A COMPARATIVE ANALYSIS OF CLIMATE ACTION PLANS FROM THE REGION OF SOUTHERN DENMARK AND THE CENTRAL VALLEY OF CALIFORNIA

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Master Thesis

Master of Science in Urban, Energy, and Environmental Planning: Cities and Sustainability

Aalborg University – Department of Planning

Title
A Comparative Analysis of Climate Action Plans from the Region of Southern Denmark and the Central Valley of California

Semester Framework
Master Thesis

Project Period
1st February 2024 – 7th June 2024

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Acknowledgement
I would like to acknowledge and thank the co-supervisors of this thesis, Lars Bodum and Anna Deeg. Their support and advice were invaluable to the completion of this research. Additionally, I would like to extend gratitude to the other students involved in the collaborative lab that fostered knowledge sharing and interdisciplinary support.

Aalborg University, 7th of June 2024

AALBORG UNIVERSITET

Abstract

Anthropogenic impacts are their repercussions are undeniably being felt around the world and exacerbating the already increasingly unstable global climate. There are many efforts being employed to mitigate and adapt to these impacts. Climate action planning is at the forefront of these efforts. These documents set goals and targets, and with the collaboration of planners and scientists, strategies and actions are developed to achieve the set goals. As climate change continues, climate action planning must advance. This research examines how to enhance climate action planning through comparing established climate action plans from the Region of Southern Denmark and the Central Valley of California.

Preface

This research was conducted alongside a collaborative lab comprised of master's and bachelor's students at Aalborg University (AAU) that were working regarding the topics of urban planning, land surveying, and climate action planning. The presented work makes some assumptions that are worth noting. The term municipality is used to references land areas under a local government's jurisdiction, at a scale larger than individual towns or cities. In Denmark these areas are often called Kommuner, and in the US they are called Counties. The word municipality is used for clarity and ease of communication. Similarly, climate action plans as they are called in California, and climate action planning frameworks, as called in the Region of Southern Denmark, are referred to as climate action plans (CAPs), for ease of communication and cohesion. Point of departure for this master's thesis research was from existing collaboration between AAU and the DK2020 project and AAU and the University of California Davis (UC Davis), with assistance through knowledge sharing within the student lab group.

Executive Summary

This research seeks to explore and capture the power of a comparative analysis of municipal Climate Action Plans (CAPs), with specific consideration to agriculture, forestry, and other land uses (AFOLU), from the Region of Southern Denmark (RSD) and the Central Valley of California (CV) with the aim to conclude how such an analysis can enhance climate action planning. CAPs are documents that combine traditional planning with technical climate and ecological science from field experts. Such documents address relevant obligations and requirements from various governance levels, set climate related goals and targets, and outline mitigation and adaptation strategies and actions to achieve stated goals. The general question posed by this study is how climate action planning can be enhanced through CAP comparison.

To narrow down the document analysis four municipalities were selected, two from the RSD and two from the CV. Billund and Vejen from Denmark, and Butte and Sutter from California. These selections were made based on criteria of total municipal population, population density, the percentage of greenhouse gas (GHG) emissions from AFOLU, AFOLU land area, and whether the municipality was land locked or not. These four case studies were selected due to their similarities across these criteria.

Methods utilized throughout this research included literature review, document review, spatial analysis, and comparative case study. These methods were supported by conceptual, theoretical, and analytical frameworks. The conceptual framework set the foundation for the meaning of climate action planning in the context of this research by relating it to AFOLU and the rurban characterization. A definition was established for climate action planning with detail to climate mitigation, adaptation, and AFOLU. The theoretical framework employed is multi-level governance theory (MLG), with specific focus to the ideas of systems thinking and policy coherence, this is applied to analyze the CAPs, and informs conclusions about the analysis. The analytical framework details the scale at which the comparison was done, namely at the municipal level, and justifies this against smaller and larger scale possibilities.

Results of the comparison highlight the similarities and differences found in the development influences and content of the four CAPs. Generally, the Danish CAPs had greater external influence for multiple governance levels, primarily due to the DK2020 project, while the CAPs from the CV municipalities had lesser external influence due to the lack of CAP development regulation in the United States (US). The content was found to be relatively similar, excluding the CAP from Sutter, which was considerably older than the other three, and lacked consideration to climate adaptation. From this comparison it was found that collaboration, stakeholder involvement, MLG, and regulatory requirement for developing CAPs are critical for enhancing climate action planning.

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List of Abbreviations

AAU - Aalborg University

AB - Assembly Bill

BAU – Business as Usual

BCAQMD - Butte County Air Quality Management District

CARB - California Air and Resources Board

CAP(s) - Climate Action Plan(s)

CCTP - Climate Change Technology Program

CV - Central Valley of California

GIS – Geographic Information Systems

MTCO2e - Metric Tons of CO2 Equivalent

EU - European Union

FRAQMD - Feather River Air Quality Management District

GHG - Greenhouse Gas

RSD - Region of Southern Denmark

SB - Senate Bill

UC - University of California Davis

UNFCCC - United Nations Framework Convention on Climate Change

UNSDGs - United Nations Sustainable Development Goals

US - United States

US EPA - United States Environmental Protection Agency

1. Introduction

The global climate is becoming increasingly unstable due to anthropogenic activities that generate climate altering consequences. Changes in the global climate are an inevitable and ongoing phenomenon. However, it is being continuously exacerbated by anthropogenic impacts and the repercussions are undeniably being felt around the world. Global greenhouse gas (GHG) emissions continue to rise, and 2023 was another record year (NOAA, 2023). Despite the present situation, there are ways by which to slow GHG emission growth and potentially reverse the trend. If GHG emissions globally can be quickly brought down, there is the possibility to mitigate the most austere consequences. To make this feasible, there must be a collaborative and extensive effort by governments, businesses, local decision makers, and citizens (Ea Energianalyse, 2023).

There are myriad efforts worldwide dedicated to making meaningful impacts towards reducing GHG emissions through adaptation and mitigation measures. Climate action planning has emerged as an intersection between more traditional spatial planning, and scientific fields such as climate and environmental science (Boswell et al., 2019). Climate action planning has become an increasingly common effort set forth to address climate change from a planning perspective that heavily involves scientific expertise. Such plans are being developed on various scales, from supranational or semi-global, to national, state, and local levels. In best practice cases, at each governance level a multitude of stakeholders are involved as a means to bolster the efficacy of the plans (Bassett & Shandas, 2010). Climate action plans (CAPs) are unique compared to more traditional planning documents due to their scientific and technical nature. Climate change and the problem that is often central to CAPs, GHG emissions, is highly technical and requires specific data, along with input from experts in a range of natural and climate science fields (Bassett & Shandas, 2010). The esoteric quality of CAPs can also inhibit the widespread and quick adoption of such plans as the necessary technical skills and knowledge are not present in all municipal or local institutions. Addressing this limiting factor of CAPs through wider spread collaboration and policy coherence across governance levels and geographic borders is important for enhancing the development of successful climate action planning.

The call to establish CAPs comes from various actors across the world. In Europe, for example, the European Commission created The European Climate Law, which "sets a legally binding target of net zero greenhouse gas emissions by 2050. The EU Institutions and the Member States are bound to take the necessary measures at EU and national level to meet the target" (European Commission, n.d.). The law also requires measures to track progress, climate action plans are one method of doing so (European Commission, n.d.). Many EU member states have created their own initiatives or laws to expand upon the European Climate Law.

Denmark is one of these EU member states that has created their own initiative to act regarding climate change. The DK2020 project, a collaboration between Local Government Denmark, the five Danish regions, Realdania, and CONCITO, "requires municipalities to regularly monitor and evaluate their climate action, and to review their climate action plans every five years" (Ea Energianalyse, 2023, p. 6). This effort aims to establish a common framework and backs

Danish municipalities in developing CAPs that align with the Paris Agreement (Ea Energianalyse, 2023). The primary focus of the CAPs created by Danish municipalities is GHG emission reduction, in all sectors through both adaption and mitigation actions. The Danish Climate Act set the objective to reduce GHG emissions by 70% by 2030 compared to 1990 levels and become carbon neutral as a country by 2050 (Ea Energianalyse, 2023). This has been taken a step farther by the current Danish political platform, which aims to cut GHG emissions by 110% of 1990 levels and achieve carbon neutrality by 2045 (Ea Energianalyse, 2023). Denmark is taking great strides in its climate action, along with other countries around the world. The overarching institutions involved such as the EU and the Paris Agreement play a role in urging countries to create their own nationwide targets which then can lead to regional and local action that aims to achieve the national and supra-national targets.

Not all countries are part of these supra-national initiatives, or even have a national framework for climate action. The United States (US) is a nation that does not have a national framework for climate action. It was an original signer of the Paris Agreement in 2016, however, in 2020 President Donald Trump pulled the US out of the agreement. This was in the midst of national gridlock and turmoil of creating a unified target and action strategy for the country toward fighting climate change. This drastic action by President Trump pushed 25 states to join the United States Climate Alliance which committed the states to the goals of the Paris Agreement (Basseches et al., 2022). Since 2016, the US has rejoined the Paris Agreement under President Biden. Under the Biden administration the *The Long-Term Strategy of the United States Pathways to Net-Zero Greenhouse Gas Emissions by 2050* was created, with the goal for the US to be carbon neutral by 2050 (Kerry & McCarthy, 2021). However, neither of these have resulted in a national policy or framework for creating CAPs within the country.

California was, and still is, one of the leading states in the nation for climate action. A decade before the Paris Agreement and 15 years before the creation of the United States Climate Alliance, California passed the Global Warming Solutions Act (AB32) in 2006 (Haden et al., 2013). AB32 required “California to reduce its GHG emissions to 1990 levels by 2020 — a reduction of approximately 15 percent below emissions expected under a “business as usual” scenario” (California Air and Resources Board (CARB), 2018). This legislation prompted a senate bill in 2008 that required regional administration “to develop sustainable land-use plans that are aligned with AB32” (Haden et al., 2013). This policy did not require or encourage the development of CAPs specifically, but acted as a step, if you will, in the process of planning regarding climate change.

Despite no federal requirement to develop climate action plans, many states, including California, have put forth documents stating their targets, strategies, and monitoring commitments. In March 2024, California released their *Priority Climate Action Plan*, with the target to reduce anthropogenic GHG emissions to “85% below the 1990 level by 2045 and to also achieve carbon neutrality by 2045” (California Air and Resources Board (CARB) & California Environmental Protection Agency (CalEPA), 2024, p. 15). State and regional level action is immensely important for tackling the climate problem the world is facing, however, going beyond that to the local level is a capital step to enforce and monitor climate goals.

Local level climate planning is critical for addressing specific issues related to land use, population, emission sectors, etc., as each of these factors interacts with climate change in a particular (Reckien et al., 2018). Discussion of local level planning often focuses on cities given that much of the global population lives in cities. Cities can be critical to climate action "because they are located at the interface of local action and national and international level climate change adaptation and mitigation commitments" (Reckien et al., 2018, p. 208). The less urban areas outside of cities require climate action planning as well. Such buffer or 'rurban' areas contribute to GHG emissions and pose climate altering impacts in unique ways, as well as simultaneously offering their own possibility for meaningful solutions. Cities are primarily built-up environments with less natural spaces, more impermeable surface, and greater populations, all of which contribute to anthropogenic climate impacts. Outside of cities, the characterization of the land and population distribution are quite different, resulting in emission sectors and climate change influences that may not be present in cities. It is fairly common practice that CAPs are developed to encompass entire municipalities which can contain cities along with more rural and buffer areas, this is the case for both the Region of Southern Denmark (RSD) and the Central Valley of California (CV). In both locations there are municipalities or counties, respectively, that have urban centers along with much more rural areas, often with a gradient or buffer between the two. That transition area can be characterized as rurban, and as noted, have its own influence on climate change and thus must be incorporated into local level CAPs.

There can be quite a range of factors that characterize rural and rurban areas across geographic regions, one being land use designation. The IPCC has put forth the sector deemed AFOLU, Agriculture, Forestry and Other Land Uses, which is critical for climate action planning given that this sector accounts for "almost a quarter of anthropogenic emissions" (IPCC, 2023a, p.7). This sectoral designation has been adopted or maintained by some institutional CAPs, but not all. It is worth noting that CAPs are not standardized and can use different terminology and sectoral designations, thus the term AFOLU may not be used. AFOLU is focused on managed ecosystems rather than the human population or other directly related emission factors (IPCC, 2023a). There is a connection between this IPCC designation and population outside of cities; it is generally true that the areas outside of cities, where populations are often smaller and less dense, is also where the elements of AFOLU are located.

As discussed, there are multiple elements that influence the contents of CAPs and their development. Population and development (urban vs. rurban), and land use (AFOLU) are the primary content drivers focused on here. Governance and regulatory obligation are focused on for the motivation behind CAP development. These elements vary enormously within countries and between countries; in turn, the way CAPs incorporate these elements fluctuates. While it is important for local CAPs to address the uniqueness of their location, each CAP should be developed with outside influence, whether it is from the state, regional, national or supranational level. Given the global nature of climate change there should be international, national, regional, and local collaboration within the development of CAPs. There are numerous ways to go about such collaboration, but to do so effectively, there needs to be an understanding of the benefits that can come from that effort and how to go about it. This challenge of climate action planning is addressed through investigating the comparison of rurban climate action planning specifically regarding AFOLU in the RSD and the CV.

2. Problem Analysis

This research takes departure from the challenge discussed in the introduction, namely the challenge of enhancing climate action planning through the development of local level CAPs. As stated, it is important for local level CAPs to address the uniqueness of their locality with consideration to global context.

Throughout the world there are various levels of involvement through tiers of government, institutions, and agencies when it comes to addressing climate change. In Europe there is supranational governance for example from the EU or the Paris Agreement, as well as national governance from individual countries which impact the development of CAPs both at a national and local scale. The US is part of the Paris Agreement so there is that form of supranational influence on addressing climate change, however the country lacks other supranational or national level guidance, leaving action to individual states, regions, or municipalities. This difference between places fosters comparison that aids in understanding the implications of such differences and allows for an understanding of how different places could influence or enhance climate action planning beyond their borders.

The scope of this research pulls from the examples of Denmark and the US, specifically focusing on the RSD and the CV. Information and challenges outlined above informed the research question:

How can comparing climate action plans from rurban municipalities of the Region of Southern Denmark and the Central Valley of California, specifically regarding agriculture, forestry, and other land uses, enhance climate action planning?

The research question is further broken down into sub-research questions to enable a more detailed understanding of the research and deeper analysis. The sub-research questions are:

Sub-research question 1: What is climate action planning in the Region of Southern Denmark and the Central Valley of California?
Sub-research question 2: How does the rurban characterization impact climate action planning?
Sub-research question 3: What role do agriculture, forestry, and other land uses have in climate action planning?

3. Methods

3.1 Conceptual Framework

The conceptual framework for this research takes form the central concepts of climate action planning, climate change adaptation and mitigation, agriculture, forestry, and other land uses, and the 'rurban' setting idea. It is imperative to define these concepts within the specific scope of this research. Individually each has their own definition, which is important to understand, beyond that, they are joined in a unique way that builds the conceptual framework for this research.

There are many existing definitions of climate action planning. This research draws upon the definition of climate action planning utilized by DK2020 which includes "planning of climate mitigation and adaptation" (Tollin et al., 2023, p. 5). This led to the inclusion of both mitigation and adaptation as part of the research. While this definition of climate action planning, which includes climate mitigation and adaptation, was formulated based on research involving municipalities in the RSD, it aligns with other definitions that are connected to research in diverse geographic locations as well as with the IPCC's consideration of climate planning. In the Working Group II definition of climate resilient development, which can be intuitively linked to climate action planning, the IPCC refers to implementing mitigation and adaptation measures as a means for achieving climate resilience development (IPCC, 2023b). Additionally, the Fourth and Fifth Assessment Reports of the IPCC discusses mitigation and adaption in an interconnected manner and "links between the two strategies (particularly evident in landscape management)" (Locatelli et al., 2015, p 586). Mitigation and adaption are respectively defined as well, "mitigation: an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse;" and "adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (Denton et al., 2007, p. 750). Understanding the individual definitions of mitigation and adaptation facilitates the establishment of a definition of climate action planning that forms the foundation of this research for comparing climate plans in the RSD and the CV. To establish a specific definition for climate action planning as it pertains to this research, two other ideas must be fleshed out, namely, the term rurban, and the designation of AFOLU as coined by the IPCC (IPCC, 2023a).

The idea of 'rurban' as a municipal setting is paramount to this research. The Cambridge Dictionary offers a general and widely understandable definition of this concept, "land in the countryside on the edge of a town or city, on which new housing, businesses, etc. are being built" (*Cambridge Business English Dictionary*, n.d.). To better understand the idea another widely understandable definition is provided by Lancaster University, defining rurbanization as "the process of increasing the presence of green space and or agriculture in towns and cities: a ruralisation of the urban" (*What Is Rurbanisation?*, n.d.) As it pertains to this research, rurbanity is used as a description for characteristics of municipalities within the RSD and the CV. The description is also used as an analytical tool which will be discussed further in Chapter 3.4. To use the term as a descriptor, a clear definition of how it applies to this research must be established.

Rurban in the context of this research is to be understood as the land outside of an urban center; it can contain agricultural, forested, or generally vacant land as well as residential and limited commercial or industrial areas. Based on relevant literature, there is no set distance from an urban center that can be characterized as rurban, rather it seems judgement based depending on the urban-rural gradient. The presence of many kinds of land uses is key as “there is a co-evolution of the countryside and the city” (Hoffman M. et al., 2023, p. 5). Hoffman M. et al. (2023) discuss that city and surrounding rurban areas are inherently connected through place, flows and connectivity, livelihoods and lifestyles, institutions and behavior, and the dynamics of natural lands and human developed infrastructure (Hoffman M. et al., 2023).

AFOLU is used as a label for land uses that are not established residential, commercial, or industrial areas; rather, these lands are agricultural, forested, or otherwise open natural areas, protected or not (IPCC, 2023a). In this research AFOLU is characterized as such. While not all municipalities in the RSD and the CV use this exact land use characterization within their planning, liberty has been taken to join their respective designations that are like AFOLU with the aim to create a sense of uniformity for comparing locations.

Based on the definition provided for the term rurban and the characterization of AFOLU, climate action planning can be defined as it pertains to this research. Climate action planning as stated above is “planning of climate adaptation and mitigation” (Tollin et al., 2023, p. 5), with the inclusion of areas outside of cities or urban centers, rurban areas, and focus given to agricultural, forested, and other non-residential, commercial or industrial land areas. This understanding of climate action planning also sets the expectation for what should be included in a compressive CAP, namely, the inclusion of mitigation and adaptation, acknowledgement of urban areas, rural areas, and areas in between which can be considered rurban, and consideration to AFOLU.

3.2 Theoretical Framework

The term multi-level governance (MLG) was developed by Gary Marks around 1993, with the aim to capture and understand political pressures related to the emergence of large-scale governing institutions and to facilitate analysis of decentralized decision-making processes in which sub-national level institutions and civil-society have come to have increasing influence (Saito-Jensen, 2015). As the name suggests, this concept encompasses many state and non-state actors at different levels. MLG as a concept identifies that multi-dimensional issues, such as climate change, require coordination and collaboration across levels of government, from local to global, across sectors, and among stakeholders (Pangalos, 2023). Addressing the complex issue of climate change necessitates a holistic and cooperative approach that transcends top-down governance models, which is just the aim of MLG. However, with diverse levels of power there can be difficulty aligning definitions and achieving goals (Saito-Jensen, 2015). This theory, with its emphasis on systems thinking and policy coherence, acts as a tool by which the comparison of climate action planning in the RSD and the CV can be partially analyzed. Systems thinking and policy coherence are paramount in the theoretical framework due to the need for inclusive and participatory decision-making processes across levels of governance and with the engagement of many stakeholders (Pangalos, 2023).

Systems thinking is a process for understanding the relationships and interconnectedness of fundamental parts of a system (Sanneh, 2018). This aptly applies to climate action planning given the interconnectedness of the issue. The process of systems thinking underscores that climate change is not only and environmental problem, but social, economic, and political as well, and requires cohesive solutions (Sanneh, 2018). Systems thinking as part of MLG also underlines the interrelations between governance levels and stakeholders involved in climate action planning, this idea will be elaborated upon further in coming chapters.

Policy coherence points to the need for agreement and uniformity of goals, policies, and actions across governance levels and sectors, as well as stakeholders (Pangalos, 2023). This is critical for ensuring that policies are not created and enforced in isolation, but rather contribute to achieving common goals, and avoid conflicting policies or lead to unintended consequences that could obstruct effective climate action planning (Pangalos, 2023). Policy coherence as part of MLG is an element that will be analyzed in the CAPs.

Multilevel governance theory with a focus on the two elements of systems thinking and policy coherence create the theoretical framework employed throughout this research. The following chapters will delve deeper into the analysis of rurban climate action planning in the RSD and the CV with a concentration on AFOLU.

3.3 Analytical Framework

The analytical framework of this research pertains predominantly to the scale at which the comparison analysis is done. Two municipalities in the RSD and two municipalities in the CV are the focus of this research. The selection process and explanation of the case study follows later in Chapter 3.7.

Comparing rurban climate action planning as it relates to AFOLU is carried out at the municipal level given the nature of rurban characteristics. As the conceptual framework defines, the rurban phenomenon is the area outside of urban centers that is less densely populated and contains a mix of agricultural, forested, residential, minimal commercial and industrial, and other types of land uses. The elements described clearly do not relate to cities, thus comparison at the city level was not sufficient, as cities generally do not contain land areas meeting the definition of AFOLU and are densely populated. While towns are smaller than cities and often less densely populated with more AFOLU land area, they too are not sufficient for the comparison at hand. The definition of rurban provided for this research highlights the relation between cities or urban centers and the surrounding areas. Towns generally do not cover enough geographical space for this relation to be apparent, and there is greater possibility that towns do not have established CAPs.

Looking at the broader scale, a regional or national comparison presents boundaries regarding rurbanity and AFOLU. CAPs at this level tend to be less focused on specific elements of localities and discuss climate action more broadly in ways that pertain to the entirety of the region or country.

The municipal level comparison supports the inclusion of rurban areas and AFOLU into the investigation of climate action planning. Municipalities are a large enough geographic area that there are many land use types present, often with one or multiple urban centers, that diffuse into rurban and possibly rural areas. Outside of the urban centers there is generally land that falls under the AFOLU umbrella, while at a smaller scale like cities or towns, these types of lands may not be present or be quite minimal. Municipal level comparison also allows to the analysis of MLG within CAP development.

3.4 Literature Review

Literature review was a primary research method used throughout the development of this project. As a method for academic research, literature can be described as a "systematic way of collecting and synthesizing previous research" (Snyder, 2019). It is a vital method for developing and justifying research questions (Torres-Carrión et al., 2018). Literature review was conducted to identify gaps in existing knowledge and inform the research question and sub-research questions. A solid understanding of the relevant topics was formed from literature review. Topics of reviewed literature include climate action planning, climate change, adaptation and mitigation, and multilevel governance, to name a few. It is important to note that these topics were researched through literature review generally to form a base understanding, as well as specifically relating to the RSD and the CV. The literature reviewed was found through various search methods, including many online academic platforms where key words and phrases such as "climate action planning in Denmark," "local climate action planning in California," "influence of population on climate action planning," "influence of land use on climate action planning," "how to characterize the rurban phenomenon," etc. were searched to narrow the research results. Reviewed literature was also obtained through works cited within other sources. The types of literature reviewed includes books, book chapters, journal articles, and peer-reviewed articles.

3.5 Document Review

Document review is a methodical process for reviewing and evaluating documents that like literature review. It is a qualitative research method, so it requires data be examined and interpreted to extract meaning, gain understanding, and cultivate empirical knowledge (Bowen, 2009). The key distinction between literature review and document review is the type of material used. Document review involved texts or images that have been produced without the involvement of a researcher (Bowen, 2009). For the purpose of this project, policy texts, planning documents, and reports were reviewed. Specific documents to note are the multiple municipal CAPs from both the RSD and the CV, climate and GHG emission policies pertinent to both locations, reports from the IPCC, as well as reports and policies from the EU Commission, the Danish National Government, and the State of California. These documents were sourced using online library search engines, municipal websites, or provided by Aalborg University (AAU) staff in the case of the Danish municipal CAPs.

3.6 Spatial Analysis

Spatial analysis examines, assesses, evaluates, and models geographic data and related attributes to establish results with spatial correlation. This can expose structural and statistical characteristics of data, that are geometric (2D), or geographical (3D), and relationships or patterns that are otherwise not evident (Kanada, 2022; Paramasivam & Venkatramanan, 2019). Geospatial data includes information regarding size, shape, position of an object on Earth, and can contain more than just location specific information. Geometric, geographic, and thematic data is stored as coordinates and topology (Paramasivam & Venkatramanan, 2019). This data can be stored as two types, raster data and vector data, depending on the storage technique. Raster data is presented in a grid of pixels or cells, each with their own value (a unit of measurement or a color). Vector data is generalized as the graphical representation of the real world, and can be divided into three subtypes, point, line, and polygon data.

There are many geospatial techniques that can be used based on the type of data available and the research being conducted. Geographical information systems (GIS) enable these techniques. GIS enables attribute interaction with geographical data to improve interpretation accuracy and prediction of spatial analysis (Kanada, 2022; Paramasivam & Venkatramanan, 2019). GIS can be used for organizing existing data and building new geographical data,and are also useful for spatially visualizing data.

Spatial analyses using ArcGIS Pro were conducted to understand and display population density and land use data. The table below provides a comprehensive overview of the data used and the sources.

Table 1. Overview of ArcGIS Pro data layers and sources

Layer	Layer Type	Description	Data Source
Billund Population by Postcode	Vector (polygon)	Shows the number of people per square kilometer broken down by postcode within the municipality	ArcGIS Online
Vejen Population by Postcode	Vector (polygon)	Shows the number of people per square kilometer broken down by postcode within the municipality	ArcGIS Online
Butte Population by Postcode	Vector (polygon)	Shows the number of people per square kilometer broken down by postcode within the municipality	ArcGIS Online
Sutter Population by Postcode	Vector (polygon)	Shows the number of people per square kilometer broken down by postcode within the municipality	ArcGIS Online
Billund Land Use	Vector (polygon)	Displays land use types	DATAFORSYNINGEN Styrelsen for Dataforsyning og Infrastruktur
Vejen Land Use	Vector (polygon)	Displays land use types	DATAFORSYNINGEN Styrelsen for Dataforsyning og Infrastruktur
Butte Land Use	Vector (polygon)	Displays land use types	California Natural Resources Agency
Sutter Land Use	Vector (polygon)	Displays land use types	California Natural Resources Agency
Billund Municipal Boundary	Vector (polygon)	Shows the outline of the municipality	ArcGIS Online
Vejen Municipal boundary	Vector (polygon)	Shows the outline of the municipality	ArcGIS Online
Butte Municipal Boundary	Vector (polygon)	Shows the outline of the municipality	ArcGIS Online
Sutter Municipal Boundary	Vector (polygon)	Shows the outline of the municipality	ArcGIS Online

Some layer manipulation was necessary to visualize the data in the manner necessary for this research. The Butte and Sutter Population data was presented as population per square mile. To convert the units to square kilometer to create consistency with the Danish data, the attribute tables for the Butte and Sutter population layers were exported to .csv files in which the data was converted from square miles to square kilometers. This .csv file was then imported into the ArcGIS Pro project. A join was done between the Butte and Sutter population layers and their respective .csv files. The symbology was set to graduated colors to display the people per square kilometer field, and five natural breaks were used to best display the findings visually. The population layers for Billund and Vejen originated from a layer containing the entire country, so selection by attributes was used to create two new layers, one for each municipality. These layers contained fields of how many people per postcode and the square kilometer area of the postcodes. The approach to achieve the necessary data of people per square kilometer was different than for Butte and Sutter. Instead, it was obtained through symbolization. When symbolizing the established field, an expression of "$feature.POP/$feature.AREA" was used with the graduated colors symbology option to display the people per square kilometer using five natural breaks to remain consistent with the symbology for Butte and Sutter.

The available and utilized land use layers for the Danish municipalities and the Californian municipalities were quite different. Land use for Billund and Vejen were only categorized for various developed areas, lakes, and wetlands. While the layers for Butte and Sutter have a much more detailed breakdown, with different kinds of developed area, urban unspecified, and many kinds of agricultural and natural areas. To create the most consistent analysis and visualization possible with this data the categories available, in each case the land uses related to AFOLU were grouped and displayed as the background satellite image, as there was not a way to create features to be symbolized for the Danish layers. The developed areas were grouped based on the original data for each location, and displayed with individual color assignments for the polygons, see Chapter 4.1 for the created figures.

3.7 Case Study

Case study is a method used across many fields of research.
Flyvbjerg claims that its "main strength is depth – detail, richness, completeness, and within-case variance" (Flyvbjerg, 2011, p. 314). According to Crowe et al. (2011) there are three types of cases. The first is the *intrinsic* case, which deals with circumstance and characteristics which set that individual case apart from other cases. The second kind is the *instrumental* case, which is a typical case for the issue or phenomenon that is to be investigated. Lastly, there is the *collective* case, which involves multiple cases which are analyzed to compare them. Further, they offer four steps on how to conduct a case study, see Figure 1.

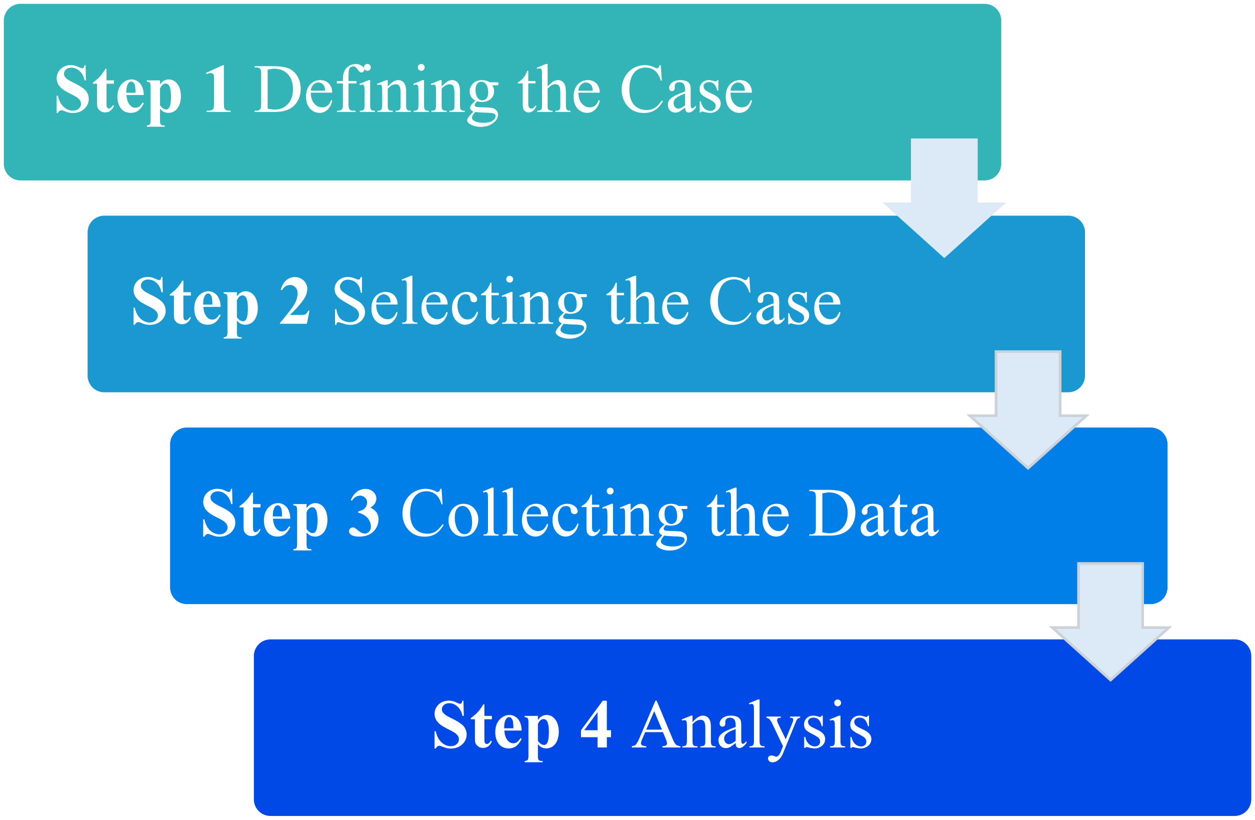

Figure 1. The four steps of conducting a case study (Source: Adapted from Crowe et al., 2011)

The first step is defining the case. In this step the researchers narrow down the problem and formulate clear research questions. During this step it is imperative to define the boundaries of the research, i.e., the time period of the research, the demographic, and the scale that is going to be studied. The next step is the selection of the case. At this time the type of case study to be carried out is defined. The case area is chosen during the second step based on the decisions made in the first step as well as on practical reasons that affect the study – i.e. data availability and timeframe. The third step is the collection of data, where they stress that a mixed-method approach should be chosen to increase the validity of the case study. The final step is the analysis, interpretation, and reporting of the case study. In this step, it can be helpful to work within a theoretical framework while also reflecting on the framework itself (Crowe et al., 2011).

The approach of a *collective* case study was chosen as the aim of the research is a comparison. Comparative case studies investigate and synthesize the similarities, differences, and patterns across cases (Goodrick, 2014). According to Goodrick (2014) this comparison is made across two or more cases, while Crowe et al. (2011) argue that the number of selected cases can vary; “two or three replications” are suggested to suffice if the “theory is straight forward and five or more if the theory is more subtle” (Crowe et al., 2011, p. 6). Collective case studies generally apply both qualitative and quantitative methods; for both kinds of methods it is imperative that data sources for each case are comparable, when possible, to minimize inaccuracies in the respective case which could result in faulty conclusions (Crowe et al., 2011; Goodrick, 2014). This kind of case study is valuable for understanding the context of each case so that conclusions from the comparison can be fully understood, and the resultant proposed intervention can acknowledge contextual differences that may be pertinent to future outcomes from the research (Goodrick, 2014).

The results of a case study can be used to understand the specific cases individually, while also drawing broader conclusions of the topic at large. In the scope of this research, rurban climate action planning regarding AFOLU is assessed for four individual municipalities in two very different locations. As a result, a broader understanding of climate action planning will be presented which enables conclusions to be made about how these cases meet overall climate action planning expectations, and how climate action planning can be enhanced in these locations and globally. This case study method can be applied to other municipalities, thus this research can be replicated and applied to many other cases.

3.7.1 Case Study Selection

The point of departure for this research was the existing collaboration between AAU and UC Davis. This collaboration is the foundation for selecting the case study municipalities from the RSD and the CV. Both universities are extensively involved in climate action planning. For the scope of this research the case study areas had to be narrowed down from the regional level.

To begin the municipality selection process the municipalities of the regions had to be assessed according to rurban and AFOLU characteristics. To analyze the two regions based on the definition of rurban provided in the conceptual framework, total population and population density data were sourced and evaluated from Danmarks Statistik and the US Census (StatBank, 2024; United States Census Bureau, 2023). These data points were evaluated for each municipality looking at the comparability between the two regions.

The analysis of AFOLU at the regional scale evaluated the percentage of GHG emissions produced from this sector for each municipality, the total land area of AFOLU within each municipality, and the percentage of land designated as AFOLU for each municipality. The GHG emission data for the municipalities of the RSD were sourced from their respective CAPs, such data for the municipalities in California was sourced from CAPs and separate GHG inventory reports. This data was not publicly available for all municipalities in the CV, and some data used has not been recently updated and dates as far back as 2004. The complete data set that was assessed at the regional level is provided in Appendix A, note that not all municipalities have data for each field, this was considered when selecting the case study municipalities as data availability is critical.

Once the data was compiled it was assessed to select the case study municipalities. The assessment aimed to select municipalities that best matched the definition of rurban based on their population data as well as having a significant amount of land within the municipality fall under the AFOLU definition. Additional criteria included their respective similarities to municipalities in the other location, i.e. which municipalities in the RSD best matched municipalities in the CV based on the criteria. Two municipalities in the RSD and two in the CV were selected based on their:

- Total population
- Population density
- AFOLU GHG emission percentage
- Percentage of AFOLU land area
- Data availability

Once the four municipalities were selected for the case study additional data was collected and analyzed to understand the context associated with each municipality first, before beginning the comparison, just as Goodrick (2014) calls for in their collective case study methodology.

4. Results

The results of the comparative case study conducted for this research are given to follow. Beginning with the results of the case study selection process that is detailed above, followed by a thorough presentation of the analysis findings from each municipal CAP reviewed, concluding with a summary of the analysis results. The content of this chapter answers the main research question, and the sub-research questions as presented.

How can comparing climate action plans from rurban municipalities of the Region of Southern Denmark and the Central Valley of California, specifically regarding agriculture, forestry, and other land uses, enhance climate action planning?

Sub-research question 1: What is climate action planning in the Region of Southern Denmark and the Central Valley of California?
Sub-research question 2: How does the rurban characterization impact climate action planning?
Sub-research question 3: What role do agriculture, forestry, and other land uses have in climate action planning?

4.1 Results of Case Study Selection

The two selected municipalities from the RSD are Billund and Vejen. The two selected municipalities from the CV are Butte and Sutter. These four municipalities are very similar in terms of population density throughout the entire area, AFOLU land cover percentage, and the percentage of GHG emissions produced by AFOLU. It is important to note that Vejen and Billund are the only two landlocked municipalities in the RSD which enhanced their favorability for selection, as all municipalities in the CV are landlocked.

As noted in Chapter 3.7.1, the complete data tables for all municipalities in the two regions are in Appendix A. Table 2 below displays the total population, population density, AFOLU land cover area, AFOLU landcover percentage, and percentage of GHG emissions produced by AFOLU for the four selected municipalities.

Table 2. Case Study Municipality Data (Billund Municipality, 2021; Butte County, 2021; PBS&J, 2010; StatBank, 2024; United States Census Bureau, 2023; Vejen Municipality, 2020b)

	Total Population	Population Density per KM^2	AFOLU Land Area KM^2	AFOLU Land Cover (%)	AFOLU GHG Emissions (%) (from year presented in CAP)
Billund, DK	27,135.00	50.23	523.10	96.83	53.00
Vejen, DK	42,814.00	52.62	748.80	92.02	60.00
Butte, CA	211,632.00	48.73	3,599.39	82.88	50.00
Sutter, CA	99,633.00	63.30	1,378.93	87.61	66.00

The two municipalities in the RSD have a total population that is much smaller than the CV municipalities, this aligns with the overall population difference between the nationwide totals of Denmark and the US, and the population of the State of California. Therefore, total population alone does not provide much insight regarding the rurban nature of the municipalities, rather, population density provides a more appropriate measure for comparison. To gauge this, the overall population density for the municipalities was used, Table 2 shows that the population density is quite similar across the four case study locations.

The total land area in square kilometers dedicated to AFOLU differs between the two regions; the two CV municipalities have greater AFOLU land areas. This is because the total area each municipality is larger than Billund and Vejen. The column displaying the percent of land cover that is AFOLU highlights that in fact the four municipalities have a similar amount of AFOLU land based on their individual municipal land areas. Likewise, the four case study locations all report similar GHG emission percentages produced by the AFOLU sector.

To further understand the population and land use breakdowns for each municipality, the data was visualized using ArcGIS Pro. Figures 2-5 below depict the population density of each municipality broken down by postal code, by using this smaller scale within each municipality the distribution of the population can be seen which helps to understand the rurban characteristic of the municipalities, i.e. show areas that contain an urban center and areas that do not. The use of postcodes to break down the population density was determined by data availability; postcode was the smallest scale that the RSD and CV had in common that was accessible. Billund is broken into five postcodes, Vejen into nine, Butte into fifteen, and Sutter into eight. It is important to note that in each municipality there are some postcodes utilized that extend past the municipal boundary line. This may slightly impact the population density for those postcodes, if the postcode boundary matched the municipal boundary the number could be different, it is not believed that this is detrimental to the data. As stated, this is due to available data, it would be preferred to use data that is only within the municipal boundary area. None the less, the general idea of population density for those postcodes can be understood from Figures 2-5.

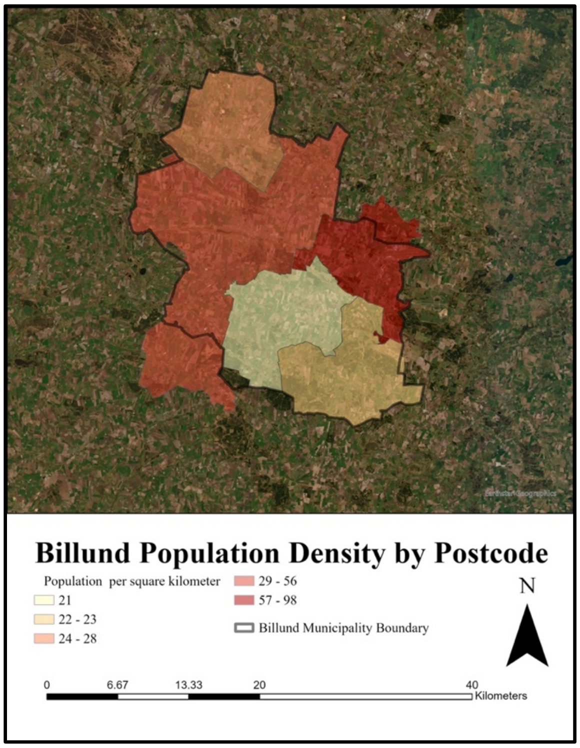

Figure 2. Billund Population Density by Postcode

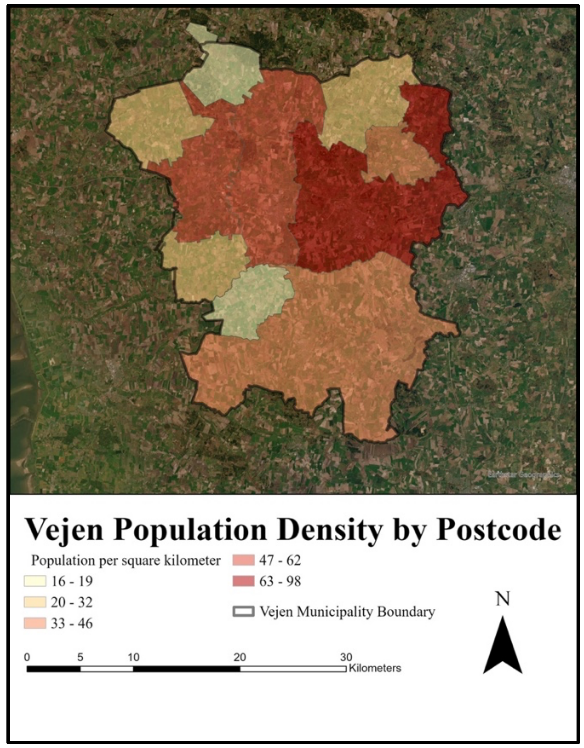

Figure 3. Vejen Population Density by Postcode

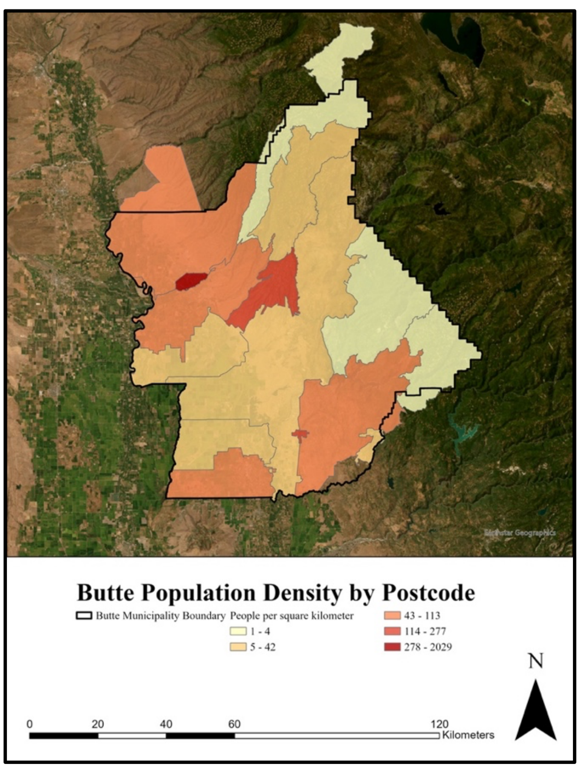

Figure 4. Butte Population Density by Postcode

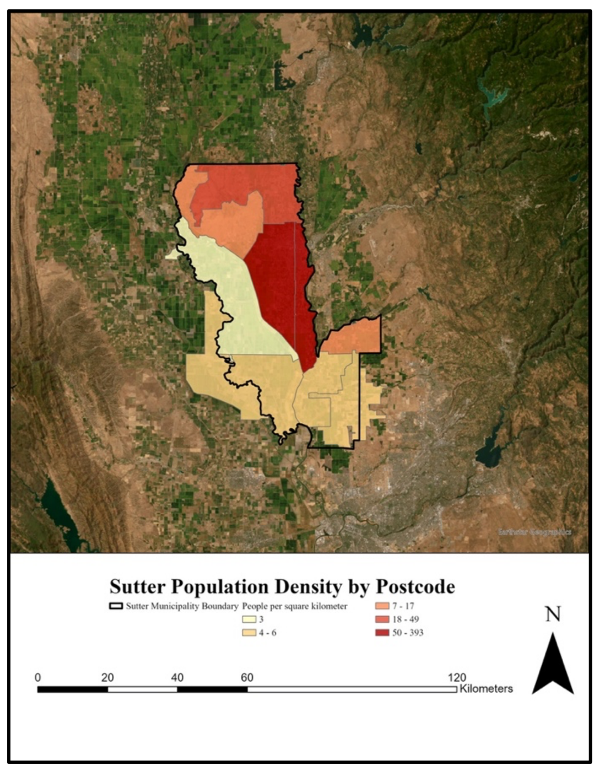

Figure 5. Sutter Population Density by Postcode

Land use for each case study location was also visualized using ArcGIS Pro. Figures 6-9 depict the various land uses present across all four municipalities. The visualization below distinctly agrees with the AFOLU land cover data presented in Table 2; it is evident that the largest land use sector of these municipalities is AFOLU, visualized as the satellite imagery to show the natural landscape variation within the sector.

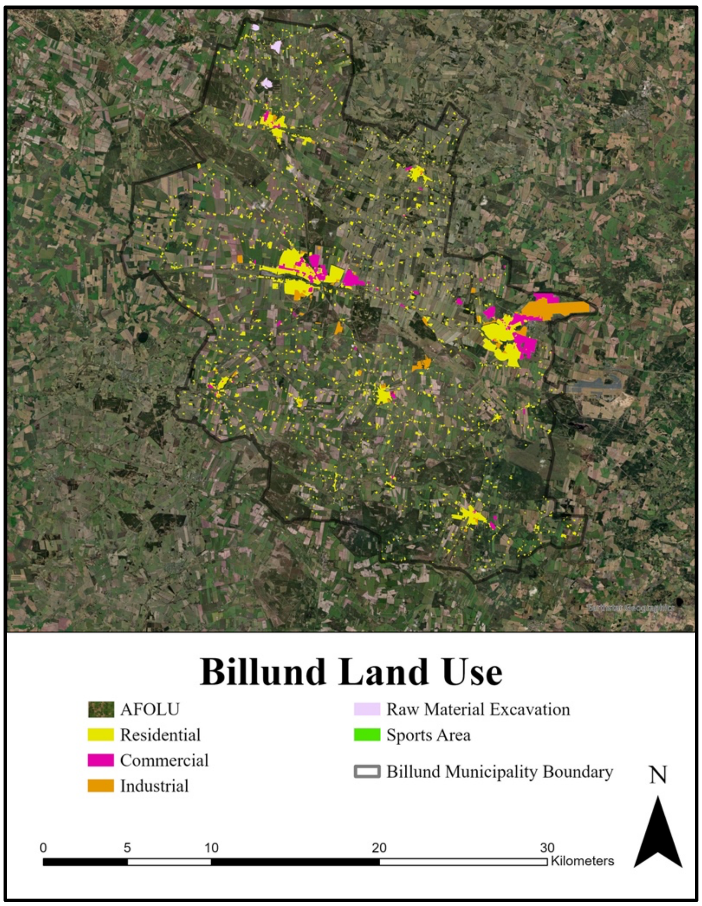

Figure 6. Billund Land Use

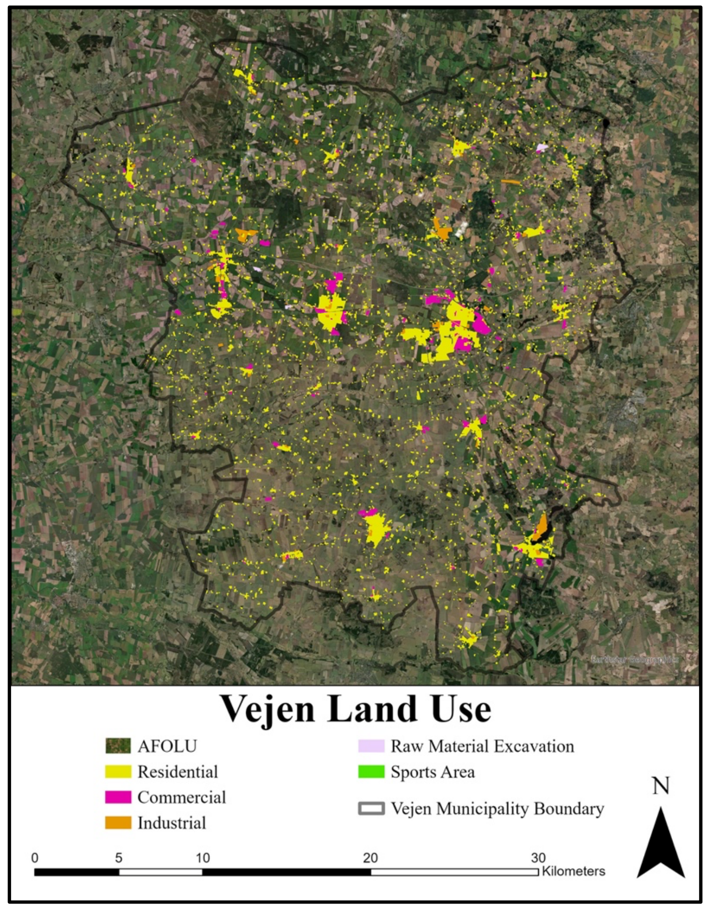

Figure 7. Vejen Land Use

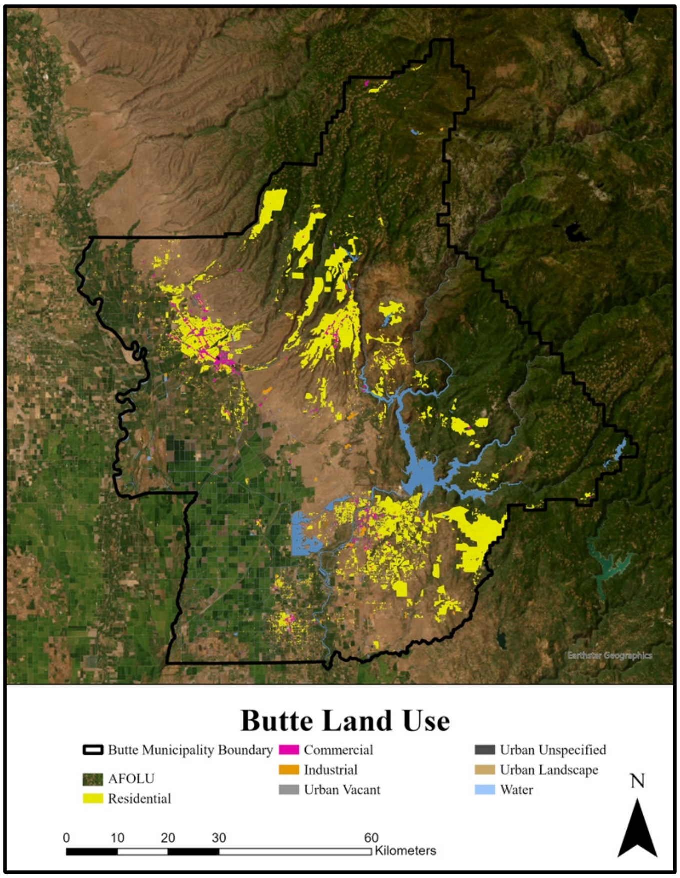

Figure 8. Butte Land Use

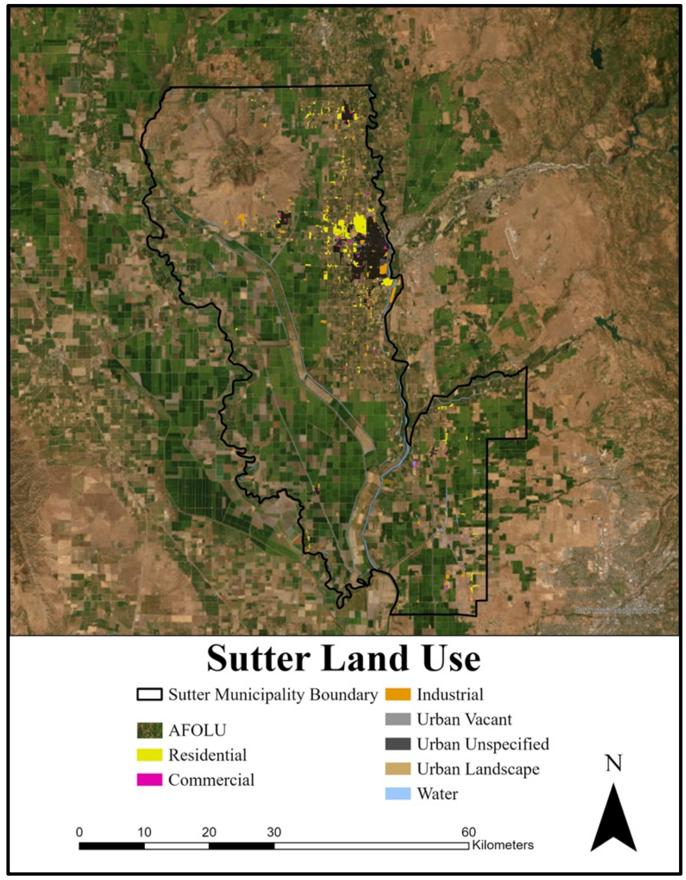

Figure 9. Sutter Land Use

The population density and land use maps are overlayed in Figures 10-13 to show the relation between population density and land use. The postcodes with the highest population density also have the most development, primarily residential and commercial in Billund (Figure 10) and Vejen (Figure 11), predominantly residential in Butte (Figure 12), and residential and urban unspecified in Sutter (Figure 13).

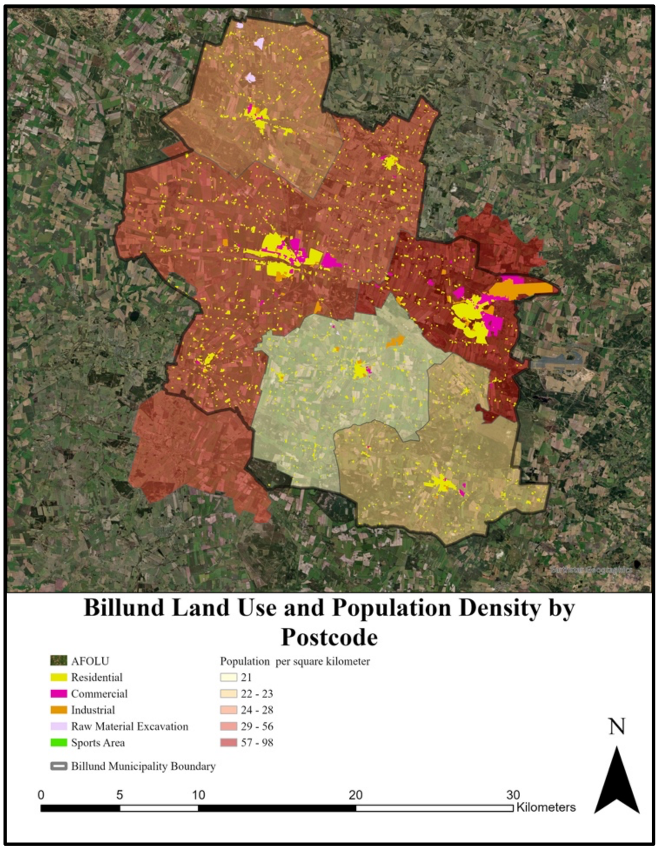

Figure 10. Billund Land Use and Population Density by Postcode

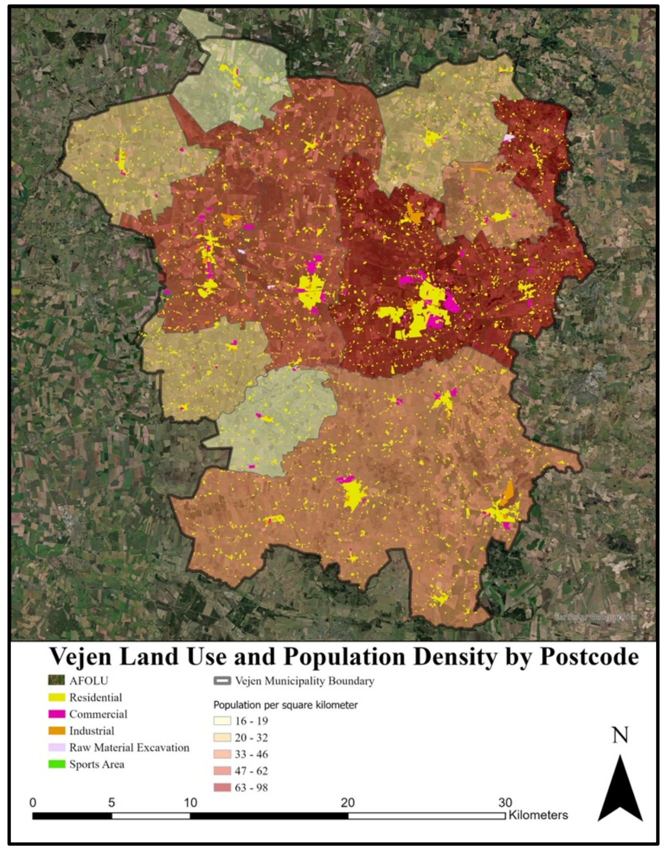

Figure 11. Vejen Land Use and Population Density by Postcode

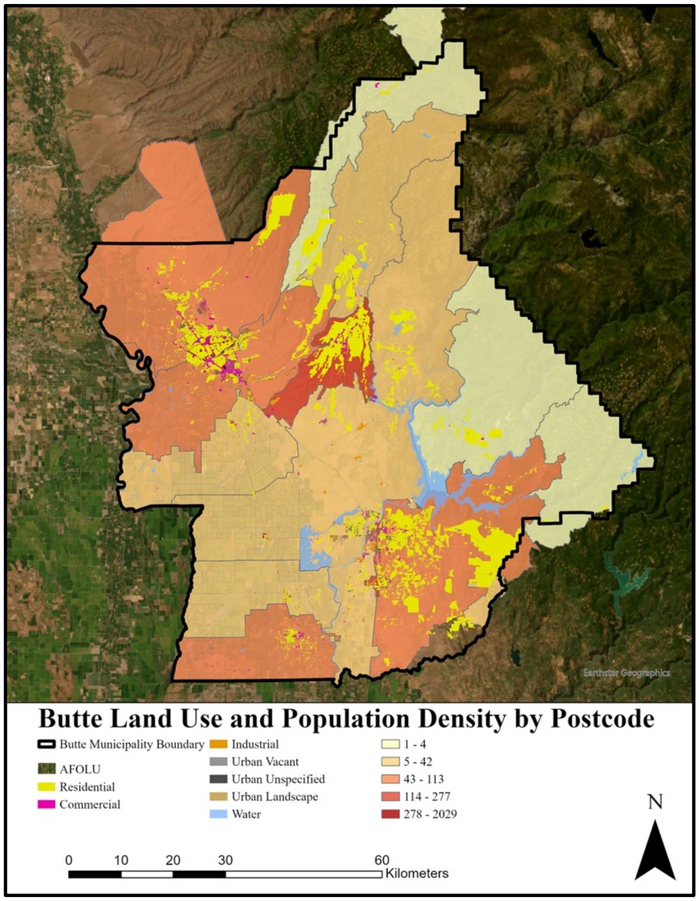

Figure 12. Butte Land Use and Population Density by Postcode

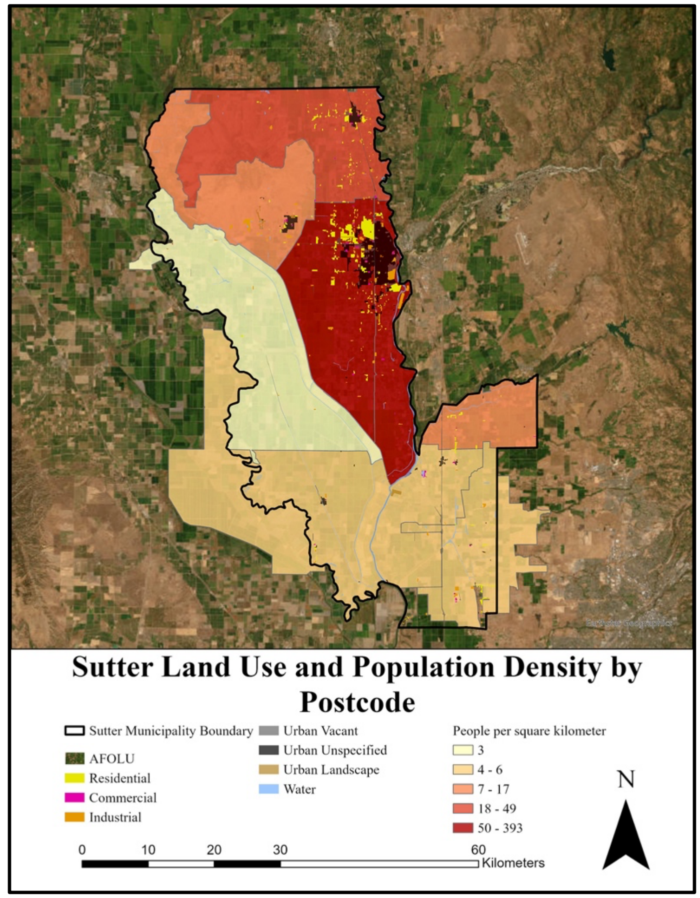

Figure 13. Sutter Land Use and Population Density by Postcode

The results of CAP analysis as they relate to development influence, the rurban characterization, and AFOLU, for each case study location are to follow. Throughout this chapter assume the source is the respective municipal CAP, unless otherwise cited.

4.2 The Region of Southern Denmark Case Study Locations

To begin the presentation of results specific to the two Danish municipalities, an overview of the RSD's approach to CAP development will be discussed to provide context and begin the comparison of climate action planning between the RSD and the CV.

The twenty-two municipalities of the RSD developed CAPs according to an adaption of the C40 Climate Action Planning Framework (CAPF); this effort resulted from the DK2020 project (Tollin et al., 2023). The DK2020 project was the first time that the C40 CAP standard was used for smaller cities and municipalities, as some it was originally implemented for some of the world's largest and climate forward cities, including Copenhagen, Berlin, and Los Angeles. DK2020 is in collaboration with Realdania, C40, and CONCITO (Lind & Hansen, 2023). DK2020, drawing from the C40 CAP standard, provides a common framework to support all Danish municipalities in the development of CAPs that uphold Paris Agreement and national climate targets; the municipal CAPs were developed in three rounds from 2019 to 2021 (Tollin et al., 2023). Billund created their CAP in round 2 (2021) and Vejen created their CAP in round 1 (2020); these CAPs follow a common structure and contain the same type of information as all RSD municipal CAPs (Tollin et al., 2023). The similarity aids in the analysis and understanding of these plans.

4.2.1 Billund

Billund municipality is located in the southern central area of Jutland and is landlocked, see Fogure 14. It borders six other municipalities. The municipality is largely characterized as agricultural, the land is predominantly flat with few scattered hills, and two notable features of the municipality are the airport and Legoland. Billund has two main urban centers noted as towns, five smaller urban clusters categorized in the CAP as villages, and open rural country side; throughout the municipality there were about 390 farm holdings as of 2020 (Billund Municipality, 2021). There are areas within the municipality that are more urbanized, generally more commercial and residential hubs (see Figure 10), that then spread out into less densely populated areas with a few smaller residential hubs. This gradient between urban centers, residential hubs, and rural land with few residences spread out highlights the rurban characterization.

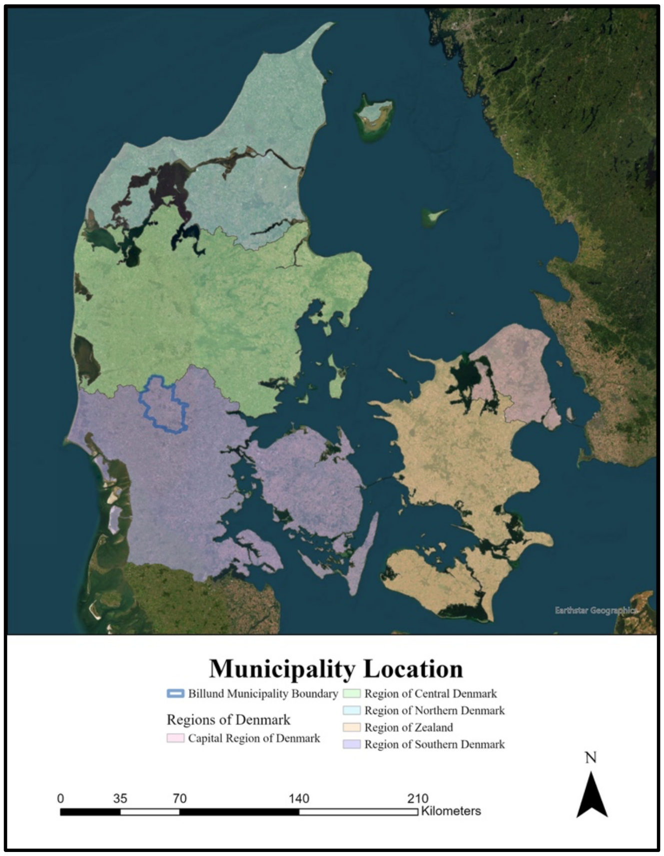

Figure 14. Billund Municipality Location

Influence on CAP Development

The DK2020 CAP created by Billund Municipality was founded on many prerequisites that predated the 2021 plan, including international and regional guidance, and national legislation, as well as municipal plans and visions (Billund Municipality, 2021). Billund's CAP then influences the municipalities internal plans, policies, and regulations so as to improve climate action practices (Billund Municipality, 2021). A number of climate action related plans have been created to date, and will continue to be developed into the future within the municipality to address both mitigation and adaptation goals, as these are both key components of the municipality's CAP (Billund Municipality, 2021). Likewise, there are numerous directives, at many governance levels, which impact climate action work in all sectors and influence this CAP, and all DK2020 CAPs:

Table 3. International, EU, National, and Regional Obligations that Influenced CAP Development in Billund

<table>
<tr><th colspan="6">International</th></tr>
<tr><td colspan="3">Paris Agreement 2020 – A global agreement to reduce GHG emissions, and a commitment to keep global temperature rise below two degrees Celsius compared to pre-industrial times.</td><td colspan="3">United Nations Sustainable Development Goals (UNSDGs) – The 193 member states are committed to 17 goals and 169 sub-goals including climate action and limited global temperature rise.</td></tr>
<tr><th colspan="6">EU</th></tr>
<tr><td colspan="3">Growth Strategy – Targets intelligent, sustainable, and inclusive growth, promoting environmental benefits, job creation, and security through increased recycling and resource efficiency.</td><td colspan="3">Climate Plan (European Green New Deal 2021) – The plan aims to transform the EU into a resource-efficient society which will ensure a climate neutral Europe by 2050, economic growth decoupled from resource consumption, and no person or place left behind with a GHG emission reduction goal of 55% reduction from 1990 levels by 2030.</td></tr>
<tr><th colspan="6">National</th></tr>
<tr><td colspan="2">Climate Act 2020 – This builds off the Paris Agreement to create a national target for GHG emission reduction that is to reach 70% reduction from 1990 levels by 2030 and to be climate neutral by 2050. The act also includes annual climate status and projection updates.</td><td colspan="2">Responsibility for Denmark (The political basis for the government 2022) – Many actions are set to boost the green transition, secure targets for GHG reduction and ensure the country can withstand future climate change.</td><td colspan="2">Climate agreement on green electricity and heat 2022 – A framework for ensuring a fourfold increase in total electricity production from solar energy and onshore wind by 2030.</td></tr>
<tr><td colspan="2">The Planning Act 2022 – The act sets the basis for planning by public authorities, recent changes include climate to ensure the municipalities have a better chance to reduce GHG emissions and improve resiliency.</td><td colspan="2">The Energy Agreement 2018 – This sets the goal that by 2050 the energy supply will be 100% renewable.</td><td colspan="2">The Agricultural Agreement 2021 – This agreement sets targets for the agricultural sector for GHG reduction. The goal is to reduce emissions for the sector by 55-65% by 2030.</td></tr>
<tr><th colspan="6">Regional</th></tr>
<tr><td colspan="6">The Regional Development Strategy 2020-2023 – The strategy sets a framework for how the RSD contributes to the climate agenda and GHG reduction targets. Green transition, climate and resources are included in the strategy.</td></tr>
</table>

The municipality makes the distinction between the municipality as a geographic area and as a 'corporation' and breaks out goals separately; given the scope of this research, the goals regarding the geographic area as a whole were the focus.

CAP Goals

The municipality's principal goal stated in the CAP is to reach a 70% reduction from 1990 GHG emission levels by 2030 and to achieve carbon neutrality by 2050 (Billund Municipality, 2021). 2020 GHG emissions were dominated by three sectors: AFOLU, energy, and transportation. The municipality set forth specific GHG emission reduction targets for these sectors. The goal for AFOLU is 60% reduction by 2030 and 85% reduction levels by 2050 from 1990 levels (Billund Municipality, 2021). Multiple adaptation and mitigation measures, along with projected climate impacts, are presented in the CAP. Specific goals and actions are outlined for mitigation and adaptation.

Mitigation

The primary focus of mitigation measures for AFOLU, and all other sectors, is on GHG emission reduction to achieve the stated reduction goal of the CAP. The AFOLU related mitigation actions sector are:

- *"Emissions in the agricultural industry must be reduced by focusing on the individual farm and the actions that will be relevant in the individual case. The path to reductions must be paved in collaboration with agricultural organisations"* (Billund Municipality, 2021, p. 75).
- *"A targeted effort to plant more forest in Billund Municipality is an important climate initiative, as reforestation contributes to increased absorption of CO2 from the atmosphere. Billund Municipality wants both private afforestation projects and wants to plant more forest itself on its own land and in cooperation with investors and other players. Forests must be placed so that they do not crowd out the good food areas"* (Billund Municipality, 2021, p. 75).
- *"Organic soils account for approximately 30 percent of emissions from agriculture. We will reduce precisely these emissions by taking the areas out of operation and instead restoring natural and wetland areas on the areas"* (Billund Municipality, 2021, p. 76).

The 2020 baseline for GHG emissions had AFOLU responsible for 53% of total emissions, or about 141,000 metric tons of CO_2 equivalent ($MTCO_2e$). Note that $MTCO_2e$ is used as a metric to report the combination of all GHGs as they each have different potencies, for this research assume that $MTCO_2e$ and GHG when used for reporting emission levels are interchangeable. Numerically, the emission reduction goal for AFOLU by 2030 is about 97,963 tons $MTCO_2e$ and by 2050 the number increases to 198,138 tons CO_2e. A land analysis concluded that about 5,000 hectares have been identified for reforestation efforts. To achieve the AFOLU GHG reduction goal the target of 150 hectares of reforestation annually until 2030 has been set, which would amount to 4,000 hectares by 2050. Reforestation is a key source for GHG reduction within the municipality, it has been estimated that forest uptakes about 4.9 tons of $MTCO_2e$ per hectare. The addition of 4,000 hectares of forest by 2050 would account for a 29% increase from the 2020 amount. Conversion of agricultural land to natural and wetland areas is targeted at 460 hectares by 2030, reaching 1,780 hectares by 2050.

Adaptation

Future climate hazards are to be from rainfall, heat, and drought (Billund Municipality, 2021). Adaptation goals and actions were created regarding the above climate hazards, rather than strictly related to specific sectors as was done for mitigation actions. The three hazards and their respective climate adaptation goals and actions are listed below:

- Flooding
    - **Goal:** The municipality will protect current economic values as a priority
        - **Action:** Set priority between potential damages to exiting values in the municipality.
    - **Goal:** Billund will plan and build intelligently to protect future economic values.
        - **Action:** Analyze areas for new development using updated flood maps and run a risk analysis.
        - **Action:** Secure future buildings with basements.
        - **Action:** Examine possible groundwater monitoring methods to supplement the national program.

- Heat and Vulnerable Populations
    - **Goal:** Ensure the well-being of vulnerable populations.
        - **Action:** Analyze shade options in municipal areas playgrounds to support learning and playing outdoors.
        - **Action:** Train personnel on good handling and management for heatwaves.
        - **Action:** Examine green cooling methods for municipal buildings.

These goals and actions are not discussed directly in relation to AFOLU, however, added values from these adaptation plans are considered in relation to the environment, nature, and biodiversity. The relation between flooding and heat climate hazards, and AFOLU, are acknowledged through added values such as the creation of urban green spaces which contribute to cooling and thoughtful development of rural areas for reforestation, removal of low-lying areas, and multifunctional land distribution projects.

Monitoring and Implementation

The CAP includes information about how the plan and related plans will be presented and implemented throughout the municipality to increase the effectiveness and successes of reaching the targets. Assessment and prioritization of the GHG reduction actions are done based on effect (directly measurable, behavioral influence, or analysis), complexity of barriers (low, medium, high), and group (based on added value, resource actualization i.e. funding, actor identification, and technology or method identification). Each of these three parameters are scored 1-3, and based on the cumulative score of an action it is placed at a prioritization level, with the note that an action could be moved to a higher or lower prioritization based on recommendation. Additionally, each action is assigned as the responsibility of a specific municipal department or other stakeholders. The AFOLU related actions are distributed between municipal legislators, private entities such citizens with municipal approval, agricultural entities such as farmers, or corporations. Barriers to implementation are identified for each action, as well as methods to overcome them.

The CAP provides a clear path for future GHG inventories and monitoring. The mitigation and adaptation goals and actions will all be monitored annually to assess if they are sufficient and being actualized properly. Each autumn the assessment conclusion for each action project is presented with recommendations for progress. To aid in the assessment key performance indicators (KPIs) were developed for each action. Key performance indicators for AFOLU related efforts include:

- The creation of at least one initiative launched annually through a partnership with the agriculture sector to reduce emissions.
- To revise the municipal land use plan to create a designated geographic plan for afforestation and renewable energy plants.
- That afforestation and the removal of low-lying areas follow the development plan to decommission organic soils.
- The afforestation area follows the development laid out in the reduction path.
- Removal of low-lying areas follows the development laid out in the reduction path.
- The revised municipal plan includes a revised development scheme for designation for afforestation and for renewable energy plants.

An updated GHG inventory is prepared every two years, accompanied by evaluation reports, beginning in 2025. An evaluation report of adaptation measures will take place every four years; this allows for an assessment of revision needs.

Inclusion of rurban specific dialogue

There is not specific mention to rurban populations or areas like there is consideration to both urban and rural areas. However, given the nature of the municipality it could be inferred that the CAP addresses rurban areas and populations.

4.2.2 Vejen

Vejen is a landlocked municipality located in the RSD in central Jutland, just south of Billund, and borders six other municipalities, see Figure 15. Topographically Vejen is quite flat with some foothills which are characteristic of the central area of Jutland. It is noted as the municipality with the most rainfall in Denmark, as well as being considered the food center for the country (Vejen Municipality, 2020b). There are four urban towns, Vejen, Brørup, Holsted, and Rødding, many smaller villages, and rather expansive rural countryside with about 500 livestock farms (Vejen Municipality, 2020b). This overall characterization of the municipality aligns with the rurban definition presented in Chapter 3.1. There are areas within the municipality that are more urbanized, generally commercial, and residential hubs (see Figure 11), that then spread out into less densely populated areas with a few smaller residential hubs.

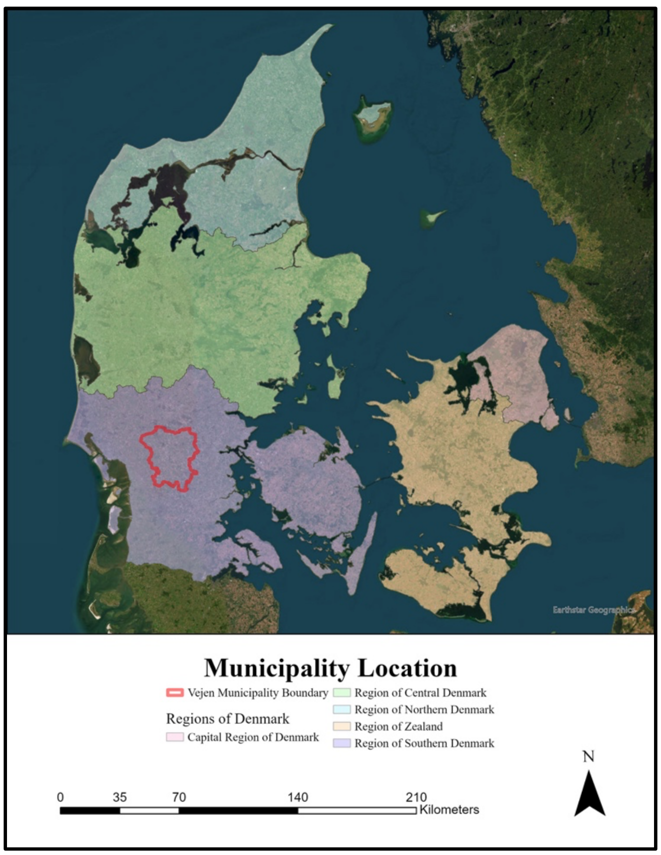

Figure 15. Vejen Municipality Location

Influence on CAP Development

Vejen's CAP, as stated, was the result of the DK2020 project, however, climate-based agreements and obligations began well before the project. Table 2, above, lists the relevant obligations that influenced the CAP development for Billund, and all DK2020 municipal CAPs.

Vejen's CAP makes note of additional influences not listed in Billund's CAP. In 2009 the municipality entered an agreement with Denmark's Nature Conservation Association which lead to the adoption of its first climate strategy in 2012, aimed to reducing GHG emissions by 30% by 2030, and in 2014 the first climate adaptation plan was developed. Vejen's CAP was influenced by an additional regional partnership called Kongeå committee between Kolding, Vejen, and Esbjerg which manages watercourse systems and areas close to watercourses to protect areas, plants, and animal life while also considering drainage needs. The municipality makes the distinction between the municipality as a geographic area and as a 'corporation' and breaks out goals separately; given the scope of this research, the municipality as a geographic area was the focus, strictly relating to AFOLU.

CAP Goals

The municipality set forth the goal to reduce emissions by 70% from the 1990 level by 2030, and reach net-zero by 2050. Adaptation and mitigation are key themes of the plan with consideration to all sectors. Sub-goals are outlined through three planning periods from 2022 to 2050 for three sectors AFOLU, Energy, and Transport. Goals applicable to AFOLU are:

- 2022-2026: "partnership agreements, low-level projects, establish biogas plants"
- 2027-2030: "cooperation with agriculture on the handling of livestock manure, cooperation with agriculture on livestock digestion, establish grass protein factory"
- 2031-2050: "establish biocoal plant" (Vejen Municipality, 2020b, p. 12).

A numerical GHG emission reduction goal for AFOLU is not given in the CAP, but projected AFOLU emissions for business as usual (BAU) in 2030 and 2050 are provided, and municipal total emission targets for the action scenario are given for 2030 and 2050. The 2019 baseline GHG emissions from AFOLU was 432,284 MTCO_2e, about 60% of the total. The BAU 2030 projection for AFOLU GHG emissions is to be 72% of the municipal total of 582,166 tons MTCO_2e, or about to be 419,159 tons. The BAU 2050 estimate is 84% of the municipal total of 493,243 tons, so about 414,324 tons. This accounts for a 13,125-ton reduction from 2019 by 2030, and a 17,960-ton reduction by 2050 for the BAU scenario. The action scenario emission targets are not broken out by sector in the CAP. AFOLU is discussed as being one of the more difficult sectors to plan for given that "a large part of the action(s) are not yet fully implementable, or not yet fully developed – (as) these are biological processes that must be controlled" (Vejen Municipality, 2020b, p. 8).

Mitigation

The AFOLU mitigation goals listed above are aimed at reducing GHG emissions to reach the municipality's 2030 and 2050 goals. AFOLU mitigation actions and two added values are associated with these goals. The actions and respective added values are:

Action: Afforestation

> **Added Value:** Provides improved opportunities for outdoor life, increased biodiversity, and property value.

Action: Establishment of low-lying areas

Added Value: Provides increased biodiversity and reduced nutrient load to aquatic ecosystem.

Action: Increase capacity at existing biogas plants

Action: Creation of biogas plants

Action: Development of grass protein factory

Action: Reduction of emissions from livestock digestion

Action: Management of livestock manure

Action: Creation of biochar plants (Vejen Municipality, 2020a).

Regarding the first action listed, areas throughout the municipality have been analyzed and designated for reforestation efforts, the total area accounts for about 29% of the total municipal area, which would be valuable for GHG reduction through sequestration, although not stated in the CAP. Not all actions have been clearly defined and discussed in the CAP, at the time of the plan's release, not all actions were fully implementable or developed. There is an additional mitigation plan document to supplement the CAP, which focuses on agriculture, energy, and transport, to provide more extensive details.

Adaptation

Adaptation goals concern climate hazards such as flooding, water, heat, biodiversity, and infrastructure. The CAP states "the primary goal for climate adaptation is that Vejen Municipality as a geographical area achieves a robustness to handle both violent rainfall events and rising groundwater, and that climate-related floods are handled" (Vejen Municipality, 2020b, p. 16). Although no specific adaptation goals or actions are given to AFOLU, those addressing biodiversity inherently relate to the AFOLU sector. This is noted in the CAP as the municipality "works to achieve synergy with prevention (mitigation) and adaptation measures" through anticipated added values from the set actions (Vejen Municipality, 2020b, p. 19). The sub-goals presented above regarding AFOLU are detailed into mitigation actions which connect to biodiversity adaptation goals pertaining to lowland, wetland, and forest projects which contribute to biodiversity and are a part of the AFOLU sector (Vejen Municipality, 2020b). As with mitigation, there is an additional adaptation plan document to supplement the CAP, which focuses on better data, the cities, the open country, preparedness, and information.

Monitoring and Implementation

The prioritization of implementing of AFOLU actions has conversion of agricultural land as a high priority, GHG reduction from livestock digestion and manure handling to follow, and work to establish biogas plants and grass protein factories as a lower priority. This prioritization relates to the order of implementation and the planning schedule, as referenced above in the overall AFOLU goals.

The municipality also addresses their collaboration with stakeholders and their engagement in community outreach as part of implementing this plan. "Vejen Municipality alone does not have sufficient powers to achieve the climate plan's goals. […] it is necessary to enter into cooperation with key actors within the sectors. In the agricultural area, a partnership agreement has been entered into with the local farmers' organizations" (Vejen Municipality, 2020b, p. 19). Separate mitigation and adaptation plans outline the responsible parties for each action, including municipal entities, external actors, business and citizens.

The CAP will be revised every four years and with each revision the mitigation and adaptation actions and emission calculations will be updated, along with the separate mitigation and adaptation plan documents.

Although not directly related to AFOLU, there is an emphasis on regional, cross-municipal collaboration with the Kongeå committee to address overall climate adaptation as it pertains to water and the river system of the region.

Barriers to implementation of mitigation and adaptation efforts are described, but no methods for overcoming them

Inclusion of rurban specific dialogue

As with Billund, Vejen's CAP does not specifically address rurban populations or areas, however, given the nature of the municipality the CAP addresses such.

4.3 The Central Valley

To begin the presentation of results specific to the two Californian municipalities an overview of the CV's approach to CAP development will be discussed to provide context for the comparison of climate action planning between the RSD and the CV.

There are eighteen municipalities in the CV, there is not a regional governing power, rather, the State and municipalities are the official government powers. In the US there are numerous legislative acts that address climate change. The goal to achieve carbon neutrality by 2050 was put out in 2021 (Kerry & McCarthy, 2021), yet there is no national obligation to develop CAPs. At the state level in California there is legislation in place that requires GHG emission reduction, the most recent being the 2016 amendment to SB-32 which set a reduction goal and requires reporting of emissions by major sources, but it does not requirement to create CAPs to aid in achieving that goal (The California Global Warming Solutions Act of 2006, 2016). The State of California has created a Priority Climate Action Plan created under the US EPA's Climate Pollution Reduction Grants Program which will "advance the national climate goals pursuant to the Paris Agreement" (California Air and Resources Board (CARB) & California Environmental Protection Agency (CalEPA), 2024, p. 6). Many municipalities have acted on their own accord to create CAPs that aim to support the achievement of the statewide GHG emission reduction goal, this was clear during the initial research to select the case study locations.

4.3.1 Butte

Butte municipality is situated at the northeastern end of the Sacramento Valley and spreads into the northern Sierra Nevada mountains to the east, see Figure 16. It is one of the eighteen municipalities in the CV, and is known for its agricultural production (Butte County, 2021). The municipality borders seven others and has four urban centers designated as cities, Biggs, Chico, Gridley, and Oroville, numerous smaller towns, and vast open and agricultural lands, as depicted in Figure 12. The rurban phenomena is characterized in Butte by the relation of the four cities and the smaller towns dispersed around the more commercial and residential centers, and then the rural agricultural and open land that extends far.

Figure 16. Butte Municipality Location

Influence on CAP Development

Butte's initial CAP was created in 2014 and updated in 2021; the 2021 version was used for the purpose of this research. Throughout the CAP, there is a distinction made between goals of the municipality as an area and the municipality as an operational 'business' entity; the focus of this research is on the municipal area as a whole. Development of the CAP was spurred by regional, state, national, and international governance. These influences as stated in the CAP are explained in Table 4.

Table 4. International, National, State, and Regional influence on the 2021 Butte CAP

International			
Global Protocol for Community-Scale Greenhouse Gas Inventories developed in 2014 – Is intended for use in developing community-scale GHG inventories.			
National			
United States Environmental Protection Agency (US EPA) – The agency has authority over emissions from mobile sources, through the Clean Air Act.			
State			
Executive Order S-03-05 2005 - Established the first statewide GHG reduction goals for California: reduce emissions to 2000 levels by 2010, reduce emissions to 1990 levels by 2020, and reduce emissions 80 percent below 1990 levels by 2050.	**Assembly Bill (AB) 32, the California Global Warming Solutions Act 2006** – This legislation required the California Air Resources Board (CARB) to create methods to reduce GHG emissions to 1990 levels by 2020.	**The Climate Change Scoping Plan (Scoping Plan) 2008 - updated in 2014 and 2017** – Uses GHG reduction strategies and identifies local governments as strategic partners for achieving state reduction goals.	**Senate Bill (SB) 375, the Sustainable Communities and Climate Protection Act in 2008** – The bill was adopted to connect GHG emission reduction goals created in the 2008 Scoping Plan to land use decisions primarily focused on travel and mobility.
Executive Order B-30-15 in 2015 - Set a goal of reducing GHG emissions in California to 40% of 1990 levels by 2030.	**SB 32 and AB 197 in 2016** - Signed into law, making the Executive Order B-30-15 goal for 2030 a statewide required legislative target.	**Executive Order B-55-18 in 2018 -** Established an additional statewide goal of achieving carbon neutrality by 2045.	**California Environmental Quality Act (CEQA) as amended by SB 97 in 2010** – Required "proposed projects to analyze their GHG emissions and contributions to climate change" (Butte County, 2021, p. 21).
Regional			
The Butte County Air Quality Management District (BCAQMD) – "Is the local air district responsible for local air quality regulation in Butte County. The BCAQMD's primary responsibility is to regulate stationary sources and develop plans to achieve and maintain air quality standards" (Butte County, 2021, p. 23).			

CAP Goals

The municipality's goal is to reduce emissions to 40% below 1990 levels by 2030 and continue towards carbon neutrality by reducing emissions to at least 80% below 2006 levels by 2050 (Butte County, 2021). An individual goal is given for each sector; the agriculture goal is for Butte to be "a state leader in maximizing the efficiency and sustainability of natural and working lands countywide" (Butte County, 2021, p. ES 7). Mitigation and adaptation are both carefully accounted for in the CAP.

Mitigation

Mitigation is centered on GHG emission reduction. GHG emissions are broken out by sector, these include: agriculture, transportation, energy, solid waste, off-road equipment, water and wastewater, land use and sequestration, and two "informational items," wildfire and controlled burns and stationary source sectors (Butte County, 2021, p. ES 2). Of these, agriculture, land use and sequestration, and wildfires and burns are the sectors that concern this research given their relation to AFOLU. When GHG emission inventory data and future projections are given in the CAP, the agriculture and wildfires and burns sectors are shown as emission producers, while the land use and sequestration sector show a negative numerical value for emissions, indicating that there is accounted GHG absorption. 2019 is used as the baseline year for GHG emission data, at that time agriculture accounted for 50% of the total emissions with about 501,630 $MTCO_2e$, wildfires and burns produced about 15,730 $MTCO_2e$, and land use sequestration took in about 346,340 $MTCO_2e$. The amount of GHG absorption by land use and sequestration compared to agricultural emissions highlights the power of natural lands as a mitigation strategy, with this it is important to consider the amount of land area designated to each of these when creating land conversion goals for example. The GHG inventory for the county specifies totals with and without land use and sequestration included. Emissions from wildfires and burns are not included in the county inventory total and are provided for informational purposes only given that wildfires are largely a natural process not a human caused activity, so their GHG emissions are "biogenic," naturally occurring.

Goals and action strategies are also broken out by sector, however the land use and sequestration, and wildfires and burns sectors are not included in this part as they are considered informational in the CAP. Three strategies are presented for the agriculture sector (strategies 12-14 in the CAP), each detailed by multiple actions and anticipated GHG reductions (Table 5).

> **Strategy 12:** Reduce GHG emissions related to agricultural equipment, in collaboration with regional partners, agencies, and members of the agricultural community.
>
> **Action:** Promote the Sustainable Agricultural Lands and Conservation Strategy to aid farmers in replacing agricultural equipment.

Action: Encourage farmers to participate in programs to replace old diesel equipment and vehicles with more fuel-efficient models before the required compliance date.

Action: Coordinate with BCAQMD, Farm Bureau, and other agricultural organizations to replace diesel fueled irrigation pumps with electric pumps and promote rebate possibilities for solar powered pumps.

Action: Work with BCAQMD to register all agricultural pumps.

Action: Support farmers and ranchers to install renewable energy systems in agricultural areas.

Action: Work with local partners like Chico State University and the University of California Cooperative Extension to monitor and share climate related agricultural data to enhance collaboration and understanding of best practices between farmers.

Action: Collaborate with local non-profits and agencies to create specific energy efficiency outreach efforts for agricultural processing industries.

Action: Publicize rebates for electric and clean fuel agricultural and farm equipment.

Strategy 13: Monitor agricultural operations trends and encourage existing and new farming techniques that reduce GHG emissions from crop cultivation.

Action: Assist farmers in changing to more sustainable cultivation techniques by promoting the Sustainable Agricultural Lands Conservation Strategy.

Action: Maintain collaboration with regional partners, agencies, and farmers on researching methods to reduce GHG emissions from agricultural operations in the county.

Action: Continue to collaborate with the California Rice Experiment Station to develop rice varieties that will allow the rice industry to maintain productivity and adapt to climate change.

Action: Monitor conditions that can enhance implementation of the methane offset protocol for rice cultivation.

Action: Support the Butte County Rice Growers Association to promote rice cultivation practices that maintain high yields and reduce GHG emissions, including encouraging the reuse of rice straw for additional purposes as per the Agricultural Lands Conservation Strategy.

Action: Support BCAQMD's permitting efforts to reduce residue burn.

Action: Connect agricultural operators with cost-effective sustainable waste disposal options.

Action: Encourage and incentivize the reuse of manure and other waste products from livestock to sequester emissions or convert emissions into energy.

Action: Highlight farmers on the municipal website that are doing an excellent job at reducing GHG emissions.

Action: Maintain collaboration with stakeholders that support efficient fertilizer use.

Strategy 14: Work with farmers and local and regional agencies to investigate techniques to maximize carbon sequestration of the county's natural and working lands.

Action: Discourage the conversion of agricultural land to non-agricultural uses.

Action: Partner with federal and state landowners to enhance sequestration of natural and working lands.

Action: Promote sequestration techniques as per the Sustainable Agricultural Land Conservation Strategy.

Action: Monitor development of state level sequestration on natural and working lands through CARB's Natural and Working Lands GHG inventory and California 2030 Natural and Working Lands Climate Change Implementation Plan.

Action: Implement critical recommendations from the California 2030 Natural and Working Lands Climate Change Implementation Plan.

Action: Explore techniques to increase sequestration on agricultural lands, including compost application, agroforestry, grazing land, crop covering, mulching, reduced or no-till practices, etc.

Action: Collaborate with farming groups, academic institutions, and the Butte County Resource Conservation District to implement recommendations from the State's Healthy Soils Initiative.

Action: Collaborate with CARB and other agencies to identify and seek funding opportunities.

Action: Explore reuse possibilities for cleared forest residue through working with regional partners like Butte County Fire Safe Council.

Action: Implement forest management actions from the California 2030 Natural and Working Lands Climate Change Implementation Plan, including avoiding forest conversion.

Action: Divert organic materials from open pile burning to bioenergy, biofuels, and long-lived wood products.

Action: Continue partnerships to identify innovative techniques to manage and maximize natural and working lands.

Action: Develop a comprehensive program to plant and maintain trees on county-managed roads, medians, and public parking lots.

Action: Identify areas for terrestrial and aquatic sequestration in the municipality.

Action: Support property owners to plant and maintain trees in urban areas to reduce the urban heat island effect and comply with fire-safe planting requirements.

Table 5. Anticipated Agricultural GHG Reductions by Strategy for Butte

	2030	2040	2050	2030 Emissions Projection
Strategy 12 GHG Reduction ($MTCO_2e$)	18,400	25,750	36,790	
Strategy 13 GHG Reduction ($MTCO_2e$)	43,320	79,790	143,620	
Strategy 14 GHG Reduction ($MTCO_2e$)	13,170	27,700	46,020	
Total	73,890	133,240	226,430	501,620

In Table 5, the emissions projection for 2030 alone is shown, as in the CAP the number remains the same for 2040 and 2050 in the BAU scenario given the uncertainty of activities within the sector, such as yearly burns (wildfires and controlled burns). These strategies and actions have the potential to make a meaningful impact on GHG reduction within the AFOLU sector. The detail and comprehensiveness ideally will enhance their future success and the ability to monitor progress accurately.

Adaptation

Adaptation is focused on increasing resilience to projected climate hazards such as extreme weather, wildfires, and drought. Recent state laws require the county's General Plan document to include a climate hazard vulnerability assessment with adaptation measures to address those vulnerabilities. Per state law, the 2040 General Plan for Butte includes comprehensive adaptation goals, policies, and actions, thus most of the adaptation related information is not included in the CAP. The 2021 CAP references the 2014 CAP which included climate adaptation strategies and actions, and reiterates that the 2040 General Plan addresses climate adaptation rather than the CAP. The 2014 adaptation strategies were:

- Adapt to increasing wildfire severity and frequency.
- Prepare for changing precipitation patters and drought.
- Prepare for increases in flooding severity and frequency.
- Prepare and respond to more intense and frequent extreme heat events.
- Enhance the economic viability of local agriculture.
- Support resilient ecosystems.
- Sustain a prospering economy that benefits from changing climate conditions.
- Account for climate change impacts in government operations.
- Collaborate with partners to prepare for climate change.

Given the scope of this research, the separate 2040 General Plan was not analyzed for further adaption efforts.

Monitoring and Implementation

The goals and strategies are integrated into other official municipal documents and plans to ensure the success of the 2021 CAP, each strategy is assigned to a specific department responsible for coordinating and implementing these efforts. Municipal staff will monitor the progress of strategies and provide an annual report update to the Board of Supervisors and the community. As part of the annual report the effectiveness of each strategy is to be assessed to gauge the progress towards the anticipated GHG reductions. Four implementation strategies are outlined in the CAP: to monitor and report progress toward the 2021 CAP target annually, continue collaboration with agencies and community groups that support implementation, secure funding, and continue to update GHG inventories and assess effectiveness every five years. Clear delegation of responsibility within municipal departments and extensive stakeholder engagement are prominent elements of monitoring and implementation of the CAP.

Inclusion of rurban specific dialogue

This CAP does not specifically address rurban populations or areas, however, given the nature of the municipality it could be inferred that the CAP addresses such areas and populations.

4.3.2 Sutter

Sutter municipality is located just south of Butte and the topography is quite similar, Figure 17. There are two cities, Yuba City and Live Oak, many smaller towns and communities, and expansive open and agricultural land. The rurban phenomena is characterized in Sutter by the relation of the two cities and the smaller towns dispersed around the more commercial and residential centers, and then the rural agricultural and open land that extends far, see Figure 13.

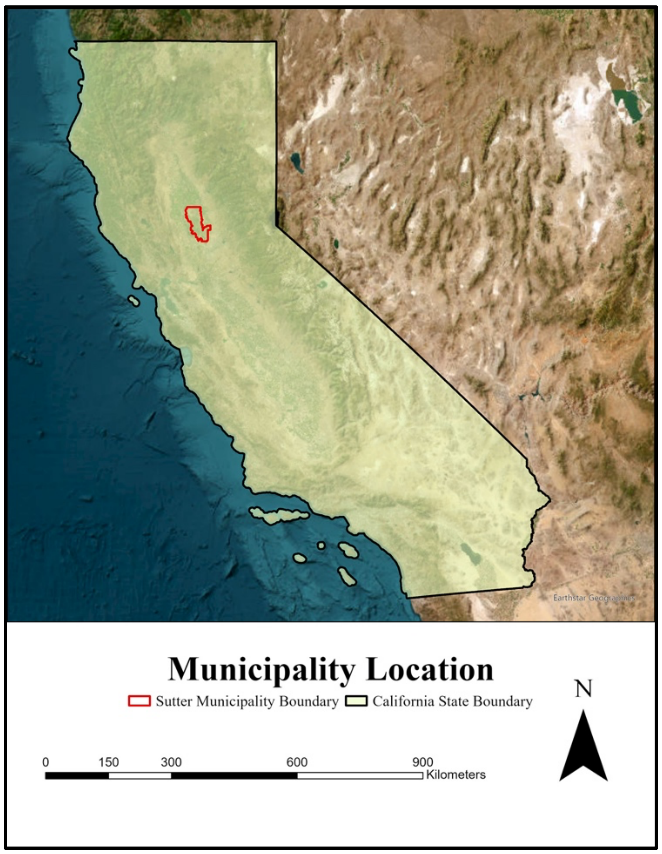

Figure 17. Sutter Municipality Location

Influence on CAP Development

This CAP is quite dated, as it was set forth in 2010 to provide a plan that supported the GHG emission reduction efforts by the municipality's region, the State of California, the Federal Government, and international agreements. Much of the national and state level influence on the CAP was the same as for Butte, see Table 4 for an explanation of the shared influences (US EPA, Executive Order S-03-05, AB 32, and SB 97). The additional influences stated in Sutter's CAP, not included in Butte's are in Table 6 below.

Table 6. International, National, State, and Regional Influences on Sutter's Municipal 2010 CAP

<table>
<tr><th colspan="6">International</th></tr>
<tr><td colspan="6">Kyoto Protocol 1994 – The US participated in the United Nations Framework Convention on Climate Change (UNFCCC). The Kyoto Protocol was a treaty under the UNFCCC and the first international agreement on regulating GHG emissions. An important note is that while the US signed the agreement, it was not ratified by Congress, thus the US is not bound to the commitments within the Protocol.</td></tr>
<tr><th colspan="6">National</th></tr>
<tr><td colspan="3">US Environmental Protection Agency (US EPA) –
The agency has authority over emissions from mobile sources, through the Clean Air Act.</td><td colspan="3">Climate Change Technology Program (CCTP) – The US chose a voluntary approach for emissions reduction instead of the Kyoto Protocol's mandatory framework. The CCTP was a multi-agency effort to implement the President's National Climate Change Technology Initiative.</td></tr>
<tr><th colspan="6">State</th></tr>
<tr><td colspan="2">CARB – As part of the California Environmental Protection Agency the Board is responsible for coordination and administration of federal and state air pollution control programs in the State.</td><td colspan="2">Executive Order S-13-08 in 2008 – Also known as the Climate Adaptation and Sea Level Rise Planning Directive, provides direction for how the State should plan for climate impacts.</td><td colspan="2">California Code of Regulations (CCR) Title 24, Part 6 – Originally established in 1978 were the energy efficiency standards for residential and nonresidential buildings, the influence to this CAP came from the 2008 update to the standards.</td></tr>
<tr><th colspan="6">Regional</th></tr>
<tr><td colspan="6">Feather River Air Quality Management District (FRAQMD) – The district is responsible for promoting and improving the air quality of Sutter and Yuba municipalities.</td></tr>
</table>

CAP Goals

The GHG emission reduction target of this CAP is to contribute the statewide goal of reaching 1990 levels by 2020, consistent with AB 32. 2008 is used as the current GHG inventory year for this 2010 CAP, at that time AFOLU accounted for 66% percent of the municipality's GHG emissions, or about 805,005 $MTCO_2e$ of the 1,221,024 $MTCO_2e$ total. It is interesting to note that the countywide total emissions in 1990 was 1,338,192 $MTCO_2e$, so there had already been a reduction in those 18 years. However, the projected total for 2020 with no action taken was 1,500,000 $MTCO_2e$. This highlights the need for mitigation actions. No specific numerical reduction goal is stated for AFOLU.

Mitigation

The approach to reaching mitigation goals is included in three categories:

- R1: Efforts expected to reduce GHG emissions at the municipal level.
- R2: Measure that can be quantified to show their value of reduction.
- R3: Not quantifiable at the time of the CAP, but a means by which reduction could occur as they supported R2 efforts.

Each sector, energy, transportation, agriculture, landscape, and solid waste has unique mitigation goals and strategies in each of these three categories. The AFOLU applicable items are:

R1

Goal R1-A1: Methane capture at large dairies.

Strategy: Encourage the installation of methane digesters to capture methane emissions at large dairies. This strategy was set forth as a statewide voluntary measure in the Scoping Plan referenced in Table 4.

R2

Goal R2-A1: Agricultural water management.

Strategy: Encourage the agricultural community to be aware of the need to conserve water and provide access to technology and information on how to do so. As well as promote the use of recycled water whole maintaining water quality and quality for agricultural practices.

R3

Goal R3-A1: Promote soil management practices.

Strategy: Reduce nitrogen dioxide emissions by educating and promoting fertilizer management, nitrification inhibitors, water management, and efficient use of fossil fuels. Additionally, support the use of cover crops during fallow times to prevent erosion, nutrient leaching, and increase sequestration.

Based on these mitigation strategies the AFOLU GHG emissions were anticipated to be 752,739 MTCO_2e in 2020, and 722,283 MTCO_2e in 2030, which are below the 1990 level for AFOLU emissions in the county, 956,315 MTCO_2e. That accounts for about a 7% and 11% reduction from 2008 levels, and about 22% and about 25% reduction from 1990. The projected total 2020 GHG emissions with all anticipated mitigation benefits included was 1,288,571 MTCO_2e, which is 49,621 MTCO_2e reduction from 1990 levels.

Adaptation

Adaptation efforts are not discussed in this CAP or stated to be included in another municipal document.

Monitoring and Implementation

These strategies would be implemented following a three-phase schedule based on the categories of mitigation efforts (R1, R2, and R3 above), as well as integrated into other municipal documents such as the General Plan. As part of this schedule the GHG inventory would be updated, post 2020 forecasts would be developed based on evaluated progress and success to use for planning past 2020, and planning for post 2020 would begin at the midpoint of the schedule (around 2015). The CAP states that a monitoring plan will be created and that it will be adjusted as opportunities arise. Based on this research it appears that this CAP is the most up to date GHG inventory data and CAP that is publicly available for Sutter municipality.

Inclusion of rurban specific dialogue

As in the other three CAPS, rurban populations or areas are not specifically addressed, however, given the nature of the municipality it could be inferred that the CAP addresses such areas and populations.

4.4 Summary of Results

The results of the CAP document analysis and geospatial analysis for each of the four case study locations has been presented above. Table 7 below provides a comparative overview to synthesize and summarize the findings. Findings are broken out to show similarities and differences across the four cases. Each of the categories in the table will be discussed as they relate across the municipalities and their respective CAPS.

Table 7. Results Summary, CAP Findings

	Billund	Vejen	Butte	Sutter
CAP Year	2021	2020	2021	2010
Governance Level Influence	International EU National Regional	International EU National Regional	International National State Regional	International National State Regional
Inclusion of Mitigation and Adaptation	Yes	Yes	Yes	Mitigation only
GHG reduction goal	Yes 70% reduction of 1990 GHG emission levels by 2030 and to achieve carbon neutrality by 2050	Yes 70% reduction of 1990 GHG emission levels by 2030 and to achieve carbon neutrality by 2050	Yes Reduce emissions to 40% below 1990 levels by 2030 and reduce emissions to at least 80% below 2006 levels by 2050	Yes Reduce emission to reach 1990 levels by 2020
Numerical AFOLU GHG reduction goal	Yes 60% reduction by 2030 and 85% reduction levels by 2050 from 1990 within the AFOLU sector	No	No	No
Clear mitigation goals for AFOLU in the CAP	Yes	Yes	Yes	Yes
Clear adaptation goals for AFOLU in the CAP	Yes	No	Yes	No
Monitoring plan	Yes	Yes	Yes	No
Implementation plan	Yes	Yes	Yes	Yes
Stakeholder partnerships and collaboration	Yes	Yes	Yes	Yes
Inclusion of rurban specific discussion	No	No	No	No

CAP development

Three of the four municipalities have CAPs that were created within the last five years, Billund, Vejen, and Butte; Sutter's CAP is fourteen years old at this time, dating back to 2010. The age difference seems to impact the contents of the CAPs. In the discussion of influence from international, national, state, and regional obligations and regulations the date of Sutter's CAP is apparent through the reference to the Kyoto Protocol, which is thirty years old now. The state regulations are also dated and therefore impose less strict regulations than the more recently updated ones included in Butte's CAP, limiting policy and goal cohesiveness. With that, the Paris agreement was not referenced in either Butte or Sutter's CAP, it was not included in Sutter's as the agreement is more recent than the CAP. The exclusion of the Paris Agreement from Butte's document is for reasons unknown.

The commonality of national level regulations and obligations is evident in both Denmark and California, through the DK2020 project and related influences, and the State regulations in California. The two Danish CAPs are much more uniform than the two US CAPs despite both having shared influences from their respective governance institutions. This results largely from the authority of the DK2020 project which provided municipalities with a CAP framework containing specific guidelines for what was required to be included.

Each municipality was also influenced by regional level institutions and obligations, either limited to the individual municipality, or through collaboration of municipalities. Billund and Vejen share a regional influence which focuses on a strategy for addressing climate change across of municipalities in the RSD. Vejen has an additional obligation with the Kongeå committee, similar to the FRAQMD in Sutter, both of regional influences are comprised of three or two municipalities, respectively. These multi-municipal influences allow for the specific concerns and needs of the involved municipalities to be incorporated into the obligatory or regulatory requirements. It also enforces a uniformity that strengthens the effectiveness of climate action and highlights the systems approach that is necessary for climate action, as discussed in Chapter 3.2. Butte listed one regional influence that pertains only to the municipality itself, however, it is hierarchically impacted by national environmental regulation from the US EPA, so the significance of this regional influence is not as apparent as the other cases.

Based on this comparison of case studies, it appears that CAPs in Denmark have much more uniformed influence from multiple governance levels, while in the US and specifically California, there is less uniform influence on CAP development, with the most notable absence being the requirement to develop municipal level CAPs.

Climate action planning in the RSD and CV, mitigation and adaptation

Billund, Vejen, and Butte all incorporate mitigation and adaptation into their CAPs, albeit to various degrees, while only mitigation is incorporated into Sutter's. Vejen acknowledges the importance of including both mitigation and adaptation, but only clearly defines mitigation efforts within the CAP, as there is a separate document addressing climate adaptation planning for the municipality. As per the Conceptual Framework of this research presented in Chapter 3.1, this exclusion of adaptation goals and strategies from the CAP does not fully align with the definition of climate action planning or the expectation of CAPs based on the framework.

Climate adaptation efforts for Billund, Vejen, and Butte are centered around climate hazards, primarily flooding, rainfall, heat, drought, and fire. In the Danish municipalities' rainfall, flooding, and heat are the key concerns that are being planned for. In California the key concerns are heat, drought, fire, and changing precipitation patterns. Adaptation efforts are not specifically related to AFOLU, however as discussed in the individual municipal sections, there is relation to AFOLU through biodiversity, conversion of lands, and farming techniques. The adaptation efforts are relatively similar for Billund and Vejen as they have the same climate hazard concerns, while those for Butte are different and result in distinctive adaptation measures that address the climate hazards Butte is expected to face.

All municipalities discuss mitigation goals and strategies. The terminology used varies but the general type of contents is the same, goals, strategies, and actions for example. Mitigation efforts are relatively similar, with the greatest variance being in the specificity and number of measures included in the CAPs. Butte's mitigation efforts as they relate to AFOLU seem to be the most detailed based on the number of strategies and actions as well as the inclusion of specific stakeholder partners to be involved in actions; followed by Billund, Vejen, and Sutter providing less specific actions. Do note that Billund is the only municipality that provided a numeric GHG reduction mitigation goal for AFOLU.

Each municipality includes a GHG inventory that is broken down by sector, including at least agriculture, Butte is the lone municipality that includes additional sectors that can be combine with agriculture to account for AFOLU. With that, Sutter is the only municipality that does not detail the sequestration of GHGs in its GHG inventory counts. All CAPs incorporate sequestration into other areas of the CAP such as mitigation efforts in multiple sectors including agriculture, and adaptation efforts as an added value.

Monitoring and Implementation

Monitoring plans are provided for each municipality except Sutter, which states that at the time of the CAP development they were planning to create a plan for monitoring progress of the planned efforts towards the achievement of the CAP goal. All other CAPs outlined plans and methods to monitor process over set amounts of time, with reports of assessed progress also at set time periods.

Implementation in each municipality differed, but all incorporated municipal departments or staff and external stakeholders, ranging from citizens, groups, agencies, to educational institutions depending on the individual case. Additionally, as part of implementation in each municipality there are clear designation of the CAPs influence and connection to other municipal documents and plans.

Rurban characterization and climate action planning

None of the CAPs specifically addressed rurban areas and populations or used the term. However, the analytical framework of this research set out to perform this comparative analysis across municipalities that fit the definition of rurban as per the Conceptual Framework in Chapter 3.1. Thus, each CAP addresses rurban areas and populations even without intentionally doing so. The omission of the term rurban, and the specific focus to it in the CAPs, make it quite difficult to answer how the rurban characterization can influence climate action planning. CAPs are unique to the specific characteristics of the location, including population and development patterns that typify rurban areas, thus it can be said that the rurban phenomena impacts climate action planning by influencing CAP contents.

5. Discussion

The development of CAPs is an ongoing effort throughout the world, while they are becoming more common, there are still many locations and governance levels that have not undertaken the action. It is important for CAPs to be unique to the respective location that it concerns so it can be best fit for future climate projections and address the current context of the location, like population, land use, industry, energy types, etc. Through the comparison conducted for this research an example of the uniqueness of CAPs is apparent. External influences on the development of local CAPs can also be unique. This research does not explore specifically what the varied influences on CAP develop mean for their content or efficacy, yet some points can be extrapolated and discussed further. This chapter will address topics that have been touched on throughout this research, namely, the influence of different land uses, agricultural crops, and livestock; external influence on CAP development in relation to multilevel governance; and the limitations of this research.

5.1 Land Use, Agricultural Practices, Crops, and Livestock

Land use can vary widely from location to location, even within a region or state, thus each local CAP should address the specific land uses at hand and take into consideration future land use planning, what may already be planned and how the CAP could influence future planning. As seen in this comparison, the CAPs are all connected in some capacity to the municipal general plan, or some kind of plan that includes the land use of the municipality and current and future zoning. Climate action planning is both influenced by current zoning and land use and influences future zoning and land use. An example of the influence of current zoning and land use is through the inclusion of the agricultural sector, or AFOLU in CAPs. Specifically, through its inclusion not only as an industry or economy but as a spatial category. This is done by addressing impacts from the industrial side of the sector and the other, naturally occurring impacts like GHG emissions from land conversion or wildfires, and land use benefits such as GHG sequestration.

Other types of land uses such as residential and commercial are addressed in CAPs and impact the contents of the documents. Given the scope of this research, other land uses were not investigated but that does not mean they don't bear weight to climate action planning. Municipalities with more developed commercial or industrial areas would likely have a greater emphasis on those areas within their CAPs than was found in these case studies.

The type of agricultural practices, crops, and livestock also influences the contents of CAPs as seen through this research. While the specific types of practices, crops, and livestock present within the agricultural sectors of these case study municipalities was not examined, it is evident that there is variation. This is evident through brief discussion of such within the CAPs, but also through the goals, strategies, and actions presented for each municipality. From the document review it appears that there is a wider variety of crops generally grown in Butte and Sutter municipalities than in Billund and Vejen, this could be for several reasons and was not investigated further in this research but could certainly be a point for future research.

During preliminary literature review for this research various studies were found that highlight climate adaptation work being done in California in terms of agricultural crops. This is not to say that Denmark is not going similar work, just that literature of such was reviewed pertaining specifically to California as part of general review to find credible and relevant sources. It is interesting that while this type of climate adaptation is being researched, there was not direct inclusion of agricultural adaption strategies within the CAPs, aside from one action item in Butte's Strategy 13 pertaining to adapting rice crops. This may be due to uncertainty of effectiveness, known barriers to widespread implementation, lack of knowledge sharing and collaboration between CAP developers and researchers, or other factors. Moving forward, as CAPs are updated, findings from this type of research should be included if findings are determined to be viable climate adaptation solutions. Despite not being included in the Californian CAPs, the research on climate adaptation specifically for crops could serve as education for other locations with the same crops, or as innovative inspiration for other crops. Agricultural climate adaptation efforts and the lack of specific inclusion into CAPS could be a topic of future research based on the findings from this comparative case study.

Livestock as part of the AFOLU sector is a topic in each of the four CAPs examined here to various degrees. Different types of livestock have different climatic impacts, i.e. cows produce much more methane than other animals. Thus, cattle farms and dairies often produce greater GHG emission amounts than other livestock. This discrepancy in GHG emissions is likely why cattle were the only livestock animal specifically discussed in the CAPs. Again, a separate study of livestock in relation to climate action planning could be explored based on the foundation of this research as a comparative case study.

It is important to note a potential point of contradiction between mitigation efforts that were presented in the results sections for Billund, Vejen, and Butte. Butte's mitigation action 'discourage the conversion of agricultural land to non-agricultural uses' seemingly opposes mitigation efforts put forth by Billund and Vejen, which seek to convert organic or agricultural lands to natural or wetland areas. Butte's mitigation action is rather vague, as it does not reference what kind of land use the land could be converted to, however the conveyed sentiment is that converted agricultural land would increase GHG emissions, which is the opposite thought expressed in the mitigation efforts from the Danish municipalities. If Butte is referencing land conversion from agricultural to commercial or industrial than this is an appropriate action, as commercial and industrial land use could result in increased GHG emissions. If this action from Butte is regarding conversion to natural lands, then clarification on their reasoning would be beneficial, as natural lands would likely result in emissions reduction. Had interviews been conducted with parties involved in CAP development some clarity could have been brought to this point, however, that was outside the scope of this research.

AFOLU was the sector that produced the most GHG emissions in all four municipalities. While this is a small sample size and a trend cannot be determined based on it, it is reasonable to infer that would be common for municipalities with similar rurban qualities to also have this division of GHG emissions by sector. It is important to focus on AFOLU for a comparison such as this given the potential for GHG reduction through mitigation actions targeted at AFOLU. From this comparison it was brought to light that climate adaptation within the sector is lacking compared to others, making visible a gap in action that can now be more aptly addressed.

5.2 External Influence, Multi-Level Governance, and Collaboration

A key factor in CAP development is external influence. The external influences for the four case study municipalities varied. Each had multiple governance levels (international, national, and regional) that informed the obligation to create a CAP and/or the contents of the document, depending on the municipality. It is widely agreed that the best climate action planning recognizes the global context, acknowledges the interdependence of local policy and the importance of integrating existing planning policies, is based on sound science, and engages in public education and outreach (Boswell et al., 2019). This idea aligns with the systems thinking approach as part of MLG theory as it underlines the interrelations between governance levels and stakeholders involved in climate action planning.

MLG can bolster the development of CAPs as seen in Denmark, where municipalities have more obligations and influence imposed on them from international and national levels of governance. The national level obligations and regulations in Denmark are in part resulting from the Paris Agreement and the EU level authority. Denmark created their own national level targets (Climate Act 2020) that contribute to achieving the international goals (Billund Municipality, 2021). The US is also a part of the Paris Agreement and has also set a national climate goal. So, what does this external influence really mean? And how does this comparison answer that? Both the US and Denmark have international influences that have led to the creation of national level climate goals, but what has resulted from those goals differs greatly. The US has created no framework or regulation to require the development of CAPs at any governance level, leaving it up to the individual states and municipalities. Whereas Denmark, through the DK2020 project created a national framework to facilitate and require the development of municipal level CAPs.

This comparison has shed light on two approaches to CAP development. In one case, Denmark, international level climate action drove national level action. Resulting in a collaborative project, DK2020, which led to nationwide CAP development at the municipal level. The other case, California, is also subject to international influence and national influence, the difference is the lack of municipal action required by the national influence. The absence of a requirement to develop CAPs, at the national level and at the State level has led to a disjointed approach to climate action planning and CAP development by municipalities within the CV, and the US as a whole.

What is gained from this comparison as it relates to MLG is that there is evidence indicating different levels of governance or influence can enhance climate action planning and lead to CAP development. Based on this case study it appears that collaborative effort and requirement can bring about widespread municipal level CAP development.

It is argued that local governments can act as a catalyst in connecting top-down agendas and bottom-up delivery when it comes to climate action planning (Damsø et al., 2016). This is done through their influence as critical stakeholders in the local economy and local regulators, meaning that they are seemingly ideally placed to provide a strategic approach to governance of global climate risk (Damsø et al., 2016). With that, it is imperative to assess whether local governments are willing to act and if those actions are relevant contributions in the global context (Damsø et al., 2016). Not all local governments are willing to act, as seen with the cases in the CV. While both Butte and Sutter Counties had CAPs, not all municipalities across the CV had developed such documents as found during the case study selection process. This sentiment aligns with a barrier to CAP development stated in the Danish report, *Empowering Local Climate Action,* that a "lack of support for climate action from international frameworks and national legislation" can lead to a lack of CAP development and/or reduce the ambitions set forth if a CAP is developed (Tollin et al., 2023, p. 5). Stakeholder engagement and partnership can be a means to support climate action planning when governments are not acting.

Collaboration and partnerships can be essential for successful implementation and monitoring of CAPs. There was a great deal of stakeholder involvement and collaboration in the development of the Danish CAPs. For example, this research itself built on existing collaboration between two universities, and the larger network of collaboration regarding the DK2020 project. National and community partnerships with universities and institutions to share knowledge and resources and engage in collaborative planning can result in enhanced climate action planning as exemplified by DK2020 and the Danish municipal CAPs examined in this research (Boswell et al., 2019). Many universities and colleges in the US have committed to climate action and in doing so partnered with local governments to pursue climate action planning and the creation of local CAPs (Boswell et al., 2019). Butte addresses collaboration with local universities and institutions in its mitigation strategies, but not regarding the plan's development. It is evidenced that collaboration and partnerships elevate climate action planning. Subsequent research could look specifically at the influence of collaboration and partnership on the development of CAPs.

5.3 Limitations

The spatial analysis in this research was limited by data availability. Finding data that was comparable between Denmark and California posed a challenge. The data used was the most up to date that was openly available for each. Similarly, land use data that was compatible with GIS differed enormously. The land use categories presented in the figures throughout were grouped using the author's best judgement based on the given information and knowledge of the municipalities. The AFOLU category was based on the definition presented in the Conceptual Framework, Chapter 3.1.

Language was not a substantial limitation to the research as the Danish municipal plans were translated into English, however, some translations were not direct and could have skewed understanding, there are no known cases where this happened. Similarly, some of the terms used throughout the plans, such as targets, strategies, and actions could have been used interchangeably and may not always have the same intended definition across all CAPs, this is not believed to be a notable limitation of the analysis.

Interviews were not conducted as part of this research, but could have provided valuable insight to the analysis. The timeframe, location from which research was conducted, and the locations of the case studies hindered the inclusion of interviews as a method of this research design.

The number of case studies can also be understood as a limitation. Comparing more municipalities could provide a deeper understanding of how climate action planning could be enhanced. Similarly, conducting a comparison of municipalities from more than two countries could deliver an even greater understanding of how to enhance climate action planning. Despite these limitations, this research resulted in valuable findings that can be employed to actualize enhanced climate action planning.

6. Conclusion

The results of comparing two municipal CAPs from the RSD and two municipal CAPs from the CV brings to light similarities and disparities between the two regions and provides a foundation for future action to enhance CAP development and climate action planning. Based on this research and existing literature, local governments are a powerful mechanism for climate action, particularly when combined with international and national legislation, and stakeholder collaboration. The primary means for enhanced climate action planning is to require the development of municipal level CAPs, increase knowledge and innovation sharing between stakeholders and geographical borders, and establish comprehensive and cohesive climate policy across governance levels. Increased knowledge sharing, collaboration, and innovation will heighten the contents of CAPs, benefitting climate action planning. Comparing the CAPs of four rurban municipalities, focused on AFOLU, has underlined the need for CAP development and stakeholder collaboration to enhance climate action planning.

This conclusion can be understood at a global scale and replicated to deepen the understanding of rurban climate action planning and the AFOLU sector within CAPs, as well us understand shortcomings of existing plans and subsequently inform future documents. Continued research on climate action planning is critical for achieving climate goals and tackling climate change.

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Appendix A. Case Study Selection Data

Central Valley Municipalities, Case Study Selection Criteria Data

Municipality	Population 2020 Census	% AFOLU GHG Emissions	Column1	Land Area Sq Miles	Land Area Sq Kilometers	Overall Municipal Population Density per sqKM	AFOLU Land Cover	AFOLU % Landcover
Butte County	211,632	50% 2019	Landlocked	1677.00	4343.00	49	3,599.39	82.88%
Colusa County	21,839	N/A	Landlocked	1156.00	2990.00	7	2,739.29	91.62%
Fresno County	1,008,654	19% 2019	Landlocked	6011.00	15570.00	65	3,165.59	20.33%
Glenn County	28,917	N/A	Landlocked	1327.00	3436.00	8	3,149.55	91.66%
Kern County	909,235	N/A	Landlocked	8163.00	21142.00	43	9,117.88	43.13%
King County	152,486	1% 2019	Landlocked	1392.00	3605.00	42	3,438.27	95.38%
Madera County	156,255	N/A	Landlocked	2153.00	5580.00	28	2,084.65	37.36%
Merced County	281,202	N/A	Landlocked	1979.00	5130.00	55	2,057.04	40.10%
Placer County	404,739	2% 2015	Landlocked	1502.00	3890.00	104	N/A	N/A
Sacramento County	1,585,055	15% 2021	Landlocked	994.00	2570.00	617	1,537.63	59.83%
San Joaquin County	799,233	N/A	Landlocked	1426.00	3690.00	217	3,020.96	81.87%
Shasta County	182,155	9% 2008	Landlocked	3847.00	9960.00	18	N/A	N/A
Stanislaus County	552,878	25% 2005	Landlocked	1515.00	3923.00	141	2,854.93	72.77%
Sutter County	99,633	66% 2008	Landlocked	608.00	1574.00	63	1,378.93	87.61%
Tehama County	65,829	8% 2008	Landlocked	2962.00	7671.00	9	N/A	N/A
Tulare County	473,117	63% 2007	Landlocked	4839.00	12532.00	38	4,419.84	35.27%
Yolo County	216,403	21% 2016	Landlocked	1024.00	2652.00	82	N/A	N/A
Yuba County	81,575	18% 2007	Landlocked	644.00	1667.00	49	1,460.31	87.60%

Region of Southern Denmark Municipalities, Case Study Selection Criteria Data

Municipality	Population March 2024	% AFOLU GHG Emissions	Location	Land Area Sq Miles	Land Area Sq Kilometers	Overall Municipal Population Density per sqKM	AFOLU Land Cover Sq Kilometers	AFOLU % Landcover
Aabenraa	58,657	64%	Coastal	363.20	940.70	62	860.10	91.43%
Ærø	5,946	50%	Island	35.13	89.40	67	85.80	95.97%
Assens	40,626	31%	Coastal	198.00	511.10	79	452.50	88.53%
Billund	27,135	53%	Landlocked	208.60	540.20	50	523.10	96.83%
Esbjerg	115,357	40%	Coastal	286.70	757.20	152	683.50	90.27%
Faaborg-Midtfyn	52,252	44%	Coastal	246.10	633.00	83	555.60	87.77%
Fanø	3,347	19%	Island	21.62	57.30	58	88.60	154.62%
Fredericia	52,489	3%	Coastal	51.91	133.20	394	94.70	71.10%
Haderslev	55,319	58%	Coastal	314.10	815.30	68	747.40	91.67%
Kerteminde	23,911	28%	Coastal	78.00	204.70	117	175.00	85.49%
Kolding	95,073	25%	Coastal	233.60	604.30	157	514.70	85.17%
Langeland	12,214	70%	Island	109.70	289.70	42	266.70	92.06%
Middelfart	40,205	28%	Coastal	114.00	298.50	135	248.90	83.38%
Nordfyns	29,562	53%	Coastal	174.80	449.60	66	397.30	88.37%
Nyborg	32,178	21%	Coastal	107.00	276.70	116	238.40	86.16%
Odense	209,352	4%	Coastal	117.50	304.60	687	192.70	63.26%
Sønderborg	74,075	N/A	Coastal	191.08	494.90	150	423.00	85.47%
Svendborg	59,766	32%	Coastal	161.40	415.00	144	349.10	84.12%
Tønder	36,646	82%	Coastal	457.00	1182.40	31	1,161.70	98.25%
Varde	49,733	45%	Coastal	477.00	1233.10	40	1,286.20	104.31%
Vejen	42,814	60%	Landlocked	485.00	813.70	53	748.80	92.02%
Vejle	121,835	36%	Coastal	411.77	1058.50	115	947.50	89.51%