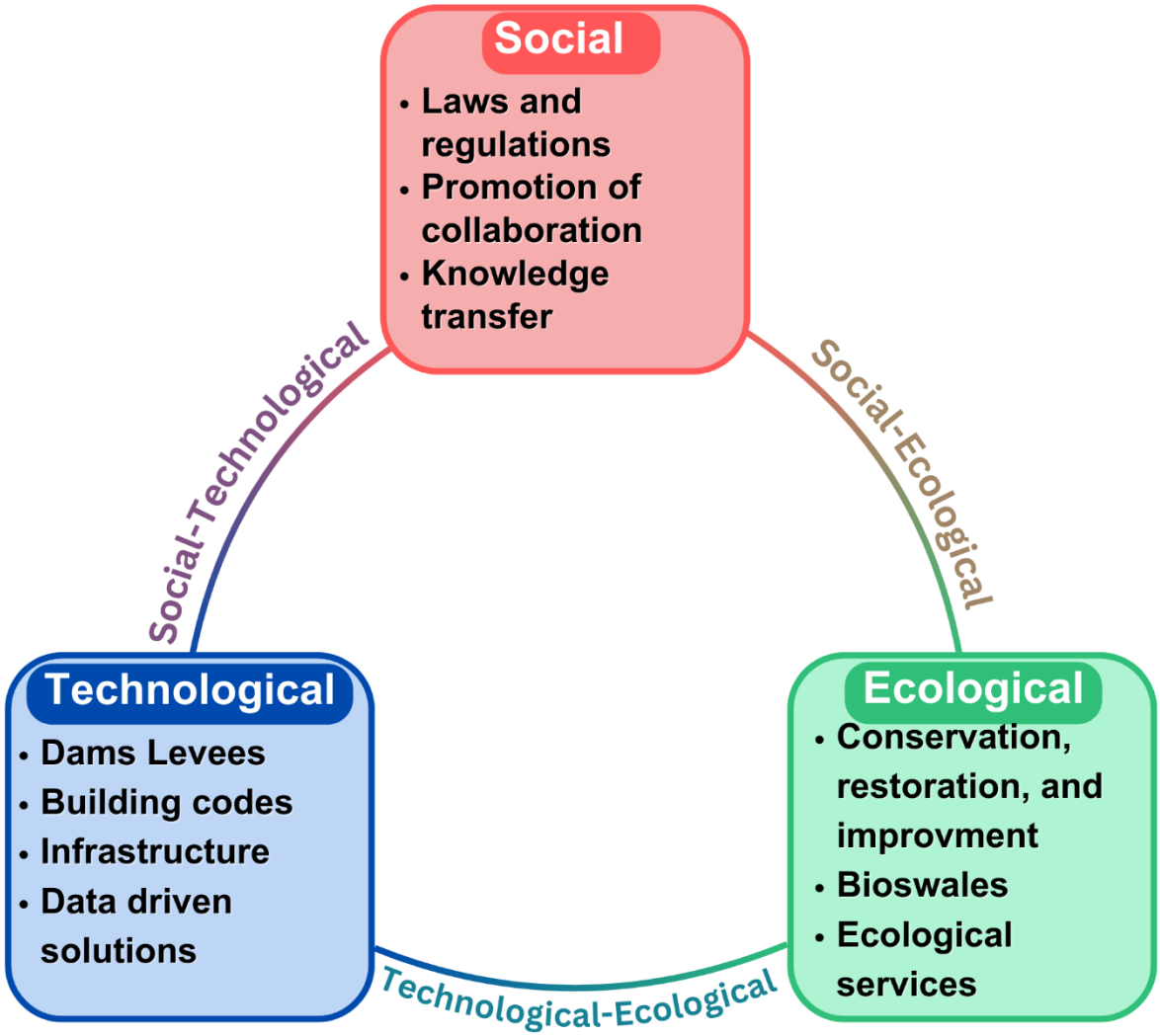


Figure 6: SETS Diagram with Examples

Obispo County for the SETS strategies, each variable was coded for where it falls on the RRT scale as well. This research seeks to assess what approaches are used in

each county, through county document analysis and coding, in the hopes to understand what part of SETS is dominant (if any) in each county, to offer possible areas of development.

The SETS variables categories are defined as S (social approach), E (ecological approach), or T (technological approach) (Chang, et al., 2021). Social approaches can include public outreach, education, and community preparedness for a disaster. Ecological approaches can include enhancing natural waterways and maintaining the natural environment for the purpose of flood management (Chang, et al., 2021). Technological approaches can include man-made structures (like dams and levees) and floodplain mapping (See Figure 6). The combination of strategies was also coded and recorded (e.g. SE, ST, ET), for example hazard mapping to improve public awareness would be a combination of Social and Technological. Examples of this coding can be found in Chart 1. Chang et al. described the importance of Social-Ecological-Systems (SES) interaction with Technological Systems, highlighting the importance of a balance of SETS approaches. A balance of SETS approaches to FRM help to maintain a more resilient community, as all these systems are nested in and interact with each other (Chang et al., 2022). Technological Systems interactions with Social Systems in numerous ways, for example infrastructure, such as dams impacting the public, where homes can be built when they’re constructed and where people can live (Social-Technological interaction) (Kim et al., 2022). Technological systems shape and are shaped by social systems, and equally each influence ecological systems. A more diverse approach to FRM observes each element of SETS as intertwined rather than existing in their own categories separate from one another. SETS approaches can help

improve how resilient a region is, by incorporating Social-Ecological-Systems approaches with Technological approaches to FRM, acknowledging the importance of these connections in a complex system (Chang, et al., 2021). In this research the complex systems we are observing are Ventura County and San Luis Obispo County. Using this lens the General Plans were examined to explore how FRM was approached in each county, identifying FRM strategies as SETS variables.

Each county in California is required to have a General Plan, the county's blueprint for meeting the communities' long-term goals and vision for the future (General plan information 2024). The general plan "embodies public policy relative to the distribution of future land uses, both public and private" (General plan information 2024). The General Plan is the charter to which the zoning ordinances must conform according to the California Supreme Court. As such the General Plan for each county serves as a document that can clearly define the goals for FRM strategies and policy and outline the current state of strategies used in each region. The General Plan for Ventura exists as one document on their county website and was collected there and coded where SETS variables where identified. The General Plan for San Luis Obispo County does not exist as one document anywhere on San Luis Obispo's county website; however, the parts are uploaded to their county website and defined in a few documents inconsistently. San Luis Obispo County, the General Plan User Guide document was used to identify the different sections of their General Plan, then the sections were collected and coded. The documents organized were retrieved via county planning websites and stored as pdfs to be analyzed in the following steps. Each document was categorized to identify policies and actions specific to flood management, additionally potential decisions that

have impact on waterways. Common variables were established to be used for coding each document. The documents were analyzed to assess what elements of SETS were the focus of the plans including combinations of multiple elements. Utilizing keywords and phrasing outlined in Chang et al. SETS variables were identified, examples of the variables were found in the General Plans, and how they were coded in this research can be found in Chart 1.

After the SETS variables are coded from each General Plan the established FRM strategies were also coded for where they fell on the RRT scale. Each SETS approach fell onto the resistant, resilient, or transformative scale (RRT). Resistance strategies act to maintain current historical structures, Resilience strategies improve the capacity of a system, while Transformative approaches advance and help transition towards new structures and functions of a system (Peterson St-Laurent et al., 2021). Identifying the SETS variables and understanding where the SETS variables fall on the RRT scale is important to understanding the region's approach to FRM, if there is diversity of thought for the approach, and how resilient the system is (Peterson St-Laurent et al., 2021). While there can be different of approaches to FRM with regards to the SETS variables it is important to consider what the goals of these strategies are. Many technological strategies utilized in both counties focus on maintaining current Technological structures, such as dams or levees, this is considered a resistance strategy as the goal only is to maintain current conditions. Maintaining current conditions are not typically associated with resilience strategies (Peterson St-Laurent et al., 2021). This also helps identify areas of comparison and learning the communities can have from one another. See Table 2 for examples of RRT scale coding in each county.

3.3 General Plan Coding Steps

The general plans were assessed as of their most recent adoption date in both cases, 2023 for both counties though the query was conducted in 2024. The documents were downloaded from the county websites of each county, as a single document for Ventura and document sections in the case of San Luis Obispo County. Once the documents were downloaded, the documents were searched using the key words: “flood”, “flooding”, “stream”, and “waterway”. Once the search was conducted the sections of the documents surrounding the key words were copied and pasted into separate documents for later coding. The documents containing the sections that appeared when searching the key words were then read and FRM strategies were identified during an initial reading, the extraneous or unrelated segments were removed for more streamlined coding. The documents were then coded identifying the SETS variables in each FRM strategy, if multiple this was also indicated. The coding was conducted using an adapted framework outlined in Chang et al.’s research. Major methodological differences being the documents coded in this research were the general plans, and only one person was coding the documents. The FRM strategies of each document were color coded to easily identify which strategy they represented, pink for social, green for ecological, and blue for technological. Once the SETS FRM strategies were coded, the documents were coded again to determine if the FRM strategy was resistance, resilience, or transformation-based strategy. The documents containing all the FRM strategies were then coded again 5 days later and, the two coding documents were compared to confirm. Once the documents were coded the

amount of each variable per county was quantified. Each county confirmed both documents are up to date yearly and released a report detailing any changes.

3.4 Document Organization and Challenges

The organization of government documents differs in each county. Ventura county has their General Plan in one collated document, including an introduction, clearly defining the goals of the document. However, San Luis Obispo County opts to list the individual sections of each document in a guide document, pointing to where each section can be found on the county website. As a result, San Luis Obispo County does not have one concise document instead sections which are adopted at different dates. San Luis Obispo County also has a document which outlines the most recent adoption dates of each section. Many of San Luis Obispo County's document sections have not been updated in recent years. The documents assessed for both counties reflect the most recent adoption date in both cases 2023, and what is accessible on each county's website. The documents assessed are reflective of what was available to the public as of March 2023. Due to the lack of collated documents in San Luis Obispo County, their general plan lacks an introduction. San Luis Obispo County Planning department was contacted to confirm that the documents that were uploaded on their website were current, and these were confirmed, it was also confirmed that the "General Plan User Guide" was the document that outlined the sections.

The primary challenges for these methods include the subjective nature of coding government documents, the qualitative approach leaves room for interpretation. Due to the nature of this research, and only having one person coding the documents, there

may be gaps in data. The organization and coding of the government documents was conducted by an individual rather than a team which is normally how the SETS research is conducted (Chang et al., 2021). This will provide a challenge in analysis of variables that may be missed as part of the SETS approach. The documents have been read and organized into variables multiple times to account for this drawback. The route to accessing the government documents and mapping are explored to better understand what the public sees when looking into their respective county's planning documents. This presents a possibility for documents that are more challenging to find or nested into subpages of government sites to not be found and categorized. Each General Plan was coded for variables specifically around FRM practices.

Table 2: SET Variables Examples (Maraviglia, 2024)

	Resistant	Resilient	Transformative
Ventura County	"The County shall place a high priority on preserving open space lands for recreation, habitat protection, wildlife movement, flood hazard management, public safety, water resource protection, and overall community benefit." (E) "New development shall be sited and designed so as not to cause or contribute to flood hazards." (T)	"New or expanded public works facilities (including roads, flood control measures, water and sanitation) will be designed to serve the potential population of the unincorporated and incorporated areas within the Coastal Zone, and designed to eliminate impacts on agriculture, open space lands, and environmentally sensitive habitats." (S, E) "The County shall support efforts of agencies and organizations that provide effective education and outreach to Designated Disadvantaged Communities on the effects of climate change, including increasing temperatures, wildfires, flooding, sea level rise, poor air quality, extreme weather events, disease prevention, and other public health effects." (S) "The County shall incorporate education elements into coastal adaptation projects to inform the public about the risks of sea level rise and options for adaptation." (S)	"The County shall promote the use of permeable paving and other passive drainage features such as bio-swales to prevent flooding, particularly in urban areas" (T, E) "The County shall apply for grants through the California Coastal Commission and other organizations for beach nourishment, dune restoration, and other adaptation activities to improve the resilience of county beaches to sea-level rise and coastal flooding" (S, E, T) "The County shall monitor projected climate change impacts, and coordinate with local, regional, state, and federal agencies to identify existing and potential projected impacts and develop strategies to maintain and improve flood control facilities accordingly." (S, T)
San Luis Obispo County	"The ground floor of all commercial, industrial, and residential structures should be located at least one foot above the 100 year storm flood profile level." (T) "Avoid major land alterations within the flood plain, except as needed to accommodate flood control projects, recreational projects, and infrastructure." (E) "Strictly enforce flood hazard regulations both current and revised. FEMA regulations and other requirements for the placement of structures in flood plains shall be followed." (S, T)	"Pursue an integrated management approach for waterway projects." (T) "Conservancy will create a balanced approach to creek management to reduce the conflicts between development and the watershed ecosystems and to identify methods to limit impacts in the future" (T, E) "Areas prone to flooding Develop a public information and education program in areas of the county prone to flooding and drainage problems to discourage new development in those areas and to inform residents and property owners about how to deal with drainage and flood control problems, use best management practices, and get assistance." (S)	

Chapter 4: Analysis and Results

Figure 7: San Luis Obispo Nacimiento Dam (Maraviglia, 2024)

4.1 Introduction

This research offers insights into the FRM strategies utilized by planners in both Ventura and San Luis Obispo counties. The categorization and organization of the FRM variables used in the county are analyzed and interpreted. Using the SETS Framework this research provides a deeper understanding of each county's strategies and an opportunity for comparison. This research conceptualizes the diversity of FRM strategies utilized in both regions, better illustrating the resilience of each system (Chang et al., 2021). The two counties have a lot of similarities in setting, landscape,

and general geographic setting, but differ heavily in population and thus tax revenue, and ultimately funding available to each county. The counties have differing strategies for organizing and outlining their General Plans utilizing different organizational systems and methods for adopting and updating sections. The difference in organization represents differing communication strategies (Social in SETS) between the two counties. San Luis Obispo opts to post theirs in sections, with general adoption updates provided in an additional document on the county website. Ventura opts for posting both the sections of the General Plan on one interactive website, as well as one PDF, adopted at the same date. The two counties likewise have different FRM strategies primarily utilized in each region. The two counties have different areas of coverage for their FRM strategies, representing divergent strategies for managing flood risk at a county scale.

4.2 San Luis Obispo County Information Access

San Luis Obispo County stores its General Plan on their Public Works Website, the organization of the information is unclear and can lead to confusion. San Luis Obispo does not publish any sections of the General Plan in Spanish. In San Luis Obispo County, 9.9 percent of the population speak Spanish, the second most spoken language in San Luis Obispo County (*State Profile,* 2023). In Ventura County, 22.7 percent of Ventura County residents speak Spanish (State Profile, 2023). San Luis Obispo County also has an interactive map along with the NFIP static maps on their public works site (See Figure 8) (County of San Luis Obispo, *Planning & building Forms & Documents*). The interactive map lacks basic information about flood risk. The difficulty of use of San Luis Obispo's website, and maps, as well as the convoluted

organization of their General Plan sections contribute to an overall lack of clarity that is evident through San Luis Obispo's General Plan. In this section the general organization and means of access of San Luis Obispo's General Plan, and Flood Risk Maps are examined.

San Luis Obispo County's General Plan is organized into numerous standalone documents that are described in a shorter "User Guide" for the General Plan found on the county public works website (County of San Luis Obispo, *Planning & building Forms & Documents*). There is also a General Plan Annual Report generated each year to identify what sections of the general plan are being updated. Most of the sections in the general plan and their subsections were last updated in the 1990s – 30 years ago. The lack of recent updates to the plan and its sections are reflected in their FRM strategies. San Luis Obispo County utilized predominantly technological approaches to FRM that are primarily resistant – resisting flood events with technological solutions was the dominant outlook in the 20th century. This mindset is evident in the documents (County of San Luis Obispo, *Planning & building Forms & Documents*). Unlike Ventura County San Luis Obispo lacks an easily accessible website, though the sections of the general plan do all appear in the same section of San Luis Obispo County's website.

Figure 8: Example of forms and documents section San Luis Obispo County Website

The General Plan Forms and Documents contains the guide outlining the sections that are in the general plan and the Annual Report indicates the dates the document sections were last updated. However, this section of the site does not contain the actual sections of the general plan. The individual plans that make up a general plan are stored in a “Elements” section of the County website. Without reading the General Plan user guide on the General Plan Forms and Documents page it may not be clear to a site visitor what “Elements” means in this context, as the “Elements” section is stored

with numerous other planning documents, that are not part of the sections of the General Plan (See Figure 9).

Figure 9: San Luis Obispo County Forms Organization Example

Many of the sections of the general plan are described as multiple documents in the “General Plan User Guide” in San Luis Obispo County however in the “Elements” Section of the site they appear as one collated document. Conversely San Luis Obispo’s General Plan User Guide indicates a singular separate document, when there are multiple section documents on the county of San Luis Obispo website (See Figure 9)(*Planning & building Forms & Documents*). This lack of consistency in how San Luis Obispo County organizes the General Plan, in the User Guide, and website, where the sections are uploaded, is carried into the General Plan Annual report. The General Plan

Annual Report in San Luis Obispo County organizes the General Plan into sections; however, these sections are listed differently than both the User Guide and how they are uploaded on the website. This is noted by comparing the optional elements according to the User Guide with the optional elements listed on the Annual Report. It is worth noting that the Master Water and Sewer Plan is left off the Annual Report but remains referenced in the User Guide.

In addition to the required elements, a city or county may adopt optional elements. The county has adopted five optional elements:

- Agriculture
- Economic
- Parks and Recreation
- Offshore Energy
- Master Water and Sewer Plan

Optional Elements	Date of Adoption or Last Major Revision
Agriculture	2010
Offshore Energy	2010
Economic	2012
Parks and Recreation	2016

Figure 10: Examples of Optional Elements in San Luis Obispo County

Similarly, the required sections of the General Plan in the User Guide do not match with the Annual Report (See Figure 10). The way documents are described in the Annual report also differs from the User Guide. For example, in the User Guide on page 2 the LUCE or Land Use and Circulation are described as having four parts: “There are four components that make up both the Inland LUE and the Coastal Zone LUE.” The four parts are later described as: Framework for Planning, The Area Plans, Community and Village Plans, and Official Maps, while the Annual report indicates only three parts

to LUCE, excluding the Official Maps section entirely. This is one of many examples of discrepancies between the way planning documents are described on one part of San Luis Obispo County's website with another. It is also worth noting that this lack of clarity also precludes one from obtaining accurate adoption and revision dates for the various sections of the General Plans, in some cases lacking them entirely as illustrated by the omission of the Official Maps section of LUCE.

Required Elements	**Date of Adoption or Last Major Revision**
Land Use and Circulation Elements (LUCE)	2014[1]
• Part I: Framework for Planning	2009
• Part II: The Area Plans	See below
• Part III: Community and Village Plans	See below
Local Coastal Plan – Coastal Plan Policies	1988
Housing	2020
Conservation and Open Space	2010
Noise	1992
Safety	2013

Figure 11: San Luis Obispo County Annual Update Example

San Luis Obispo County has documents listed on their General Plan Annual report that are not listed on the General Plan User Guide: Avila Beach Specific Plan and Black Lake Specific Plan. These do not appear in the lists of Area and Community/ Village plans that are listed in the User Guide. The General Plan User Guide is indicated as the document to work off by San Luis Obispo County when attempting to find sections of the General Plan, so these were not included in this assessment. It is unclear why the Avila Beach Specific Plan and Black Lake Specific Plan are included on

the General Plan Annual Report, as they are also excluded from the Elements section of the county website, where the rest of the General Plan Elements are found.

There are numerous sections of the San Luis Obispo General Plan that have not been updated since the last century, with the exception of population data referenced in the documents. On average the last substantive update to the General Plan sections was 1997 according to the 2023 General Plan Annual Report (See Figure 11). Of the 60 reports that are listed, 25 have been substantively updated in the 21st century – 12 after 2009, and one after 2019. The county's FRM strategies are reflective of the times in which the plans were developed.

The General Plan Annual Report indicates the last time that the sections of the General Plan were updated, there are numerous plans in San Luis Obispo County that have not been updated since the last century, with the exception of population data referenced in the documents. On average the last substantive update (beyond just updating population data) to the General Plan sections was 1997 according to the 2023 Annual Report. Of the 60 reports that are listed 25 of them have been substantively updated in the 21st century, 12 after 2009, and one after 2019. FRM Strategies are reflective of the times in which the plans were developed.

San Luis Obispo has one accessible interactive map, containing one layer that relates to flooding. The flood map layer does not contain details of where the information is coming from, or provide a legend, the information is highly simplified, though it can provide some basic insight into flood risk areas in the county, beyond the NFIP maps that are utilized as the primary Flood Risk maps in the county. Much of this interactive map which is through the building department (part of public works) pertains

to building codes, planning and permitting. However this map is not a reliable source for homeowners and residents and has a disclaimer “Data For Reference Purposes Only”. There is a power point which explains use of the map indicating when you click on a map element it should provide a pop up with more information, however clicking on the Flood Risk layer there is no pop up. There appear to be attributes in the layers attribute table but there is no way of accessing or displaying them as labels on the map, the attributes are indicated in the labeling section of the interactive map but do not display.

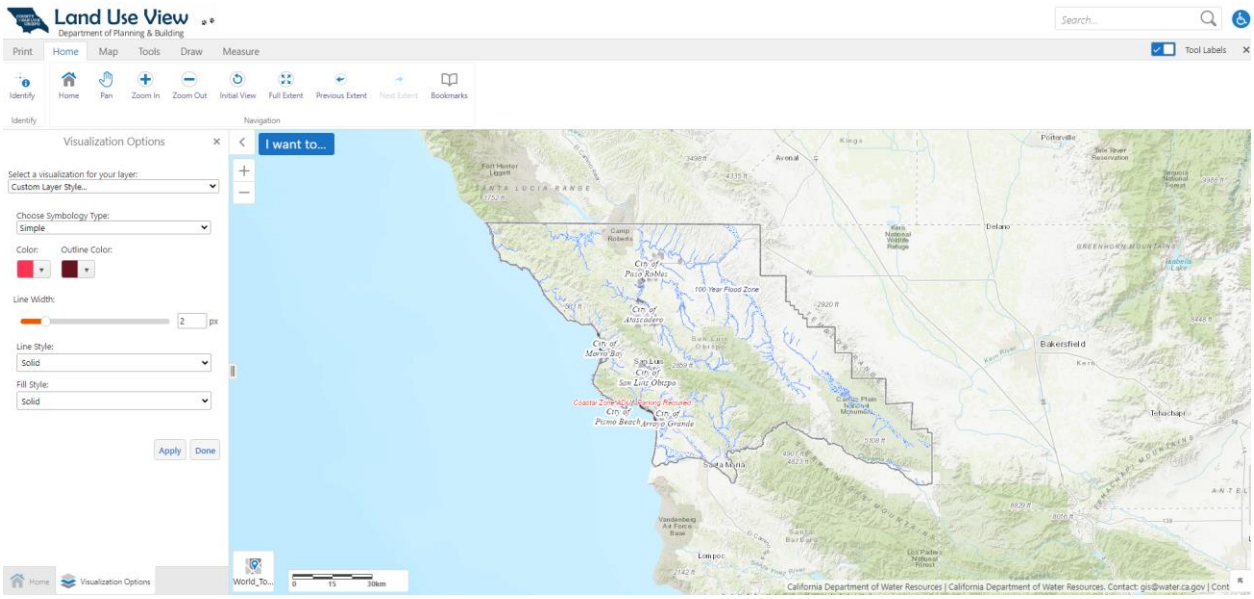


Figure 12: San Luis Obispo County Interactive Map

Overall, the mapping information and general plans are accessible through San Luis Obispo County’s website but it is unclear if all the information is accurate based on numerous discrepancies (See Figure 12). San Luis Obispo opts to upload their General Plans in sections and describe what sections are in the General Plan User Guide. Annual reports provide yearly updates, but these are not reflected in the User Guide. This creates discrepancies which make it unclear what sections are in San Luis Obispo

County's General Plan. San Luis Obispo County also lacks ease of access for their General Plan, storing the User Guide/ Annual Update and General Plan sections in different spaces of their website. The interactive maps on San Luis Obispo County's public works site do not have a legend or additional details when clicked, so while they provide some indication of flood risk it is unclear what the risk is. San Luis Obispo County's website and document organization lack clarity and consistency.

4.3 Ventura County Information Access and Mapping

Ventura County stores its General Plan on a standalone web page built for their most recent update in 2020. Ventura County stores their flood risk maps on numerous websites, including their Public Works webpage. Ventura county stores their General Plan on the Ventura County Resource Management Agency (VCRMA) site, among other places. Ventura County also has a separate General Plan Project website which was utilized to gather community engagement during the drafting of the 2040 plan (published in 2020). The General Plan Project website, VC2040 also has a copy of the completed 2040 General Plan for Ventura County in PDF format. The VC2040 website has multiple places where the public can engage and ask questions about the General Plan for Ventura County. The VCRMA site stores the Ventura County General Plan as a PDF and a website which is organized by sections of the General Plan. Ventura County also makes their general plan available in Spanish as a webpage that can be found on the VCRMA site as well. Ventura County unlike San Luis Obispo County has their General Plan and its sections consistently organized through their sites. Ventura County has multiple sources where flood risk maps can be found giving the public a

considerable amount of access to information when compared to the layout of San Luis Obispo County.

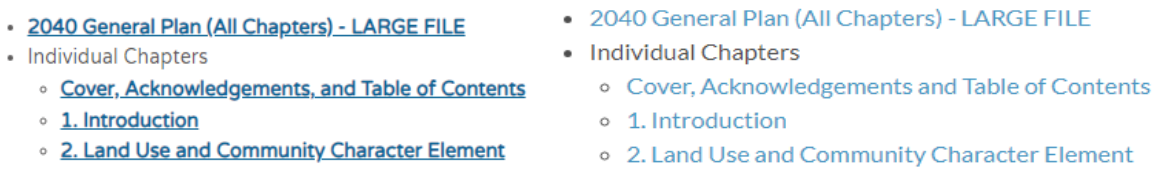


Figure 13: Ventura County General Plan Organization Comparison

Ventura County's two sites that hold the General Plan convey background information on the plan and clearly and consistently outline the sections in the General Plan. There appears to be no difference between the General Plan organization on the. Web and PDF versions. The PDF for the general plan that appears on both the VCRMA and VC2040 sites are the same (See Figure 13). The sections are also uploaded as separated files underneath the PDF of the collated General Plan, the sections on both websites are the same, outlined in the same order as they appear in the general plan. The General Plan's Policies and programs are coded using icons with different colors, and numbers, representing Environmental Impact Report Mitigation, Environmental Justice, Healthy Communities, and Climate Action Plan. Ventura County utilizes these as a means of identifying the cross-cutting topics. The programs and policies are identified in this manner, throughout Ventura County's General Plan. These provide an easily identifiable visual when trying to discern policies and programs that fall within the four categories identified above, multiple categories can appear at once. The identifiers were reminiscent of the coding utilized in this research, interestingly enough (Figure 14).

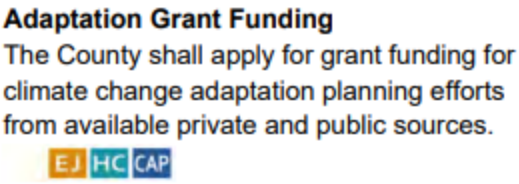


Figure 14: Ventura County General Plan Coding Example

Ventura County's General Plan, adopted in 2020, is a collated document with consistent, font, numbering and organization and including an introduction, glossary, and appendices. The document is consistent and has a clear organization and flow. It is also accessible in both English and Spanish. Accessibility of the document is something that Ventura outlines as a goal for their General Plan. There is a large volume of flood risk maps found on both websites, some are part of the General Plans. There are NFIP maps, there is also a link to an interactive map found on Ventura County's Public Works website. These maps pull in FEMA flood levels. Accessing these layers through the interactive map is inconsistent, occasionally they do not load, however the static versions of the maps are available elsewhere. Overall the maps are accessible but the interactive maps in Ventura County are inconsistent in my experience for loading certain map layers.

Ventura County stresses accessibility throughout their two General Plan websites. The commitment to accessibility of their General Plan and interest in community buy in and participation is evident in their mission statement found on both General Plan sites:

> "*Ventura County is an exceptional place to live, work, and play. Our quality of life and economic vitality are rooted in the stewardship of our cultural and natural resources, including agricultural lands and soils, open spaces, mountains, beaches, and talented people. The General Plan reflects the County's ongoing*

> *commitment to collaborate with residents, cities, businesses, and non-profit organizations to meet our social and economic needs in a sustainable manner, to protect the environment and address climate change, and to encourage safe, healthy, vibrant, and diverse communities to thrive.*" (*VC2040 general plan update* 2020)

This mission statement also highlights the key cross cutting goals of the General Plan, highlighting the importance of collaboration between stakeholders' interaction in meeting these goals. Ventura County's commitment to accessibility, and clarity are evident throughout their General Plan documents and websites surrounding their general plan. The plan is consistently laid out on both sights, the sections remain the same, and in the same order. The adoption dates of the plan are consistent as well, all of them having been adopted in 2020 (VC2040 general plan update 2020). This organization and consistency lies in stark contrast to San Luis Obispo's methods for storing, organizing, and outlining their General Plan. One notable issue with Ventura County's presentation of information is in their interactive mapping which is not always consistent in loading information. Overall Ventura succeeds in making information accessible.

4.4 SETS and R-R-T Results

Ventura County and San Luis Obispo County's General Plans were written on average over 20 years apart, considering the multiple sections from San Luis Obispo and the difference is evident in the results collected for this research. Resilience planning is a newer planning concept, due to the age of much of the planning documents in San Luis Obispo County's General Plan, resilience strategies appear far less frequently when compared to Ventura County. Ventura County has a more balanced approach to FRM when compared to San Luis Obispo County, utilizing a more

balanced percentage of Social, Ecological, Technological FRM strategies. Ventura County utilizes a higher percentage of Resilience strategies than San Luis Obispo County. San Luis Obispo County does not have any transformative strategies, while Ventura County has a small percentage. The two counties FRM strategies are explored in more detail in this section.

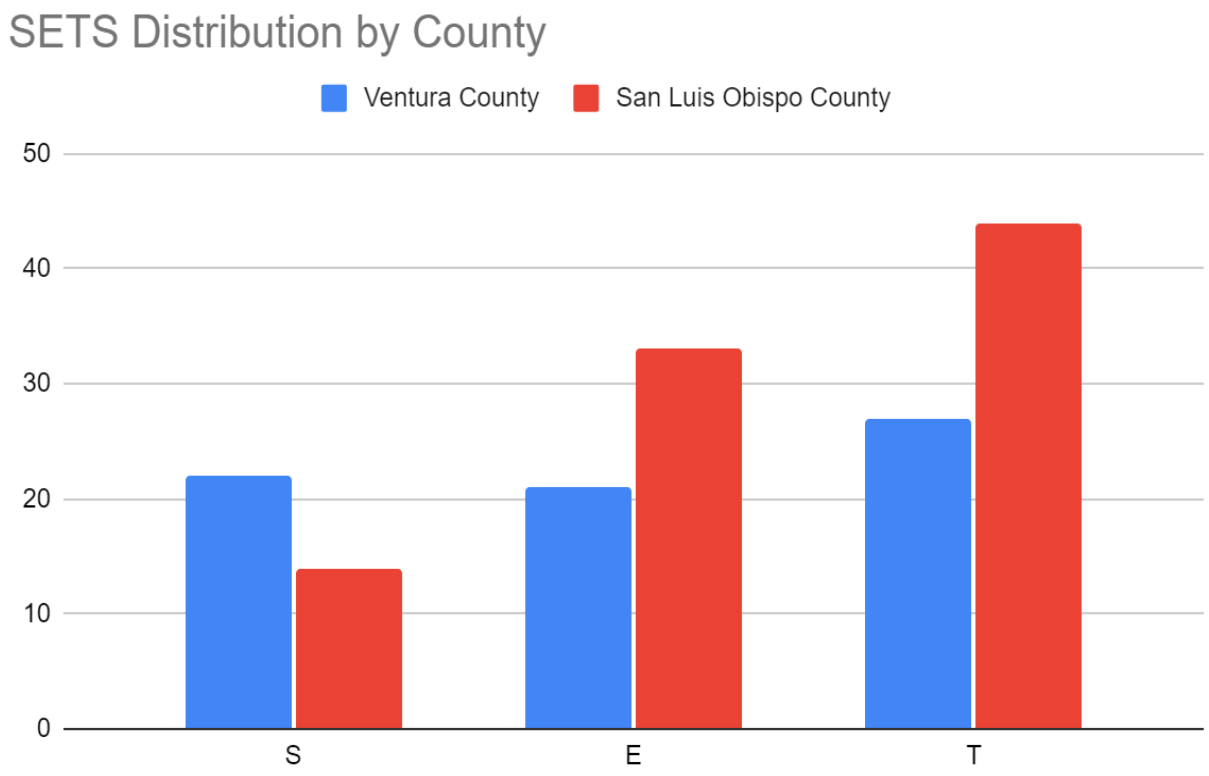


Figure 15: SETS Distribution by County

The FRM approaches in San Luis Obispo County are on average more focused on technological approaches, where resisting shock and chronic stresses is prioritized. San Luis Obispo County's documents were not collated, so a number of sections were repeated for each region listed. The repetition of these sections resulted in a lack of

diversity of approaches to FRM in the county. While they were repeated, these repeated approaches were utilized in different regions of the county, as such they were still included in the results. Figure 15 illustrates the basic distribution of S, E, T, FRM variables across the two counties, excluding the combination variables (SE, ST, ET). This figure illustrates the differing approaches in both counties. Both counties utilize a higher percentage of Technological approaches than the other two FRM approaches. In San Luis Obispo County, 43.85 percent of the FRM strategies are categorized as Technological. An additional 7.30 percent of the FRM strategies used in the county are in-part Technological approaches (Social-Technological and Technological-Ecological). San Luis Obispo County's FRM are primarily resistant, many of the strategies are repetitive, and much focus is on maintaining the status quo. "Maintaining the natural environment" and "maintaining existing structures" are common FRM strategies for San Luis Obispo County. Through coding I identified 85.03 percent of the FRM strategies in

San Luis Obispo County as resistant and the remainder as resilient with no transformative strategies.

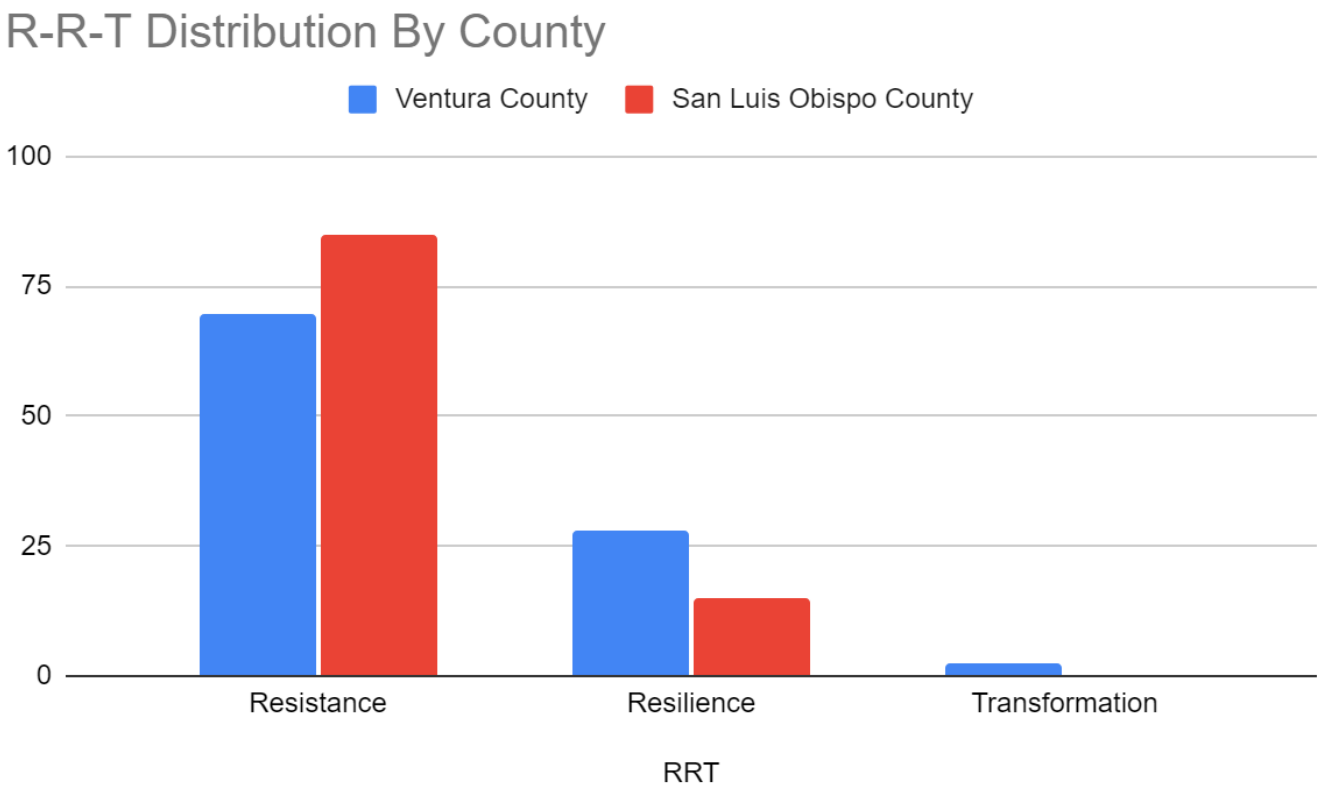


Figure 16: R-R-T Distribution by County

Ventura County's approaches to FRM are more diverse than San Luis Obispo County, however there is some repetition. Figure 15 illustrates the more balanced approach that Ventura County takes to FRM strategies. Ventura County's SETS approaches are distributed somewhat evenly: Social at 22.06 percent, Ecological at 21.07 percent and Technological at 26.96 percent. The combination approaches are less evenly distributed, but all under 15 percent. Ventura County has a number of full SET approaches, combining Social-Ecological-Technological approaches in one FRM. Additionally, Ventura County utilizes more resilient approaches than San Luis Obispo

County, however the approaches still heavily favor the resistant FRM approaches: 69.12 percent resistance-based, 27.94 percent resilient and the remainder being Transformative. Since Transformative approaches are a newer concept in planning this result is expected. Overall Ventura County makes a conceited effort to include a diversity of FRM approaches that not only maintain the current conditions, but act to improve, or transform them in some cases (See Figure 16). These efforts look to the future, which is evident throughout the General Plan, even in the title “2040 Plan”.

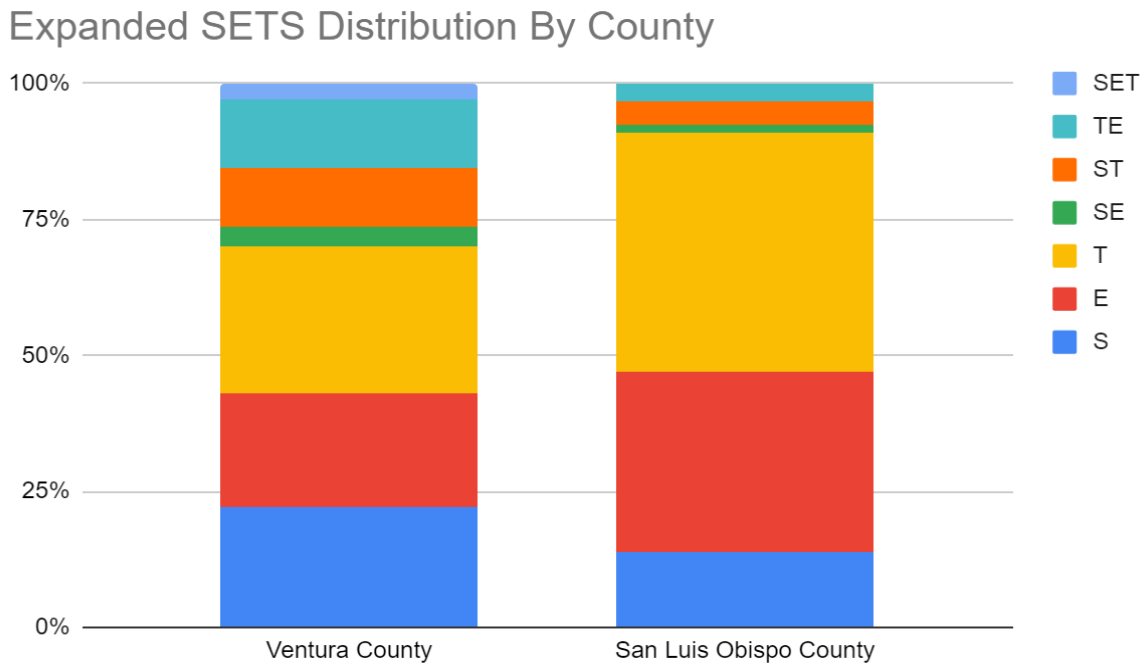


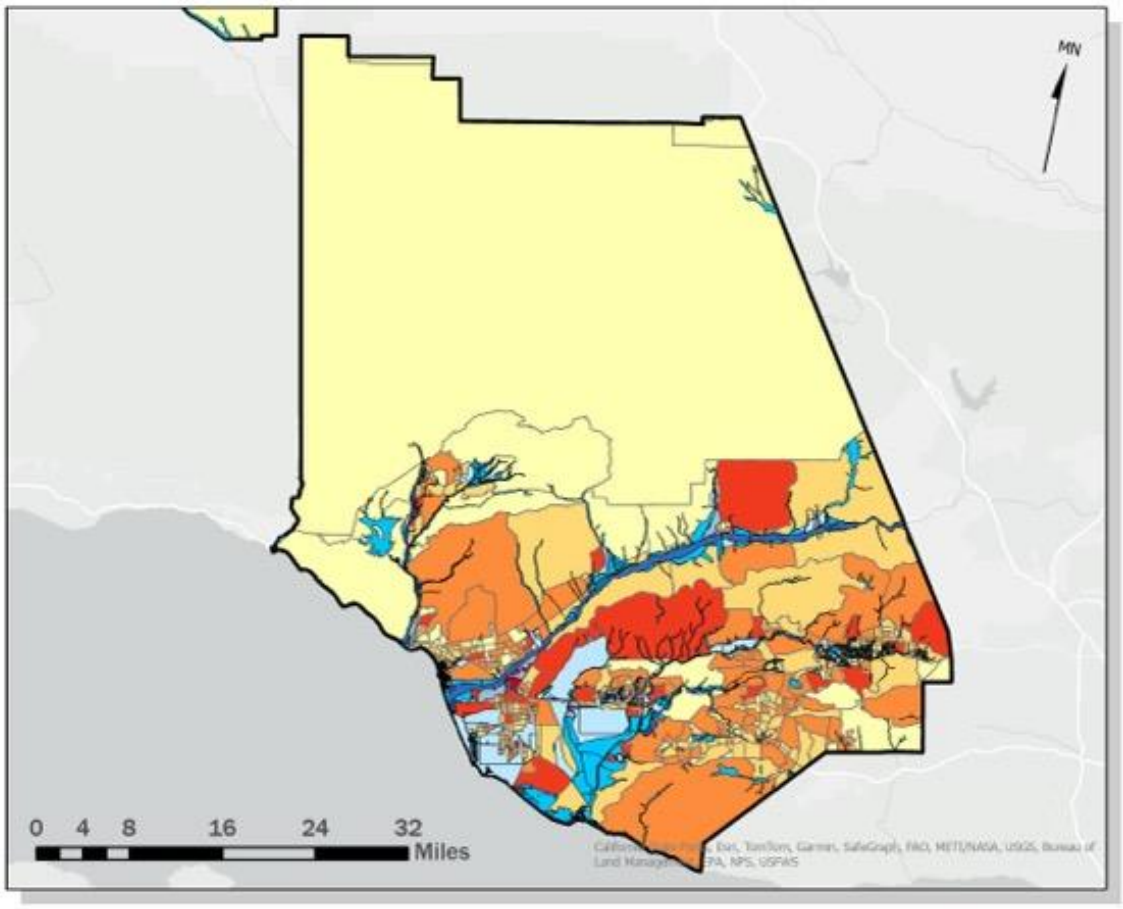
Figure 17: Expanded SETS Distribution by County

San Luis Obispo County had no SET strategies, and a Technological, and Ecological-Technological, and Social-Technological dominate solution strategies. Ventura County had a more balanced approach of combination strategies (SE, ET, ST)

when compared to San Luis Obispo County (See Figure 17). A detailed breakdown of percentages of SETS strategies can be found in Appendix C.

4.5 Mapping Discussion

As part of this research, I generated maps to visualize the regions analyzed to better understand the impact of the planning decisions in each county spatially. Figures 18 and 19 are maps that show the total population distribution in each county by census block, with NFIP data. Both counties have areas of higher population that overlap with areas of flood risk. Figures 20 and 21 are maps that show average household income in both counties by census block, it is important to consider these maps in conjunction with figure 3 and 4 which show the CRS ratings in each county. San Luis Obispo County has only two small areas of coverage under the CRS, with a somewhat homogenized income across the county. In San Luis Obispo County there are some pockets of lower income (than the rest of the county). The pockets of lower relative income in San Luis Obispo County are not all covered in the CRS coverage. Ventura County has a much less homogenized distribution of income in the county; however, the entire county is covered by the additional coverage of the CRS representing more FRM strategies used in the county. Both low- and high-income areas of Ventura County benefit from the additional coverage.



Ventura County Flood Hazard and Population

Nikki Maraviglia

Legend

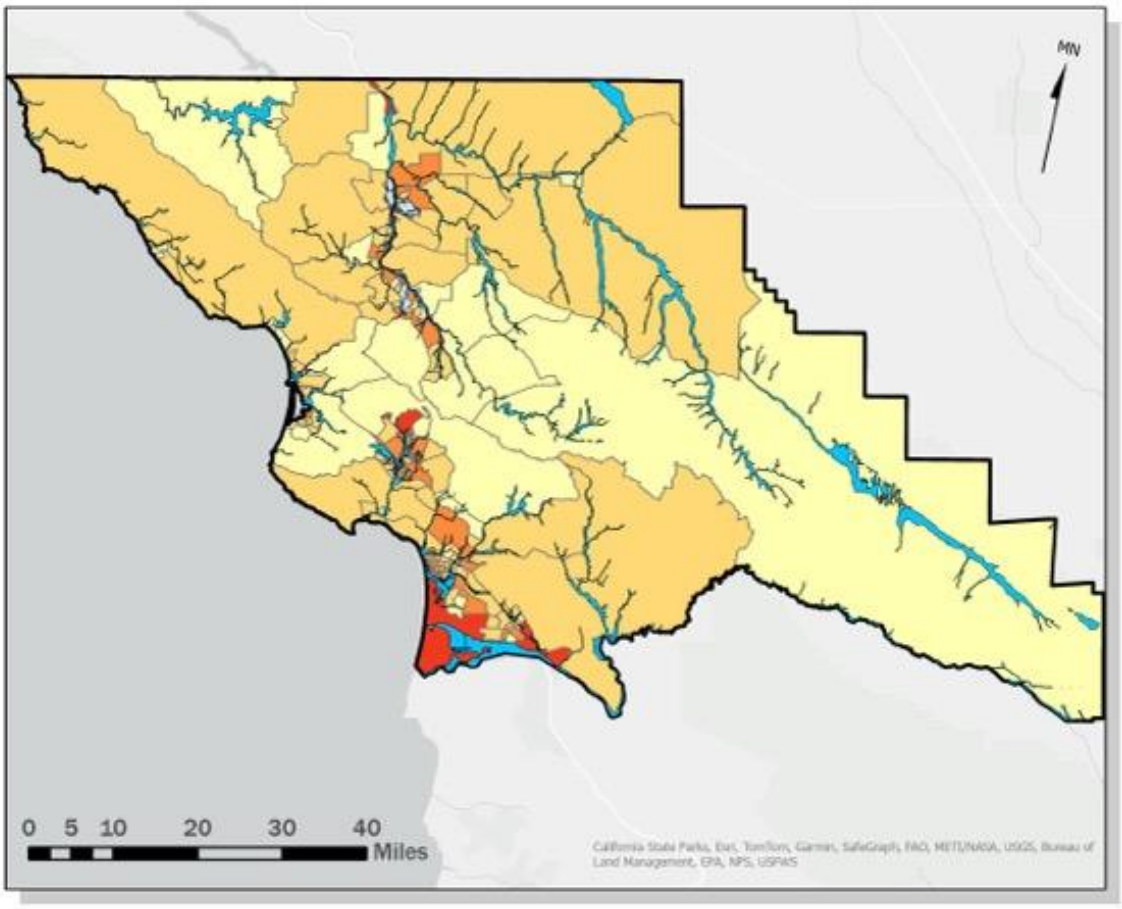
Flood Hazard

- 0.2% Annual Chance Flood Hazard
- 1% Annual Chance Flood Hazard
- Regulatory Floodway
- Area with Reduced Risk
- County Border

Total Population

- 0 - 1200
- 1201 - 1900
- 1901 - 2700
- 2701 - 4700
- 4701 - 10297

Figure 18: Ventura Flood Risk and Population



San Luis Obispo County
Flood Hazard and Population

Nikki Maraviglia

Legend

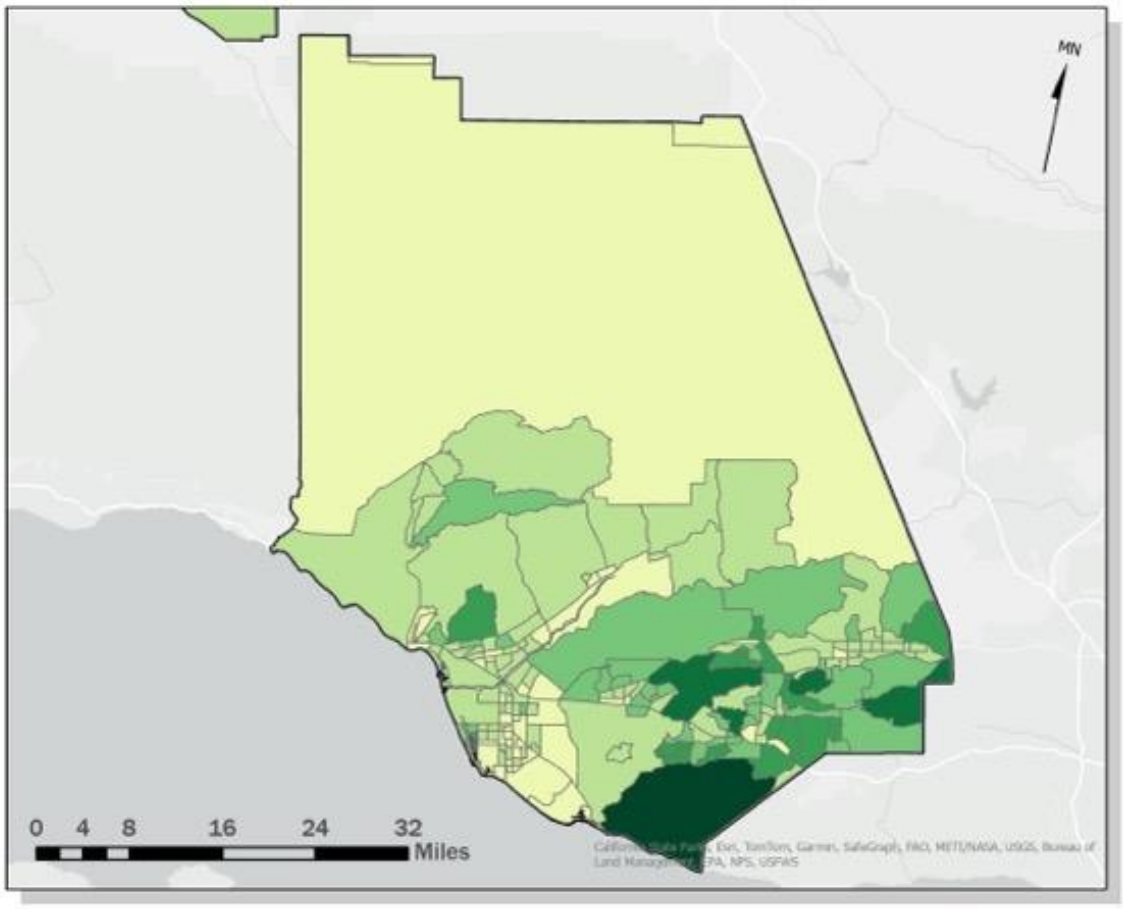
Flood Hazard

- 0.2% Annual Chance Flood Hazard
- 1% Annual Chance Flood Hazard
- Regulatory Floodway
- Area with Reduced Risk
- County Border

Total Population

- 0 - 1200
- 1201 - 1900
- 1901 - 2700
- 2701 - 4700
- 4701 - 10297

Figure 19: San Luis Obispo County Flood Risk and Population



Ventura County Household Income

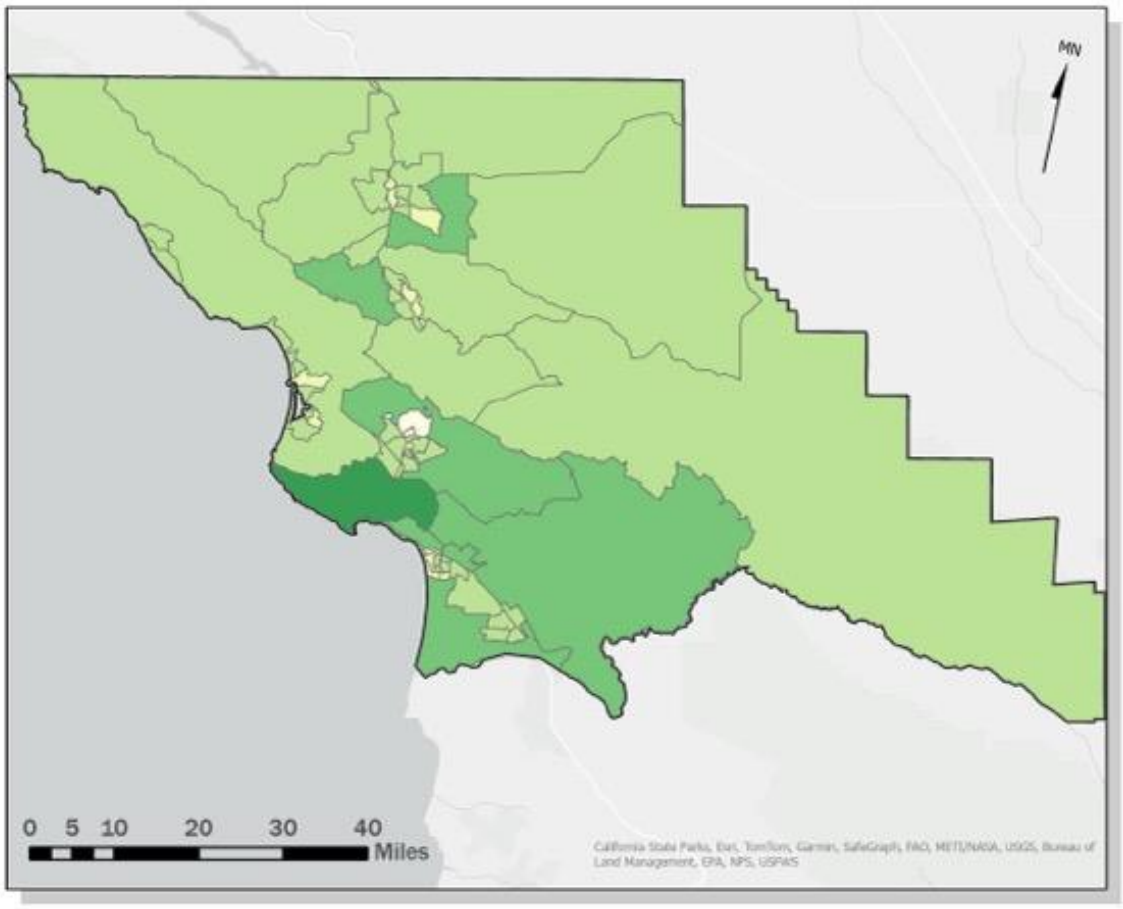
Nikki Maraviglia

Legend

Average Household Income in 2023

- ≤ 50000
- 50001 - 100000
- 100001 - 150000
- 150001 - 200000
- 200001 - 250000
- 250001 - 300000
- 300001 - 350000

Figure 20: Ventura Average Income 2023



San Luis Obispo County Household Income

Nikki Maraviglia

Legend

Average Household Income in 2023

- ≤ 50000
- 50001 - 100000
- 100001 - 150000
- 150001 - 200000
- 200001 - 250000
- 250001 - 300000
- 300001 - 350000

Figure 21: Ventura County Average Income 2023

Chapter 5: Conclusion

Flood Risk Management is a complicated and difficult task to manage in any circumstance. Having a more balanced approach leads to more successful long-term results when facing threats such as increased chronic and shock stresses from climate change (Chang et al., 2021). San Luis Obispo County is ill equipped to deal with these stresses due to an outdated and simplified approach to FRM. Failing to update much of the General Plan for the last two decades is a contributing factor to the failings in San Luis Obispo County. Somewhat surprisingly, there have been no updates to the General Plan in San Luis Obispo County since major flooding events of late 2022 and early 2023 that lead to loss of life. Conversely, Ventura County has a more balanced approach to FRM and while not equally balanced is more prepared for future flooding events, both shock and chronic (Chang et al., 2021). Ventura County's blend of Social, Ecological, and Technological approaches through their General Plan are more forward-thinking and balanced than San Luis Obispo County's approaches.

Ventura County approaches FRM with more resilience strategies than San Luis Obispo County. Their focus on accessibility is highlighted throughout their General Plan and accompanying websites, not only do they publish their General Plan in English and Spanish, but they publish it in a collated format, with glossaries, and additional information to define terms therein. Ventura County also encourages public buy in and feedback for creating and amending their General Plan, something that San Luis Obispo County has not prioritized, as evidenced by the lack of information on community feedback. San Luis Obispo County's General Plan is inconsistently referenced through their website and accompanying documents, outlining sections that

do not appear on their General Plan or are incomplete. San Luis Obispo's lack of transparent information, and older General Plan, results in a general lack of modern strategies, and approaches to FRM. San Luis Obispo County has a significantly smaller population than Ventura County, however the lives in San Luis Obispo are equally important.

Some basic steps could be completed by San Luis Obispo County to modernize their General Plan, even with potentially less resources than Ventura County. San Luis Obispo could upload a collated document, where the sections match the sections either outlined in their User Guide or Annual Report. Maintaining consistency across documents is a simple solution for the county. This represents a Social strategy with regards to SETS as it primarily focuses on communication, however this could also represent some overlap into other SETS elements. San Luis Obispo County could also update out of date documents that reference reports or assessments that should have been long completed at this point according to the dates outlined in their own documents. San Luis Obispo County can begin to prioritize updating some of their older plan sections and consider collating a more completed document in the future. While Ventura County does not represent a perfect model for FRM, their goal of planning and preparing for the future is a key priority that highlights their willingness to change current planning strategies when need be. Ventura County also prioritizes accessibility to information, translating documents and providing multiple ways of accessing the General Plan. Overall Ventura County has a more plastic approach compared to San Luis Obispo County's rigid approach to FRM, making Ventura County more equipped to plan for chronic and shock flood events.

Future research into the other plans in each county could deepen the understanding of the counties FRM strategies. Additional research into all California counties would be beneficial for highlighting other FRM strategies and additional SETS variables that may not have been identified in this research. Inland counties would be particularly interesting to examine the FRM strategies and how they may differ from the coastlines. Additional research would deepen the FRM strategies understanding of each county pointing to potential solutions some counties could have overlooked.

Appendices

Appendix A: San Luis Obispo County Districts

District 1: Adelaide, Cholame, Lake Nacimiento, Oak Shores, *Paso Robles*, San Miguel, Shandon, Templeton, Whitley Gardens

District 2: Baywood Park, California Men's Colony, Cal Poly State University (portion), Cambria, Cayucos, Cuesta-by-the-Sea, Cuesta College, Harmony, Los Osos, *Morro Bay*, *San Luis Obispo* (portion), San Simeon

District 3: Avila Beach, Country Club, Edna-Los Ranchos, Edna Valley (portion), *Grover Beach*, *Pismo Beach*, Rolling Hills Estate, *San Luis Obispo* (portion), Shell Beach, Squire Canyon, Sunset Palisades

District 4: *Arroyo Grande*, Black Lake Canyon, Callendar-Garrett, Cuyama, Edna Valley (portion), Halcyon, Huasna-Lopez, Los Berros, Nipomo, Nipomo Mesa, Oceano, Palo Mesa

District 5: *Atascadero*, Cal Poly State University (portion), California Valley, Creston, Garden Farms, Pozo, *San Luis Obispo* (portion), Santa Margarita

Appendix B: NFIP CRS Discount Breakdown

Community Rating System Discounts			
CRS Class	Credit Points	In SFHA*	Outside of SFHA*
1	4,500+	45%	10%
2	4,000-4,499	40%	10%
3	3,500-3,999	35%	10%
4	3,000-3,499	30%	10%
5	2,500-2,999	25%	10%
6	2,000-2,499	20%	10%
7	1,500-1,999	15%	5%
8	1,000-1,499	10%	5%
9	500-999	5%	5%
10	0-499	0%	0%
* SFHA Special Flood Hazard Area			

Appendix C: SETS Strategy Results by County

Ventura County					
SETS Strategy	**Resistence**	**Reseliance**	**Transformation**	**Total**	**Percent of Total**
S	28	15	2	45	22.06
E	35	8	0	43	21.08
T	44	11	0	55	26.96
SE	4	3	0	7	3.43
ST	9	11	2	22	10.78
TE	19	6	1	26	12.75
SET	2	3	1	6	2.94
Total	141	57	6		Total
Percent of Total	69.12	27.94	2.94		204
San Luis Obispo County					
SETS Strategy	**Resistence**	**Reseliance**	**Transformation**	**Total**	**Percent of Total**
S	24	2	0	26	13.90
E	59	3	0	62	33.16
T	63	19	0	82	43.85
SE	3	0	0	3	1.60
ST	5	3	0	8	4.28
TE	5	1	0	6	3.21
SET	0	0	0	0	0.00
Total	159	28	0		Total
Percent of Total	85.03	14.97	0.00		187

Literature Cited

(Resource Management Agency). (n.d.). *The basics of sea level rise science and vulnerabilities in unincorporated Ventura County*. Basics of Sea Level Rise Science. https://vcrma.org/en/basics-of-sea-level-rise-science

About The County. About the County - County of San Luis Obispo. (2024). https://www.slocounty.ca.gov/Departments/County-Administrative-Officer/About-the-County.aspx

About Us. Flood Smart. (n.d.). https://www.floodsmart.gov/about

Ainsworth, J., & Doss, T. A. (1995). *Natural history of fire & flood cycles*. Natural History of Fire and Flood Cycles. https://www.coastal.ca.gov/fire/ucsbfire.html

Alluvial fan flooding. FEMA.gov. (2023a, July 7). https://www.fema.gov/glossary/alluvial-fan-flooding

CA.Gov. (2024). *Community rating system*. California Department of Water Resources. https://water.ca.gov/Programs/Flood-Management/National-Flood-Insurance-Program/Community-Rating-System

California State University, Sacramento . (2020a, November). Resilience planning: Tools and resources for Communities. Environmental Finance Center. https://www.efc.csus.edu/reports/resilience-planning-tools-and-resources-for-communities.pdf

Castleberry, K. (2015, August 31). *5 ways cities are preparing for a dry (or flooded) future*. Be a Force for the Future. https://www.nrdc.org/stories/5-ways-cities-are-preparing-dry-or-flooded-future

Chang, H., Yu, D. J., Markolf, S. A., Hong, C., Eom, S., Song, W., & Bae, D. (2021). Understanding Urban Flood Resilience in the anthropocene: A social–ecological–technological systems (SETS) learning framework. *Annals of the American Association of Geographers*, *111*(3), 837–857. https://doi.org/10.1080/24694452.2020.1850230

Chaparral. California Chaparral Institute. (2024). https://www.californiachaparral.org/chaparral/

Community rating system. FEMA.gov. (2024, February). https://www.fema.gov/floodplain-management/community-rating-system

Costello, C., & Chadwick, S. (2023). *Communicating flood risk*. First Street foundation. https://firststreet.org/research-lab/published-research/communicating-flood-risk/

County of San Luis Obispo, California. (n.d.). *Planning & building Forms & Documents*. County of San Luis Obispo. https://www.slocounty.ca.gov/Departments/Planning-Building/Forms-Documents.aspx

County of Ventura. (2020). *VC2040 general plan update*. VC2040.org. https://vc2040.org/

County of Ventura. (2022, March 10). *About Us*. Ventura County. https://www.ventura.org/county-executive-office/about-us/

County of Ventura. (n.d.). *B.2 climate change adaptation and resilience strategy*. Ventura County Resource Management Agency ePlan. https://egeneralplan.vcrma.org/appendix-b-climate-change/b-2-climate-change-adaptation-and-resilience-strategy/

County of Ventura. (n.d.). *Ventura County GIS Data*. VenturaCounty. https://venturacountydatadownloads-vcitsgis.hub.arcgis.com/

Environmental Protection Agency. (2022a, July). *Flood Resilience: A Basic Guide for Water and Wastewater Utilities*. EPA. https://www.epa.gov/waterutilityresponse/flood-resilience-basic-guide-water-and-wastewater-utilities

Environmental Protection Agency. (2022b, July). *Flood Resilience Checklist*. EPA. https://www.epa.gov/smartgrowth/flood-resilience-checklist

FEMA. (2022). *Community status book*. FEMA.gov. https://www.fema.gov/flood-insurance/work-with-nfip/community-status-book

Flooding History. Home - Ventura County Flood Info. (2020). https://www.vcfloodinfo.com/programs/flooding-and-flood-risk/vc-flood-history

Flooding History. SLO County. (2024). https://www.slocounty.ca.gov/Departments/Public-Works/Committees-Programs/Flood-Control-Zones/Zone-9-%E2%80%93-San-Luis-Obispo-Creek-Watershed/Flooding-History.aspx

Floodplain management. FEMA.gov. (2023b). https://www.fema.gov/floodplain-management

Governors office of Planning and Research. (2024). *General plan information*. General Plan Information . https://opr.ca.gov/planning/general-plan/

Home - Ventura county flood info. Ventura County Flood Info. (2020). https://www.vcfloodinfo.com/

Kim, Y., Carvalhaes, T., Helmrich, A., Markolf, S., Hoff, R., Chester, M., Li, R., & Ahmad, N. (2022). Leveraging sets resilience capabilities for safe-to-fail infrastructure under climate change. *Current Opinion in Environmental Sustainability*, *54*, 101153. https://doi.org/10.1016/j.cosust.2022.101153

Kuzmina, S. (2020). *Ventura County Flood Info*. Home - Ventura County Flood Info. https://vcfloodinfo.com/storm-ready

Landslide/debris flow. Ready Ventura County. (2022, December 12). https://www.readyventuracounty.org/landslide-debris-flow/

Los Padres National Forest - Nature & Science. Forest Service USDA . (2024). https://www.fs.usda.gov/main/lpnf/learning/nature-science

Markolf, S. A., Chester, M. V., Eisenberg, D. A., Iwaniec, D. M., Davidson, C. I., Zimmerman, R., Miller, T. R., Ruddell, B. L., & Chang, H. (2018). Interdependent infrastructure as linked social, ecological, and technological systems (setss) to address lock-in and enhance resilience. *Earth's Future*, *6*(12), 1638–1659. https://doi.org/10.1029/2018ef000926

McPhearson, T., Cook, E. M., Berbés-Blázquez, M., Cheng, C., Grimm, N. B., Andersson, E., Barbosa, O., Chandler, D. G., Chang, H., Chester, M. V., Childers, D. L., Elser, S. R., Frantzeskaki, N., Grabowski, Z., Groffman, P., Hale, R. L., Iwaniec, D. M., Kabisch, N., Kennedy, C., … Troxler, T. G. (2022). A social-ecological-technological systems framework for Urban Ecosystem Services. *One Earth*, *5*(5), 505–518. https://doi.org/10.1016/j.oneear.2022.04.007

National Weather Service. (2015). *National Oceanic and Atmospheric Administration*. Post Wildfire Flash Flood and Debris Flow Guide. https://www.wrh.noaa.gov/lox/hydrology/files/DebrisFlowSurvivalGuide.pdf

Peterson St-Laurent, G., Oakes, L. E., Cross, M., & Hagerman, S. (2021). R–R–T (resistance–resilience–transformation) typology reveals differential conservation approaches across ecosystems and Time. *Communications Biology*, *4*(1). https://doi.org/10.1038/s42003-020-01556-2

Planning for resilience. American Planning Association. (2022). https://www.planning.org/blog/blogpost/9124762/

Public works. Flood Control Zones - County of San Luis Obispo. (2024). https://www.slocounty.ca.gov/Departments/Public-Works/Committees-Programs/Flood-Control-Zones.aspx

Resilience planning: Tools and resources for Communities. Environmental Finance Center. (2020, November). https://www.efc.csus.edu/reports/resilience-planning-tools-and-resources-for-communities.pdf

SeaLevelRise.org. (n.d.). *California's sea level has risen over 6" since 1950*. Sea Level Rise. https://sealevelrise.org/states/california/#:~:text=In%20the%20last%20decade%2C%20the,to%20rise%20around%206%20inches.

Sauer, J., Pallathadka, A., Ajibade, I., Berbés-Blázquez, M., Chang, H., Cook, E. M., Grimm, N., Iwaniec, D. M., Lloyd, R., & Post, G. C. (2022). Relating social, ecological, and technological vulnerability to future flood exposure at two scales in four U.S. cities. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4204468

Shao, E., Rojanasakul, M., & Popovich, N. (2023, January 18). *Despite rain storms, California is still in drought*. The New York Times. https://www.nytimes.com/interactive/2023/01/18/climate/california-drought.html

Sharifi, A., & Yamagata, Y. (2014). Resilient urban planning: Major principles and criteria. *Energy Procedia*, *61*, 1491–1495. https://doi.org/10.1016/j.egypro.2014.12.154

Shively, D. (2017). Flood Risk Management in the USA: Implications of national flood insurance program changes for Social Justice. *Regional Environmental Change*, *17*(6), 1663–1672. https://doi.org/10.1007/s10113-017-1127-3

State of California, D. of W. R. (2023). *California water watch*. https://cww.water.ca.gov/

State Profile. Census.gov. (2023, July 17). https://www.census.gov/library/stories/state-by-state/california-population-change-between-census-decade.html

U.S. Department of Commerce. (2023, March 31). *What are atmospheric rivers?*. National Oceanic and Atmospheric Administration. https://www.noaa.gov/stories/what-are-atmospheric-rivers

US Department of Homeland Security. (2023, September 15). *Mitigation for homeowners*. FEMA. https://www.fema.gov/fact-sheet/mitigation-homeowners

Ventura County Conditions. Drought.gov. (n.d.). https://www.drought.gov/states/california/county/ventura

Ventura County Flood Info. (2020). https://www.vcfloodinfo.com/programs/the-crs-program/overview

Ventura County Public Works Agency. (2020b, October 28). *Flood Warning System*. Ventura County Public Works Agency. https://www.vcwatershed.net/fws/

Ventura County Public Works Agency. (2023, February 28). Watershed Protection. https://www.vcpublicworks.org/wp/

Ventura County Public Works Agency. (2023a, February 16). *Watershed Planning and permits*. Ventura County Public Works Agency. https://www.vcpublicworks.org/wp/watershedplanningandpermits/#1532968658891-60e3af83-ede0

Ventura County Public Works. (2020a, October 28). *VCPWA - WATERSHED PROTECTION HYDROLOGIC DATA SERVER*. Ventura County Public Works Agency. https://www.vcwatershed.net/hydrodata/

Ventura County. Coastal Resilience. (2021). https://coastalresilience.org/project/ventura-county/

Watershed Programs and projects. Ventura County Public Works Agency. (2023b, February 3). https://www.vcpublicworks.org/wp/watershedprojects/#1532044824191-3b460ee2-135e

What is urban resilience?. Resilient Cities Network. (2022, October 28). https://resilientcitiesnetwork.org/what-is-urban-resilience/

Wildfire climate connection. National Oceanic and Atmospheric Administration. (2022, August 8). https://www.noaa.gov/noaa-wildfire/wildfire-climate-connection