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Understanding Institutional, Social, and Ecological Systems Influencing Climate Change
Adaptation and Water Governance in Wine Regions: A Comparative Case Study of
Oregon's Willamette Valley, USA and Tasmania, Australia

by

Erin Upton

A dissertation submitted in partial fulfillment of the
degree requirements for the degree of

Doctor of Philosophy
in
Earth, Environment and Society

Dissertation Committee:
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2020

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Abstract

My research examines how water management decisions create opportunities or barriers to climate change adaptation in wine regions. Water is a critical resource for economic and environmental sustainability in wine grape growing regions. Climate uncertainty presents considerable risk and vulnerability to freshwater resources in wine producing regions where needs for access to water will increase with more frequent climate extremes. Climate adaptation in the wine industry is a complex problem that requires multi-disciplinary approaches. This research aims to strengthen the interface between water governance and technological and viticulture adaptation approaches. Water resources are shared across regions by stakeholders with varied and sometimes conflicting needs, and a deeper understanding of the influences of social and institutional systems in water management is needed for climate adaptation approaches to be sustainable. Using an Institutional-Social-Ecological Dynamics (ISED) framework, my research aims to understand the relationship between institutional, social (including economic and political) and ecological systems and outcomes for water decisions in wine regions. The project objectives are undertaken through a comparative case study of two wine regions, Tasmania in Australia and the Willamette Valley in western Oregon. The wine industries in both regions have unique challenges and opportunities specific to their geographical, historical, political and climate contexts. Each case is constructed through semi-structured interviews with key knowledge holders, and analysis of governance structure, policy, planning, and management practices. Interviews provide perspectives from a broad range of wine industry professionals, researchers, policy makers, planners

and water managers. Findings from these cases include: 1) historical legal regimes and top down management structures resulting in fragmented authority; 2) concerns about lack of transparency about financial and operational considerations regarding water management; 3) an uneven in stakeholder access to water resources; 4) social drivers like attitudes about climate change and the value of water influencing adaptation approaches; and 5) the broad range of business types and scales within the wine industry results in a range of adaptation capacity. These lessons inform broader implications of how institutional systems and water governance result in opportunities or barriers to the adoption and/or implementation of climate change adaptation practices in wine regions. Recommendations resulting from the research findings include: multi-disciplinary/multi-institutional approach to tackle complex problems; engagement with boundary organizations; redistribution of water rights; outreach, education, and incentives; engagement in institutional change; and climate change mitigation efforts.

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List of Abbreviations

ACE CRC	Antarctic Climate & Ecosystems Cooperative Research Centre
BOR	United States Bureau of Reclamation
COAG	Council of Australian Governments
DEQ	Oregon Department of Water Quality (Water Resources Dept.)
DPIPWE	Department of Primary Industries, Parks, Water and Environment
EPA (Australia)	Tasmanian Environmental Protection Authority
EPA (US)	United States Environmental Protection Agency
Hydro	Hydro Tasmania
ISED	Institutional-Social-Ecological Dynamics Framework
NOAA	National Oceanic and Atmospheric Administration Fisheries
NWC	Australian National Water Commission
NWI	Australian National Water Initiative
ODA	Oregon Department of Agriculture
ODFW	Oregon Department of Fish and Wildlife
OWRD	Oregon Water Resources Department
TI	Tasmanian Irrigation
TVID	Tualatin Valley Irrigation District
USACE	Army Corps of Engineers
WMA	Tasmanian Water Management Act

Preface

I worked for a small winery in Oregon's Willamette Valley from 2010 to 2015. As operations manager for the facility, I took on a task I had never imagined necessary in a region notorious for its rainy, cool climate: I had to arrange the trucking and delivery of water. Initially the winery was dependent on groundwater, but all eight of the wells on the property did not produce enough water for the winemaking and hospitality operations. Our vines were dry farmed, but we still needed water for vineyard spraying, winemaking operations, and for our tasting room and visitor gardens. So once a week beginning in the summer months and lasting well into the fall harvest, I coordinated with the cellar crew and calculated numbers to determine how much water they needed for production, how much water I needed to run the sprinklers for the new lawn mandated by the ownership, and how much tank space we had to store all of this water. This experience opened my eyes to the possibility that water in our region was not an abundant resource. Instead, I began to wonder if anyone in the wine industry was thinking ahead, not just a year or two ahead, but really considering long term planning about water resources in our region. My hunch was the answer was no, and this spark set me on my path of research. I was curious about who made decisions about water? How were decisions about water made? What was the future of water in my region, and how did these factors relate to the future of the wine industry? I read a number of articles, including a 2015 piece in Reuters about Harvard University buying vineyards in a drought-prone California wine region in order to invest in water.

Harvard University has quietly become one of the biggest grape growers in California's drought-stricken Paso Robles wine region, securing water well drilling permits to feed its vineyards days before lawmakers banned

new pumping ... The investment, which began as a bet on the grape market, has turned into a smart water play as the wells boosted the value of its land in the up-and-coming wine region of Paso Robles. But it has also raised questions about the role of big investors in agriculture in the midst of a water crisis (Valdmanis, 2015).

Eventually my questions took me farther afield to learn about water and climate challenges in wine regions in California, South Africa, and Australia. In 2016 while visiting Tasmania, the island state in Australia, I discovered that although located halfway across the world in the southern hemisphere, Tasmania as a wine region has many similarities to my home region in the Willamette Valley. For the next four years, I spent considerable time in both regions, conducting over sixty interviews and engaging in innumerable conversations and site visits with locals who had a range of roles in water, wine, and climate change. The result of these explorations is this dissertation, and my travels and connections have planted many seeds for research projects to come.

Chapter 1. Dissertation Introduction

1.1 Introduction to Research Problem and Justification

My research examines how water governance creates opportunities or barriers to climate change adaptation in wine regions. The research findings include: 1) climate change will result in challenges around water resources in wine regions; 2) regional variations in social values and governance structures result in different water management and climate change adaptation outcomes; 3) entrenched legal regimes make changes to water governance challenging and contribute to an unevenness in stakeholder access to water; 4) stakeholder conflict about access to water resources is likely to increase in the context of a hotter, drier climate with population and wine industry growth; 5) lack of government resources results in gaps in oversight and scientific understanding; 6) those within the wine industry have a range of attitudes and approaches to climate change planning and management; and 7) there is a variety of climate adaptation approaches around water for the wine industry which are dependent on economic resources and/or social values.

Wine regions exist on nearly every continent around the globe. Global wine grape production has grown steadily over the past twenty years (OIV, 2019). During the same time period global climate change has emerged as a driver of transformation in these wine regions resulting in a range of impacts (Jones et al., 2005). Changes to the climate are anticipated to accelerate in the future and present a number of challenges for the wine industry and wine region communities (Furer, 2006; Hannah et al., 2013; Tate, 2001). Climate change presents risks to human systems, like agriculture, labor, and economics, as well as ecological systems, like surface and groundwater. (Jimenez et al., 2014; Porter

et al., 2014). Water is a critical resource for environmental and economic sustainability in wine grape growing regions. Climate uncertainty presents considerable vulnerability to freshwater resources in wine producing regions, where water demand is anticipated to increase with more frequent climate extremes (Conradie et al., 2014; Deitch et. al., 2009; Forbes, et al., 2013; Jones et al., 2005).

Current climate adaptation research in wine focuses predominantly on viticulture science, new technologies in farming, and modeling future climate scenarios in grape growing regions (Hannah et al., 2013; Jones et al., 2005; Mozell & Thach, 2014). The wine industry puts into practice a variety of adaptation strategies to cope with climate challenges, both technological and operational. Policy, planning, and management decisions around water resources (water governance) influence innovation, adoption, and choice in climate adaptation efforts. The influence of institutions on the adoption of new science and technologies is currently underinvestigated in the wine industry. The process and outcomes of water governance need to be better understood to ensure future ecological and economic sustainability in existing wine regions, and to increase resiliency to future climate uncertainties. Climate adaptation in the wine industry is a multidisciplinary problem that requires multidisciplinary solutions, and there is a need to strengthen the interface between scientific remedies and local governance (Hannah et al., 2013). The wine industry exists within the context of regional communities where water resources are shared by stakeholders with varied and possibly conflicting needs (Lange & Shepherd, 2014; Ostrom, 2015). A deeper understanding of the influences of social and institutional systems in climate adaptation is needed for potential solutions to be sustainable (Lereboullet et al., 2013). My research adds to the broader climate change

discourse in wine industry research by going beyond viticulture and technological solutions. My research fills a gap in existing knowledge by elevating the need to examine relationships among institutional, social, and ecological systems in order to better understand climate adaptation options and outcomes in regional context (Figure 1).

Figure 1. Conceptual Framework Diagram

1.2 Research Question and Design

Given the risks and vulnerabilities to human and natural systems presented by climate change, my research aims to answer the question: *How does water governance create opportunities and barriers to climate change adaptation in wine producing regions?* Water governance is about decision making, in this case decisions about the use of water. Governance is defined as “interactions among structures, processes, and traditions that determine how power and responsibilities are exercised” (Graham et al., 2003). Some examples of water governance are: water quality standards regulated by a government agency, a nongovernmental organization advocating for fish habitat, a

federal law mandating minimum requirements for clean water, or an irrigation district responsible for procuring water access for its paying members. These interactions can occur at a range of scales from the local to the global (Urwin & Jordan, 2008). To answer the research question in a real-world context, I conducted a comparative case study of two wine regions, the Willamette Valley in Oregon in the United States and Tasmania, the island state in Australia. I wanted to understand how decisions about water are made, who is participating or left out from decision making, and the potential implications for climate change adaptation. To this end, I use an organizing framework (Arnold, 2004) called Institutional-Social-Ecological-Dynamics (ISED) to situate institutional systems, social systems (including cultural, economic, and political systems), and ecological systems in the context of each study area. I use ISED to better understand the relationships *within* and *between* these systems to consider and characterize potential outcomes for climate change adaptation.

1.3 Expected Outcomes

My research began with the hypothesis that in the wine regions of the Willamette Valley and Tasmania water demand would continue to increase while water availability would decline, due to consumption from the growing wine industries, regional populations, and tourism, combined with climate change. I suspected that many in the wine industry were not considering long-range planning for this risk, and the result would be an industry in the future only accessible to those with financial resources to confront challenges with water, which would ultimately shift the social fabric of these regions.

I wanted to understand the social drivers impacting climate change adaptation related to water in these regions, including attitudes and trends within the wine industry. I

wondered how people in the wine industry in these regions thought about water, whether they thought about climate change, or if they considered either water or climate as risks to the future sustainability of their endeavors. I wondered if the trend of outside, corporate investment coming into both regions in recent years was connected to climate change planning, and if not directly connected, if it would it still influence regional outcomes. I was curious about shifting attitudes and practices around irrigation in Oregon, and the role of irrigation schemes and emphasis on “water as an economic good” in Tasmania.

I also wanted to look beyond the farm/winery scale to examine the institutional drivers influencing action or inaction for climate change adaptation at a regional scale in the wine industry. The relationships between these social and institutional drivers are not explicit, known, or understood to those within the wine industry or academic researchers studying wine regions; and I expected to find differences in how the historical context of water management and the governance structure of each region would contribute to adaptation outcomes, both creating barriers and providing opportunities.

1.4 Research Limitations

The research focuses on two specific regions and therefore is not fully representative of the wine industry, environmental context, or institutional characteristics of other grape growing regions. I selected two regions that have important similarities regarding wine industry characteristics and climate challenges, but differences in approach to water governance. These cases can provide lessons applicable to all regions, but further research will be necessary to expand the body of knowledge to specific contexts of other grape growing regions. Conducting interviews with a select number of

regional knowledge holders does not provide all possible perspectives and insights, but rather a representative selection. Rather than present these data as the complete picture of wine regions, water governance, and climate change, my research shares insights and considerations from a diversity of perspectives that can provide valuable information for decision making by stakeholders within the wine industry, natural resource managers, and policymakers in the selected regions and beyond.

1.5 Chapter Overview

My dissertation is organized into six additional chapters, as follows: Chapter 2 is titled “Theoretical Framing and Literature Review.” In this chapter I present a literature review of historical and current scholarship that informs my research. I explain how I came to choose these bodies of knowledge, then I summarize and organize them into the following categories: a) climate change vulnerability and adaptation, including in the context of wine regions; b) drivers and potential barriers to climate change adaptation, including social systems and governance; and c) analytical frameworks for considering climate change adaptation. In Chapter 3, “Methods,” I explain my research activities and approach to data analysis. Chapter 4, “Case 1-- Willamette Valley, Oregon, USA” and Chapter 5, “Case 2-- Tasmania, Australia” introduce the case study regions, organizing the research data into ecological, social, and institutional systems contexts; including: climate change projections; water resources; water law and access; and cultural, political, and economic considerations. Chapter 6 is titled “Case Study Narratives: Climate Change and Water Governance in Wine Regions.” In this chapter I present five narrative vignettes set in the case study regions which tell the story of the relationships between water resources, governance, and climate change. I use themes that emerged from

interview data, including the unevenness in the ability for wine industry stakeholders to access water, and the role of institutions in water governance actions and climate adaptation outcomes. In Chapter 7, “Discussion and Conclusion,” I consider the relationships between the institutional, social, and ecological systems in the two regions and potential outcomes for climate change adaptation. I discuss wine industry specific adaptation considerations, barriers to and opportunities for adaptation, recommendations, and broader impacts for all wine regions.

Chapter 2. Theoretical Framing and Literature Review

2.1 Introduction

Agricultural wine regions encounter complex environmental and social challenges in the face of a changing climate. Wine regions experience ecological transformation, social shifts, and unknown climate futures, resulting in the need for climate change adaptation (Furer, 2006; Hannah et al., 2013; Mozell & Thach, 2014; Tate, 2001). Economic, cultural, and political contexts of wine regions influence adoption, implementation, and potential outcomes of adaptation efforts (Hannah et al., 2013; Lereboullet et al., 2013). In order to understand the relationships and drivers between natural and human systems, my dissertation is grounded in historical and current scholarship. In this chapter I explain how I came to choose these bodies of literature, then I summarize and organize them into the following categories: a) climate change vulnerability and adaptation, including in the context of wine regions; b) drivers and potential barriers to climate change adaptation, including social systems and governance; and c) analytical frameworks for considering climate change adaptation including the Institutional-Social-Ecological-Dynamics (ISED) Framework, which I use as a tool to organize and analyze the major themes that emerge in the research.

Exploratory Research Informs Theoretical Framing. In 2016 I conducted a series of exploratory research trips to wine regions around the globe, where I interviewed a broad group of people in order to better understand issues, attitudes, and perspectives on a wide range of themes impacting human and natural systems. I visited wine regions in Napa Valley, California; the Western Cape of South Africa; and three regions in Australia- the Yarra Valley and Mornington Peninsula in Victoria, and the island of

Tasmania. I conducted forty-seven semi-structured interviews with wine industry professionals, academic researchers, and professionals or government agency representatives in planning, climate change, water resource management, and environmental conservation. Interview participants answered a series of questions around three themes: 1) social and ecological impacts of wine industry growth on water resources; 2) the role of land use planning decisions in wine regions; and 3) attitudes and experiences regarding climate change including planning and adaptation. Refer to Appendix A for detailed information about the exploratory research. I used the results of this research to inform the development of my focused research question, and to determine which bodies of academic literature I needed to understand in order to pursue the research.

2.2 Climate Change Vulnerability and Adaptation

2.2.1 Climate Change Vulnerability

Vulnerability to climate change is defined by the Intergovernmental Panel on Climate Change (IPCC) as the magnitude and rate at which a system is exposed to changes in character (Berry et al., 2006). Vulnerability can impact both human welfare and the health of natural systems. Social vulnerability can include limits to social adaptation and perceptions of risk, such as competing demands for resources like land, water, and energy (Bierbaum et al., 2013; Dow et al., 2013).

Background: Viticulture and the Biophysical Landscape

In order to understand climate change vulnerability and adaptation in the context of wine regions, this section provides background information about geology, climate, geography, grape varieties, farming considerations, and water use specific to wine.

Geology. Soil characteristics are an important component for the suitability of a site for growing grapes, where physical characteristics of the soil, such as depth, drainage, particle size, and salinity can all affect grape quality. Controlling vigor in grapevines is important, and poorer quality, less nutritious soils help control vigor. Geology and soils are important contributors to the terroir of wine around the world (Burns, 2012). The French term *terroir* refers to how wines reflect qualities of the land where the grapes are grown. The characteristics that contribute to terroir include a combination of climate, soil, and human culture (White et al., 2009).

Climate. Growing season temperatures in wine regions are one factor in determining the boundaries for suitable grape growing regions (Vaudour, 2002). Regions that experience warm and dry summers with cool wet winters, known as a Mediterranean-type climate, are particularly suitable for growing wine grapes (Jones et al., 2005). Grapevines need enough sunshine and heat during the growing season for sugar production and ripening, which allows winemakers to ferment the sugars into alcohol in the winemaking process. Too much heat can lead to overripening and high alcohol wines (Vine, 1997).

Geography. Slope and elevation are important factors in determining where grapes can be successfully grown. Elevation can influence temperature, and often hillsides and sloping terrain are preferred. Aspect, or planting on south facing slopes in the northern hemisphere and the reverse in the southern hemisphere, can increase exposure to sunlight. In addition to receiving a greater intensity of rays from the sun on hillsides, sloped terrain will often provide better draining soils. Slopes are often safer locations for crops to avoid frost damage compared to flatter terrain (Stevenson, 2005; Vine, 1997).

Grape Varieties. As of the early 1990s it was believed there are approximately seventy-five *Vitis* species, 15,000 genotypes (the prime names of cultivars) and over 30,000 cultivars and rootstocks (Kerridge & Antcliff, 1999). Particular genotypes, cultivars, and rootstocks perform well in certain conditions, which is why different grape varieties are grown in different wine regions. Pinot noir grapes prefer cooler climates like those of Oregon's Willamette Valley or Burgundy, France, while other varieties like Merlot or Zinfandel prefer hotter climates like areas of Australia or California (Jones, 2007).

Farming Considerations. Decisions about how to farm grapes can originate from economic pressures around cost, increasing efficiency, or quality (Morris, 2000).

Mechanization is one farming trend that has been growing in the wine industry since the 1960s. Traditionally vines were tended by hand, but increasingly scarcity of farm labor, high labor costs, and competition from regions with inexpensive labor has led many growers to shift to mechanization in the vineyard, with machines pruning, thinning, shoot positioning, managing canopies, and harvesting (Morris, 2000). *Precision viticulture* is another technological farming approach that uses a range of information technology in the vineyard to increase crop yields and quality, like global positioning systems (GPS), airborne optical remote sensing, or soil moisture sensors (Proffitt & Pearse, 2004). In addition to technological trends, there are other movements in viticulture that shift away from conventional farming toward *organic* or *biodynamic* practices (Coll et al., 2011). Organic production has specific guidelines, but typically prohibits the use of synthetic pesticides, herbicides or fungicides in the farming of grapes. Practices are modified to use organic manure or composts, tilling, and cover cropping to control weeds, and the use of natural pest controls (Coll et al., 2011). Biodynamics uses a similar approach as organic,

but also has a series of specific soil and plant amendments known as preparations that practitioners believe enhance plant health and quality (Reeve et al., 2005). *Regenerative agriculture*, or regenerative viticulture, is a whole systems farming approach that follows organic principles around synthetic chemicals, but also aims to restore degraded soil, improve soil fertility and reduce erosion, in an effort to improve water quality and draw down and store carbon from the atmosphere (Rhodes, 2017).

Wine Industry Water Use. The wine industry relies on access to freshwater resources and it is predicted that climate change will result in an overall decrease in the availability of freshwater in wine regions (Ecos, 2013; Tate, 2001). Water is used in the vineyards for farming the wine grape crops, which can include irrigation; spraying pesticides, herbicides and fungicides; and overhead irrigation for mitigation of extreme climate events like frost and excessive heat (Quiggen et al., 2010). Water is used in the cellar operations during the winemaking and bottling processes, and in hospitality facilities for visitors (Comandaru et al., 2012; Conradie et al., 2014). Water use is a growing concern, particularly in regions experiencing drought (Conradie et al., 2014). One example is the Valley of the Moon region in Sonoma, California which has experienced rapid growth of the wine industry. Citizen groups have expressed concern about development, where wineries have been permitted to produce hundreds of thousands of cases of wine and drill wells near creeks. One community member feared they were “exporting their water as wine” (Bliss, 2015). In addition to concerns about over extraction from groundwater others express concern for surface water flows. Stream flow issues can be particularly impactful in regions with dry summer conditions. In the California example, although wine grapes often require less water per acre than other California crops, there is

regularly no precipitation during the summer growing season and many growers irrigate their vines (Deitch et al., 2009).

Climate Change Vulnerability and Risks to Wine Regions

Grape Varieties and Geography. Agriculture worldwide will be affected by rising temperatures and increases in extreme weather events, and these changes in climate will impact where grapes can be grown in the future (Furer, 2006; Hannah et al., 2013; Tate, 2001). Individual grape varieties are grown within narrow climate ranges for optimum quality and production, which puts wine grapes at greater risk than other crops to short-term climate variability and long-term climate changes (Jones & Webb, 2010). As climatic conditions change, there may be a need to change the grape varieties grown in some regions (Hadarits et al., 2010). Shifts in temperature patterns globally may also cause grape growing to move out of areas where it currently exists, and shift into regions that become newly suitable with climate change (Porter et al., 2014). Some estimates have found that by 2100 the United States could lose greater than 80% of its premium wine grape acreage (Kay, 2006).

Climate Impacts to Crops and Grape Quality. Wine quality grapes are significantly impacted by even minor changes in climate, and while farmers are used to annual variation in growing season conditions climate change can bring more extreme weather events with increased uncertainty (Jones et al., 2005). Certain wine regions are encountering colder than normal temperatures. Colder temperatures lead to incomplete ripening of the grapes resulting in higher acid levels, lower sugar, and unripe or “green” flavors. Other regions are experiencing hotter than normal temperatures that result in overripening, low acid, high alcohol and cooked flavors (De Orduna, 2010). With warmer

winter temperatures, grapevines are experiencing “bud break” of new leaf growth earlier in the year which increases the risk of frost damage. Extreme weather events like hail are another highly damaging risk to the grape crops (Mozel & Thach, 2014). Grapes are susceptible to pests and disease and climate changes in humidity and temperature can lead to an increase in certain insects and insect-borne diseases (Tate, 2001). Warmer winters can result in a reduction of the hardening of the woody grapevines. In most grape growing regions vines are dormant in the winter season, but warmer temperatures interrupt this natural cycle in the vines, making them more susceptible to wood rot, pests, and overall decline in the health of the plants (Jones et al., 2005). Many wine grape regions are also in areas that are highly susceptible to forest/bush fires, and with climate change fires are predicted to increase in frequency (Dale et al., 2001; Pitman et al., 2007). In addition to the threat of destruction of vineyards or facilities, there is also a serious issue with smoke taint for the grapes. Typically, the fires occur at a time when the ripening grape crop is at its highest risk of damage by the smoke, and although there is a considerable amount of time and money invested in research to reverse these impacts during the winemaking process, there is not currently a suitable solution and the result is a complete loss of the crop (Kennison et al., 2007). Finally, a number of regions are experiencing a shortening and compression of the growing season which can create challenges for the timing of harvest operations (Hadarits et al., 2010). Table 1 highlights climate change impacts and the resulting wine region risks and vulnerabilities.

Table 1. Climate change impacts and wine region vulnerabilities.

Climate Change Impacts	Wine Region Vulnerabilities	Citation
Changes to the traditional historic growing season in a wine region	<ul style="list-style-type: none"> • Earlier bud break- increased susceptibility to frost, hail • Earlier harvests - labor & operations challenges, high temperatures • Compression of harvests- impacting operations, availability of labor, capacity in the winery- availability of fermentation tanks, presses, etc. 	<p>Hadarits et al., 2010; Hannah et al., 2013; Jones et al., 2005</p>
Uncertainty of future climate	<ul style="list-style-type: none"> • Lack of knowledge when selecting new plantings (grape variety, rootstock, clone) • Uncertainty of future water needs • Expansion of vineyard plantings into previously undeveloped areas- loss of habitat, biodiversity 	<p>Hadarits et al., 2010; Hannah et al., 2013; Mozell & Thach, 2014</p>
Extreme Heat	<ul style="list-style-type: none"> • Heat stress to vine health • Damage to grape crop • Risk to human health- farmworkers • Increased need for water 	<p>Hannah et al., 2013; Jones et al., 2005</p>
Drought	<ul style="list-style-type: none"> • Drought stress to vine health, compounded over multiple growing seasons • Increased competition for or unavailability of scarce water resources 	<p>Hannah et al., 2013; Jones et al., 2005</p>
Highly variable or extreme weather events	<ul style="list-style-type: none"> • Damage to grape crop -heat, rain, hail, frost, etc. 	<p>Hadarits et al., 2010; Hannah et al., 2013; Mozell and Thach, 2014</p>
Increased rainfall during the growing season	<ul style="list-style-type: none"> • Damage to grape crop- mold, mildew, pests, etc. • Increase use of pesticides and fungicides- costs and environmental impacts 	<p>Jones et al., 2005; Mozell & Thach, 2014</p>
Warmer winter temperatures	<ul style="list-style-type: none"> • Damage to grapevines- wood rot, pests • Increase use of pesticides and fungicides-costs and environmental impacts 	<p>Jones et al., 2005</p>
Increase in frequency or severity of bush/forest fires	<ul style="list-style-type: none"> • Damage to grape crop- smoke taint • Risk to human health and property 	<p>Belliveau et al., 2006</p>

2.2.2 Climate Change Resilience, Adaptation, and Transformability

Mitigation efforts reduce carbon emissions which lessen climate change risks, but the lack of progress in reducing emissions has become evident at national and international scales, resulting in a shift of focus to approaches to adapting to climate change challenges (Dow et al., 2013; Howden et al., 2007). One approach to understanding climate change adaptation is through the lens of stability dynamics which relate to three attributes found in systems: resilience, adaptability, and transformability. *Resilience* is the capacity for a system to absorb disturbance or reorganize in the face of change, but essentially retain the same structure, function, and identity. *Adaptability* refers to the ability of human actors to manage resilience or changes in the system. *Transformability* is when a system experiences a disturbance severe enough to fundamentally alter its nature, functionality, and characteristics, where it essentially becomes a new system (Walker et al., 2004).

Current Wine Industry Approach to Climate Change Adaptation

A number of adaptation strategies are currently in practice in wine regions. In the vineyard, canopy (leaf) management of the vines can help improve the soil-water balance, although studies suggest that this alone is insufficient in the face of higher temperatures and drier conditions (Mozell & Thach, 2014). Introduction of cover crops and mulching can increase water storage in the soil (Schultz, 2000). Drip irrigation, less frequent tilling to reduce evapotranspiration, and reducing the amount of irrigation overall are all adaptation strategies to offset a reduced water supply (Mozell & Thach, 2014). Extreme daytime heat has resulted in the need to pick the grapes at night when temperatures are cooler (Mozell & Thach, 2014). To abate high temperatures,

considerations can be made for vine orientation and trellising (Hannah et al., 2013), as well as the more extreme decision to remove and replace an existing vineyard with vines that are more adaptable to new weather and climatic conditions. Recycling water can help conserve limited water resources (E-ViticClimate, 2012). The wine industry has invested in research in plant breeding and advancements in technology in the vineyards and in winery operations for greater water and energy conservation (Mozell & Thach, 2014). There is some agreement by researchers that climate change adaptation in the wine industry will require more of a focus on integrated science and a strengthened interface with policy makers (Howden et al., 2007).

Expectation of Global Variation in Climate Change Impacts and Strategies.

Although many strategies for adaptation have the potential for broad application, there are regional and even site-scale differences to consider, including different biophysical, geographical, cultural, political, and economic contexts. Predictions show that wine regions globally will experience climate change impacts differently. For example, in North America wine production is predicted to increase in cooler climate regions like Oregon, Washington, and British Columbia (White et al., 2006). In Europe, the impact is predicted to be large, where some areas in Spain and southwestern France may cool due to changes in the Gulf Stream, while current cooler climates like Burgundy and Alsace are predicted to warm significantly (Furer, 2006). South America is anticipated to have a significantly shortened growing season, while regions in Australia are predicted to become significantly hotter and drier (Ecos, 2013; Hadarits et al., 2010).

2.3 Drivers and Potential Barriers to Climate Change Adaptation Outcomes

2.3.1 Social Systems

There are limitations to the ability to adapt to climate change that come from within society. These limits relate to goals, values, and perceptions of risk; including denial of the human caused impacts on the climate (Adger et al., 2009; Moser, 2010). Other barriers to addressing climate change are based on human emotions, like fear, self-interest, or uncertainty. The complexity of climate change, where the scope and scale of the problem can often appear daunting, plus a lack of immediate or directly felt impacts can create barriers to addressing adaptation (Moser & Ekstrom, 2010). In order to adapt there is a need to build social capital to educate, inspire, and create networks of action within communities (Bierbaum et al., 2013). An adaptable society that is willing to intervene through policy is aware of diverse values and accepts some loss through change, while also considering the treatment of vulnerable people and places within decision-making structures (Adger et al., 2009). This section explores the role of social values and how they manifest in the following ways: stewardship and conservation ethics, the technology complex, critical political ecology, and privatization.

Social Values

The cognitive dimension of how people perceive their physical landscape and act within it can be connected to the idea of *social memory*, which is long held knowledge and experience about place, for example agricultural practices or water management. Social memory has also been explored as *bio-cultural refugia*, *traditional ecological knowledge* and *collective memory*, describing the practice of using community history and narratives of place to engage with the natural environment (Barthel et al., 2013; Petty

et al., 2015). Perception and social memory can be factors in water management, which can reveal long term historical trends, and decisions about “desired” conditions and what is “natural” are inherently value-laden and subjective (Barthel et al., 2013).

Understanding human values can help place natural resource decision making within a cultural context. A focus solely on economic efficiencies can be at the expense of cultural, historical, and ecological considerations. Although natural resource managers may be successful at achieving narrowly-defined economic goals, often they do not succeed in achieving long-term sustainable outcomes due to lack of acceptance and social desirability (Petty et al., 2015).

Stewardship and Conservation Ethics. Within social values, the concept of *steward* relates to landowner considerations about the long term outcomes of land and water management decisions (Chouinard et al., 2008). A stewardship approach can include a shift away from a profit maximization framework, and toward consideration of other factors when making decisions, for example: prosocial behavior instead of self-interest, i.e. “social good”; personal attachments to place; compliance with environmental regulations; or voluntary participation in subsidized conservation (Chouinard et al., 2008; Marshall, 2009).

Technology Complex. Another value that influences water resource and climate adaptation decisions is the use of technology to achieve certain human goals in the natural world. Technology as the answer to climate change problems can be found in many sectors, including agriculture. The term *technology complex* was used in describing river systems being transformed by mechanical elements to control flow, like hydro-electric dams, flood control, irrigation schemes, and water diversion projects. The

technology complex is based on social networks that embrace industrial capitalism, the fundamental characteristics of bureaucratic rationality, and the commodification of the river (Pietz, 2002). One example of a technology complex is the irrigation infrastructure found in wine regions in Tasmania, Australia, which is developed by a government-business enterprise buying stored water from a hydro-electric company and selling water to grape farmers. Pietz (2002) argues that the power the technology complex holds in society can result in degraded ecological integrity and a change in the social identity of people who inhabit the river watershed. McGinnis (2016) describes the juxtaposition of values in these terms: if we consider “a river is a lifeline that reinforces cultural identity and place-based knowledge”, and using technology turns natural systems into a commodity, then a river ends up existing in the “middle ground between mechanistic and natural.”

Critical Political Ecology and Privatization. When considering power structures, *critical political ecology theory* is a broad area of study that seeks to understand who has the power to construct scientific and social knowledge, including in the examination of economic areas like capitalism and privatization. Critical political ecology is rooted in three intellectual debates: critical theory, critical realism, and critical science, which are concerned with who has power, who constructs knowledge, how we talk about biophysical reality and social knowledge, and a critical take on orthodox scientific practices. Critical political ecology also focuses on public participation and transparency in both the scientific and political processes (Forsyth, 2004). Critical political ecology theory is a useful lens to use to analyze and understand current environmental governance issues including the management of water. In water management there is a relationship

between who has power, who constructs knowledge, and who controls water. Water systems to distribute and store water typically require large scale capital investments in infrastructure, which makes them susceptible to control of single ownership. Historically the state had a dominant role as the owner and manager of these systems for the public (Bakker, 2003). With the rise of neoliberal capitalism¹ as the dominant economic system the understanding of nature, including water, shifted to that of a commodity (Escobar, 1999; Mintz, 1985). Primary commodity production and management is conducted under market forces, and it can be argued that water is now treated as a commodity rather than a public good. No longer emblematic of public health or a basic human right, water is for profit-making and citizens are now seen as customers (Bakker, 2003; Robbins, 2003). An exclusion from access to water represents a fundamental form of citizen disenfranchisement (Strang, 2016). This privatization and commodification of water is carried out with the underlying assumption that the market is more efficient than the government and with a water scarcity only the private sector can ensure efficiency. This argument is often coupled with crises in public finances. The counterargument is that privatization maximizes economic efficiency at the cost of social equity (Bakker, 2003). One example of commodification of water is the irrigation water trading markets in Australia where water is bought and sold through abstraction licenses. This system turns water from the physical to the virtual, detaching economic activity from the material environment (Strang, 2016). As Strang (2016) points out in her Australia example of water trading markets, and also in other global instances of water

¹ Neoliberal capitalism is associated with economic policies such as privatization, deregulation, globalization and shifting economic control from government to the private sector (Springer et al., 2016).

privatization, the water supply and infrastructure are often financed, constructed, and distributed by a small number of private companies. Transferring control of water to private management coupled with weak government regulatory mechanisms results in diminished power for both the individual and the state. An alternative view is that the neoliberalization of water resource management involves landholders who are far from naïve or passive, and many farmers make use of neoliberal programs like payment for conservation practices or ecosystem services to meet their own environmental goals or supplement their incomes (Higgins & Cocklin, 2012).

2.3.2 Governance

One of the challenges of addressing climate change adaptation in environmental planning and natural resource management is the complexity of governance, where there can be a lack of clear definitions of institutional roles and responsibilities and questions arise about what scale to address the problem (Measham et al., 2011; Urwin & Jordan, 2008). The impacts of climate change will be experienced locally, therefore there is a need for geographic place-based approaches to climate vulnerability analysis and adaptation strategies. Local strategies can negotiate between individual and collective responses to vulnerability (Measham et al., 2011). One approach at the local scale is to “mainstream” climate considerations into existing plans, and “climate proof” new policies by attempting to identify and resolve the most obvious antagonisms between existing policies. There is also a call to build flexibility and adaptability into policy systems (Howden et al., 2007; Urwin and Jordan, 2008). Climate change adaptation requires cross-sectoral assessments of climate vulnerability inclusive of federal, tribal, state, and local governments and the private sector, where the focus can be on strategies

with “co-benefits” to multiple stakeholders. Although there is the risk that some adaptive actions may turn out to be maladaptive in the future (Berry et al., 2006; Bierbaum et al., 2013; Howden et al., 2007).

Governance and Environmental Planning. Governance can include, but is not limited to government institutions. Governance is defined as the “interactions among structures, processes and traditions that determine how power and responsibilities are exercised, how decisions are taken, and how citizens or other stakeholders have their say” (Graham et al., 2003). These structures, processes and traditions occur at a range of scales, from the community and local level to the global scale. “Top-down” governance frameworks pursue explicit aims and objectives set in policy, which are then directed into action. “Bottom-up” governance recognizes the importance of other actors in shaping policy and implementation, and includes many perspectives throughout the decision-making process (Urwin & Jordan, 2008). Environmental planning and management is the means of controlling or guiding the interactions between humans and the environment, with the dual purpose of protecting and enhancing human health and well-being and protecting environmental quality (see Figure 2). (Randolph, 2012).

Figure 2. Diagram of Relationships in Environmental Planning and Management (Randolph, 2012).

As it relates to climate change, the process of legislating, policy-making, planning, and management at all levels of government impacts regional adaptation and is typically more incremental than transformational (Berry et al., 2006). Although there are a number of constraints in governance around adaptation planning, including lack of funding, rigid policies, and fragmentation of decision making, there are also opportunities to advance adaptation strategies in “learning by doing” and through stakeholder engagement (Berry et al., 2006). Local institutions are uniquely situated to mediate between individual stakeholders and collective responses to climate change vulnerability, and at the same time there is a call for integration between planning and policy at

difference levels and spatial scales of governance (Measham et al., 2013; Urwin & Jordan, 2008).

Agricultural Zoning. Wine regions are dependent on the availability of agricultural land, and in both the United States and Australia, zoning of suitable agricultural land has been based solely on soil surveys (Randolph, 2012). Soil designations, rather than availability of water, climate, or access to labor, are the main determinants for agricultural zoning decisions. These decisions determine where development can occur or where agricultural land is to be preserved, a source of conflict in many wine regions (Noble, 1992).

New Governance. The term new governance describes partnerships between public institutions and the private sector. Also called *corporatist agreements*, they are defined as public policy agreements made between the state and select actors in the private sector. A critique of this approach is the potential for top-down, centralized planning, where those with property and commercial interests “harness” state institutions for their own gain (Lane, 2003; Pemberton & Goodwin, 2010). In the United States these collaborations are called *public-private partnerships*; in Australia they are *government-business enterprises*.

Cooperation and the Commons. Another approach to managing water as a shared resource is the concept of *the commons* (Ostrom, 1990). Instead of those with the most power shaping the rules of common resource management to fit their own interests, communities work to build “social capital” through frequent in-person communication and dense social networks to increase trust and compliance with rules (Dietz et al., 2003). One study looking at the successful self-governance of the commons in the freshwater

fishing industry in Brazil showed that the largest factor in willingness to participate was an individual's beliefs about the cooperation of others, or as the authors deemed it "conditional cooperation" (Cavalcanti et al., 2010).

The next step I took was to synthesize the knowledge I learned in the exploration of theory and literature related to climate change adaptation, social systems, and governance, and determine how to apply this knowledge in the examination of my research data. In order to approach this synthesis, I chose to use a framework developed to investigate the relationships between complex systems called the Institutional-Social-Ecological Dynamics (ISED) framework (Arnold, 2014; Arnold et al., 2017). The following section explains the development and theoretical grounding of the ISED framework.

2.4 Analytical Frameworks for Considering Climate Change Adaptation

Scholars have used the term *social-ecological systems* (SES) to present the concept that systems are integrated; humans are part of nature and our history of delineating or separating them is artificial (Berkes et al., 2008). One benefit of considering the interconnectivity of these different and intricate systems is that we can begin to better understand the complexity that surrounds us (Ascough et al., 2008; Berkes et al., 2008). SES are made up of both biophysical and social factors that regularly interact, and these factors form systems that exist at several scales - spatial, temporal, and organizational (Holling & Gunderson, 2002; Redman et al., 2004). SES are not static, rather they are dynamic, complex, and continuously adapt (Berkes et al., 2008). Ostrom (2009) points out that ecological sciences and social sciences have developed independently, and therefore do not combine easily when trying to understand complex

systems. She argues for the use of the SES framework in order to go beyond simple theoretical models that analyze only parts of problems and then suggest universal solutions. Rather, SES uses many variables and sub-systems to account for complexity, and advocates for analysis that identifies relationships and interactions among these variables at different spatial and temporal scales.

Building on SES, another analytical framework called ISED was developed to include the strong role of institutions. To this end the ISED framework used components of Ostrom's institutional analysis and development (IAD) framework. Where Ostrom's framework uses the terms biophysical conditions, community attributes, and rules, the ISED framework uses the categories of ecological systems, social systems, and institutional systems (Figure 3). Ecological systems encompass ecological processes in the landscape, and social systems include cultural, political, and economic drivers. Institutional systems are defined as the prescriptions people use to organize forms of structural interactions at all scales. Institutions are made up of rules, norms, and cultural beliefs which contribute to shaping social actions. Institutions include both formal and informal governance systems, decentralized and collaborative systems of collective action, and legal regimes, including legislation, regulation, enforcement, and litigation. Legal regimes can contribute to change by granting authority to governance bodies, but they can also contribute to resistance to change through entrenchment of rules (Arnold et al., 2014). ISED also pulls from panarchy and resilience models to address "inter-systemic nonlinear dynamics" (Arnold et al., 2014). Resilience models predominantly focus on abrupt regime changes when a system could no longer absorb or adapt to a disturbance. Panarchy models looked at adaptive cycles and changes in systems across

geographical and temporal scales (Gunderson, 2001). ISED is not a new theoretical construct; rather it is a functional tool to guide research.

Figure 3. Institutional-Social-Ecological Dynamics Framework diagram (Arnold, 2014).

2.5 Conclusion

In this chapter I introduced bodies of scholarly research and theoretical underpinnings that inform my research design and analysis. The selection of these bodies of knowledge was grounded in themes that emerged from interview data with key knowledge holders from exploratory research in global wine regions. My research

conducted in the case study regions of the Willamette Valley and Tasmania builds on this historical and current scholarship. I addressed the need for adaptation based on climate change vulnerabilities in wine regions; situating these needs within the context of the role of climate, geology, and geography in grape growing, as well as different contexts of farming approaches and water use. I outlined the current viticulture and technological adaptation practices and discussed how approaches will vary globally. Certain social factors may limit climate change adaptation outcomes, including values and perceptions of risk. I present an overview of different academic approaches to understanding social values and the natural world, including: stewardship and conservation ethics, the technology complex, critical political ecology, and privatization. In order to understand how these social values manifest in different wine regions, I link the social systems with approaches to decision making, or governance, around water resources. I considered different governance approaches, including “Top-down” and “Bottom-Up” government structures, “New Governance” (privatization), and the “Commons” (cooperation). Going forward, I consider complexity in decision making around water and climate change adaptation in wine regions; this involves developing an understanding of the social, economic, political, institutional and ecological contexts of the regions. In the following chapters I use the ISED framework to organize the themes (codes) that arise from the research data. I also use the ISED framework to analyze the relationships within and among the regional social, institutional, and ecological systems. From this analysis I determine the barriers and opportunities to adapt to climate change challenges in the years and decades to come.

Chapter 3. Methods

3.1 Research Approach

Introduction to Qualitative Inquiry and Comparative Case Studies

I used a qualitative approach and conducted a comparative case study between two wine regions, the Willamette Valley and Tasmania, in order to examine how water governance creates opportunities or barriers to climate change adaptation in wine regions. Qualitative research methods allow for the exploration of complex issues that need to be understood in context, versus relying solely on predetermined information found in the literature. The approach aims to develop a complex picture from multiple perspectives; a picture that identifies many factors, as well as interactions between factors (Denzin & Lincoln, 2011). This type of inquiry requires time in the field, and can evolve and change as new information is revealed (Maxwell, 2005). I use qualitative inquiry to make sense of and interpret phenomena I observed in the field (Denzin & Lincoln, 2011). My method of choice, the case study, is defined by Yin as “a qualitative approach in which the investigator explores a real-life, contemporary bounded system (a case) or multiple (cases), over time, through detailed, in-depth data collection involving multiple sources of information (observations, interviews, documents, and reports), and reports a case description or case themes.” (Yin, 2009). I analyzed data through description of the cases, their context, and emergent themes (Stake, 1995). I took an active role in the data analysis resulting in identification of themes and issues, as well as interpretation of the data leading to conclusions about overall meaning (Boyatzis, 1998; Stake, 1995; Taylor & Ussher, 2001).

I began the project with a series of exploratory research trips to global wine regions in North America, South Africa, and Australia. I used thematic analysis to determine emergent themes, which informed the development of the comparative case study research design (see Appendix A for a detailed description of exploratory research). The data gathering and analysis process are described in Table 2.

3.2 Case Selection

The criteria for the selection of case study wine regions was a combination of similarities and differences in regions, as well as familiarity and access. The Willamette Valley and Tasmanian wine regions share similarities, despite their great distance from one another. Both regions are considered cooler climate growing regions and they produce the same varieties of grapes, namely Pinot noir, Pinot gris, Riesling, and Chardonnay. The wine industries in both regions have reputations for high quality grapes and wine production. Only small amounts of wines are produced in these regions, and the wines sell for premium prices. Both regions have been experiencing growth, and are located in geographic proximity to large, well-established wine grape growing regions—California and the mainland of Australia—that are currently experiencing serious challenges with heat, drought, and wildfires. Tasmania and Oregon have not experienced extensive climate change related outcomes yet, but this is beginning to shift. In both regions, water belongs to the public, but access is controlled by federal government legislation and state government management and oversight. The regions are different in the historical and current practices of water governance, including the history of water rights, the use of irrigation, the use of surface water versus groundwater, and the development of water markets.

Table 2. Data Gathering and Analysis Process

1.	Determine broad areas of research interest
2.	Exploratory Research- visit wine regions & conduct interviews resulting in exploratory dataset
3.	Inductive Coding- generate codes from repeated patterns (themes) across the dataset
4.	Use results of exploratory dataset to craft focused research questions and interview guide
5.	Comparative Case Study- focus on two wine regions and conduct interviews resulting in a rich dataset
6.	Structured Framework for Coding- main codes based on interview guide, sub-codes emerge from dataset

3.3 Research Activities

3.3.1 Interviews with Key Knowledge Holders from Case Study Regions

I conducted fifty-two interviews with key knowledge holders, twenty-seven in Tasmania and twenty-five in the Willamette Valley. The participants were a sample representative of regional stakeholders, which provided narratives, perceptions, and insights from a broad range of perspectives, including: the wine industry, government agencies tasked with resource management, and academic and conservation institutions (see Table 3). Participants were selected through a process of targeted outreach and snowball sampling, where interview participants provide names of other contacts who could be useful in understanding particular subjects (Atkinson & Flint, 2004). Wine industry participants included a range of roles but also scale and type of business. Table 4 shows the range of wine industry perspectives represented by region. The interviews were arranged ahead of time by email and participants were provided with the interview guide in advance (see Appendix B). The interview guide for all respondents of a given type asked mainly identical questions, with some tailoring dependent on their particular position. The interviews were semi-structured, so the guide served as a starting point, but follow-up questions allowed the interview to follow new and different thematic paths. The interviews in Tasmania were conducted in 2018, with twenty-six conducted in

person and one interview conducted by phone. All interviews in the Willamette Valley were conducted in person in 2019. The interviews ranged in length from approximately thirty minutes to two hours, with the duration of most being one hour. Directly following each interview, prior to transcription and coding, I wrote detailed notes (memos) of my reflections and observations.

Table 3. Table of Key Knowledge Holder Interview Participants.

Key Knowledge Holders	Tasmania	Willamette Valley
Wine Industry- Winery and Vineyard Owners, Winemakers, Viticulturists, Marketing Representatives	11	14
Academic Researchers	6	3
Professionals or Government Agency Representatives- Planning, Climate Change, Water Resource Management, Environmental Conservation	10	10
Total- 52	27	25

Table 4. Roles of Wine Industry Participants (most participants hold multiple roles, this shows number of roles represented, not number of total participants).

Wine Industry Roles	Tasmania	Willamette Valley
Viticulturist (grape farmer)	8	10
Winemaker	4	9
Owner	7	7

3.3.2 Field Observations

I conducted field observations while spending time in each region, including site visits and tours at vineyards, wineries, and water resource infrastructure locations. I had “ride-along” driving tours with local knowledge holders to better understand the regional

geography. While in Tasmania, I attended a community input forum held by the state government about climate change preparedness, as well as a local council natural resource management committee meeting. In both Tasmania and Oregon, I attended academic presentations on regional climate change futures.

3.3.3 Policy and Documents

In order to best understand the components, structures, influences, and outcomes of governance in each region, I reviewed legislation, policy, planning, and management documents related to water resources, agriculture, and climate change. I approached this from a range of governance scales including local, regional, state, national, and global. I selected these documents referenced in peer-reviewed literature, found on institutional websites, or identified by interview participants. In addition I reviewed publicly available meeting minutes as well as popular news articles related to the research themes regarding wine industry growth, government-business enterprise, and climate change, among others.

3.4 Thematic Analysis

I used the process of Thematic Analysis (see Tables 6 and 7) to move beyond description of my data to interpretation, in an attempt to theorize significance in the patterns in the data that become themes, and the relationships between and across themes (Braun & Clarke, 2006). I personally transcribed each interview, which served to type the spoken words on the recording, but also to begin analysis and interpretation of the data (Bird, 2005; Lapadat & Lindsay, 1999). I used Atlas.ti software to assign codes (themes) to segments of text in each transcript. I began with a total of twenty-two deductive codes, which came directly from the interview guide (Table 5).

Table 5. Main (Parent) Codes for Comparative Case Study Interview Data.

1. Attitudes & Perceptions	12. Policy & Management Plans
2. Climate Adaptation	13. Political Will
3. Climate Change	14. Power & Influence
4. Decision Making	15. Private Property Considerations
5. Government Regulatory Body	16. Relationships/Communication
6. Economics/Money	17. Research
7. Environmental Concerns	18. Sharing Information or Data
8. Government Business Enterprise	19. Transformation
9. Irrigation	20. Water
10. Legislation/Regulatory Frameworks	21. Weather/Climate Variability
11. Oversight	22. Wine Industry

Following this, I developed forty-two sub-themes that were inductive and emergent and nested beneath the “parent” set of codes, for example, the parent code “Water” has seven sub-themes: *water as an economic good, water access, water rights, attitudes and perceptions, water quality, water quantity and other environmental considerations* (see Appendix C for the complete list). I used the ISED framework to organize and interpret the relationships between and across themes. In doing this my analytic narratives go beyond descriptions to interpretations of significance and meaning in the findings (Patton, 1990).

Table 6. Phases of Thematic Analysis (Braun and Clarke, 2006)

Phase	Description of the process
1. Familiarizing yourself with your data:	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes:	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes:	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes:	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic ‘map’ of the analysis.
5. Defining and naming themes:	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6. Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Table 7. Fifteen-Point Checklist of Criteria for Good Thematic Analysis (Braun and Clarke, 2006).

Process	No.	Criteria
Transcription	1	The data have been transcribed to an appropriate level of detail, and the transcripts have been checked against the tapes for ‘accuracy’.
Coding	2	Each data item has been given equal attention in the coding process.
	3	Themes have not been generated from a few vivid examples (an anecdotal approach), but instead the coding process has been thorough, inclusive and comprehensive.
	4	All relevant extracts for each theme have been collated
Analysis	5	These have been checked against each other and back to the dataset.
	6	Themes are internally coherent, consistent, and distinctive.
	7	Data have been analyzed- interpreted, made sense of- rather than just paraphrased or described.
	8	Analysis and data match each other- the extracts illustrate the analytic claims.
	9	Analysis tells a convincing and well-organized story about the data and topic.
Overall	10	A good balance between analytic narrative and illustrative extracts is provided.
	11	Enough time has been allocated to complete all the phases of the analysis adequately, without rushing a phase or giving it a once-over-lightly.
Written Report	12	The assumptions about, and specific approach to, thematic analysis are clearly explicated.
	13	There is a good fit between what you claim you do, and what you do, how you have done it- ie, described method and reported analysis are consistent.
	14	The language and concepts used in the report are consistent with the epistemological position of the analysis.
	15	The researcher is positioned as <i>active</i> in the research process; themes do not just ‘emerge’.

3.5 Conclusion

In this chapter I outlined my research design using qualitative inquiry and a comparative case study approach. I introduced the two case study wine regions of the Willamette Valley and Tasmania. The qualitative research methods allow me to explore complex issues around climate change adaptation and wine region governance. First, I conducted exploratory research in four global wine regions which informed my research question and design going forward. Next, using inductive themes from the exploratory data, I created an interview guide and carried out interviews with key knowledge holders in both case study regions. Using deductive and inductive coding, I categorized and

organized the interview data. In the following chapters I use the ISED framework to help interpret the data, organize the research findings, and tell the story of climate change adaptation and water governance in the two wine regions. The resulting analysis of the findings explores the opportunities and barriers to adaptation outcomes within the context of the regional ecological, institutional, and social systems.

Chapter 4. Case 1-- Willamette Valley, Oregon, USA

4.1 Introduction

In this chapter I introduce and present findings for the case study of the Willamette Valley wine region in the state of Oregon, USA. Using Arnold's (2014) ISED framework, I examine the institutional, social, and ecological systems in a real-world example. To this end, I organize the themes (codes) from the key knowledge holder interview data into the three ISED systems, and present background information and findings in three main sub-sections: 1) Introduction to the Willamette Valley, 2) The Willamette Valley and Climate Change, and 3) Water and the Willamette Valley. These sub-sections also include information sourced from policy documents, government agency publications, and academic research. The "Introduction to the Willamette Valley" sub-section provides background information including the history, demographics, geography and wine industry trends in the region; while also examining the political and economic contexts of the region related to water resources and the wine industry. The political context is derived from research data related to interview responses about political will to address challenges to water resources and climate change, and questions about who holds or lacks the power to influence political outcomes. In the Willamette Valley political context, main emerging themes include: the challenges of managing water within politically defined boundaries versus watershed basins; the urban/rural divide in political affiliation and resulting conflicts around climate change and natural resource policy shifts; the political efforts at county and state levels to think about long-range planning around water for multiple stakeholders with differing needs; and the role of lobbying on influencing political outcomes in the region. With regards to the economic

context of the Willamette Valley, findings are derived from interview responses related to themes (codes) about economics, power and influence, decision making, and the wine industry; which highlight: 1) wine industry growth and an increase in tourism in the region; 2) a likely future shift towards the commodification of water rights and the establishment of water markets; and 3) wine industry consolidation and outside investment from large companies potentially resulting in a wine industry with an uneven ability to access water based on financial resources. The second sub-section, “The Willamette Valley and Climate Change,” identifies ecological considerations for the region regarding future climate change projections. This section includes research findings from scientists about likely future scenarios for temperature and precipitation; as well as articulating what climate change outcomes mean for the Willamette Valley wine industry, ranging from vineyard site and grape variety selection to farming techniques to mitigating greenhouse gas emissions. Finally, the sub-section “Water and the Willamette Valley” examines the current situation for water resources in the region, including historical and current governance structures for allocating water, oversight for water quality assurance, and specifically the various ways those in the wine industry can currently access water in the region. This sub-section draws from key informant interview data around attitudes and perceptions to water in general, and specifically to irrigation practices; and these findings highlight trends like the increase in the installation of irrigation systems, to ranges of perceptions about potential future water scarcity and the difficulty or ease in obtaining permission to use water from the state government. The main findings that emerge from the synthesis and analysis of the research data using the ISED framework are: 1) climate change will result in challenges around water resources

in the Willamette Valley; 2) current water governance in the region is a top-down structure that lacks resources for oversight and scientific investigations; 3) entrenched legal regimes, like the prior appropriation doctrine, make changes to current water governance challenging and contribute to an unevenness in stakeholder access to water; 4) stakeholder conflict about access to water resources is a current challenge that will augment in the context of a hotter, drier climate with population and wine industry growth; 5) the combination of entrenched legal regimes and an increase in water demand will likely result in a future of water rights shifting to a commodity market system; 6) those within the wine industry have a range of attitudes and approaches to water resource and climate change planning and management; and 7) there is a variety of climate adaptation approaches around water for the wine industry, but they are dependent on economic resources and/or social values related to sustainable farming, winemaking, and hospitality operations.

4.2 Introduction to the Willamette Valley

History, Demographics and Geography

Oregon is a state in the northwest of the United States. Oregon became a state in 1859, following a large migration of emigrants who traveled overland on the Oregon Trail from the east as part of western expansion in the United States. Prior to that time, the land was inhabited by indigenous tribes for over 15,000 years (Robbins, 2005). In the nineteenth century after devastating impacts of introduced diseases and massacres, the remaining Native American population was moved to reservations, losing traditional fishing and hunting lands. There remains conflict and cooperation around natural resource management between tribal governments and the state and federal government

in the U.S. Today Oregon is home to more than four million people, with nearly eighty-seven percent of residents identifying as white (US Census Bureau, 2020). More people are moving into the state than leaving, and with an aging workforce, economic growth relies on in-migration (Oregon Secretary of State, 2020). Approximately seventy percent of the state's population resides in the Willamette Valley, most in the Portland Metro area in the north (Loy et al., 2001).

Oregon has a variety of diverse ecoregions in different climatic zones. Bordering the Willamette Valley, the western slopes of the Cascade Mountain Range to the east, and Coast Range to the west are heavily forested with Douglas fir trees among others, and provide habitat for many animals like deer, elk, mountain lions, and coyotes. In the mid-twentieth century, there were well over one thousand wood product plants in the small towns in the valley. By the early twenty-first century the industry had dwindled to less than three hundred large scale sawmills, pulp mills, and plywood plants. Other resource economies in Oregon like fisheries have also diminished with declines in salmon and shellfish populations in the twentieth century. Major dam projects were constructed in the mid-twentieth century on rivers throughout the state, and hydroelectricity provides more than two-thirds of Oregon's energy demands (Encyclopedia Britannica, 2020). Over the past three decades Oregon has transitioned from a resource-based economy centered on timber and agriculture, to more of a mixed manufacturing, marketing, tourism, and high tech economy. This shift has happened in areas around Portland, but has largely left out rural areas (Oregon Secretary of State, 2020). Agriculture is still prevalent in the Willamette Valley, where over one hundred seventy different crops are grown, including

grass seed, fruits, nuts, berries, hops, grapes, and field crops, plus horticulture nursery stock and Christmas trees (United States Department of Agriculture, 2020).

The Willamette Valley is a broad valley approximately one hundred and fifty miles long from north to south, located around forty-five degrees latitude in the northern hemisphere. The valley is situated fifty miles inland from the Pacific Ocean between two mountain ranges, the Coast Range and the Cascade Range. The Willamette River runs the length of the valley from the city of Eugene in the south to the confluence with the Columbia River in the city of Portland in the north. The main soil types in the Willamette Valley originate from volcanic flows of basalt, windblown loess and uplifted marine sedimentary soils.

Figure 4. Willamette Valley Wine Region, Oregon (Wine Folly, 2020).

Willamette Valley Wine Industry Trends

The modern wine industry in Oregon began in the mid-1960s and has grown substantially in the subsequent decades. Oregon is the third largest wine grape producing region in the United States, with twenty sub-American Viticulture Areas (AVA), although the majority of producers are small, making less than five thousand cases of wine annually (Oregon Wine Board, 2020). The Willamette Valley also has approximately seventy percent of the vineyards in Oregon with over 24,000 acres of planted vineyards and nearly 600 wineries (Figure 4) (Willamette Valley Wineries Association, 2020). The growth and economic success of the wine industry has also

contributed to the development of tourism amenities, lodging, and fine dining. The Willamette Valley is an easily accessible travel destination, as it is a short drive from Oregon's largest city and international airport in Portland.

Willamette Valley-- Political Context (Institutional-Social Systems)

Politically Oregon has a system of direct legislation, where citizens vote on initiatives and referendums. At the state level, Oregon has three branches of government all democratically elected by the public: the executive office headed by the governor, a legislative assembly composed of a senate and house of representatives, and the judiciary headed by a supreme court. At the county level decisions are made by an elected group of commissioners and county courts. Locally, most towns are managed by elected mayors and city councilors (Encyclopedia Britannica, 2020). Oregon, like much of the country, has political differences between its cities and rural areas. In Oregon the majority of the population lives in cities, and the majority of elected officials are affiliated with the Democratic political party. By contrast the rural areas tend to be represented by Republican politicians, although this is shifting in some counties. Oregon has a reputation for progressive politics and being “green,” supporting laws and policies to protect the environment. There has been considerable conflict in recent years at the state level regarding legislation around climate change policy (e.g. carbon tax, and cap and trade initiatives) and related issues. Agriculture and timber are cultural icons in a number of rural communities, and many residents are resistant to regulation. Other residents believe that public demand for water resource planning will increase, and the government will need to find the resources to fund studies. In 2020 the governor's office created a one hundred year water vision document for the entire state (OWEB, 2020). State government

agency interview participants emphasized that leadership at the state level is needed to successfully back programs and initiatives around water planning. The agricultural sector and municipalities have their own lobbying groups, and lobbyists play a role in influencing politics at the state level. The Oregon Wine Board is the main lobbying body for the wine industry. At the county level in the Willamette Valley, Yamhill County commissioners have initiated conversations among stakeholders by forming a water resource task force and beginning to draft a climate change adaptation plan. Some in the wine industry express a desire to shift away from politically defined boundaries, and consider basin and drainage scale management for water resources. As one winery owner and viticulturist stated: “We can't make good political decisions when we fundamentally misunderstand the fact that every piece of ground is tied into the next piece of ground.”

Willamette Valley-- Economic Context of Water and Wine (Institutional-Social Systems)

As a water user, I don't necessarily want to pay for water, but it is weird that we don't pay for it. - Willamette Valley Farmer

The Oregon wine industry has grown considerably in the last two decades, from 139 wineries in 2000 to nearly 800 wineries in 2018 (Oregon Wine Board, 2019). With this growth there are a number of considerations that relate to the economics of water resources. One economic driver in wine regions is agritourism. In order to sell wine directly to consumers, the wine industry promotes tourism in rural regions, with tasting rooms, special events, and visitor accommodations. These types of activities can come in conflict with rural residential neighbors, and other farm operations, including fears of exacerbating water scarcity issues with increased demand (Upton & Nielsen-Pincus,

2020). One interview participant highlighted concerns about the use of agriculturally zoned land for commercial purposes like winery operations:

Ag use should not be commercial. And that's where the wineries come in. I think it's an area that's getting a little abused. They bring agritourism and then you've got toilets and hand washing. This is an agricultural piece of land, but you're using it for a retail commercial operation.

Others speculate that along with money, comes increased access to development:

Oregon has pretty strict land use laws, but there are ways around some of those. Especially as more money comes into the valley, there's more sophistication in how to get around the loopholes. You're just seeing more diversity in on-farm enterprising...B&Bs and event centers and things that are pretty intense when it comes to water availability and wastewater...I just don't think there's really an infrastructure both at the local level and at the state to really know what the impacts are going to be long term.
-- Local Natural Resource Agency Employee

Another concern raised by interview participants was the potential future of water rights being decoupled from land rights and the ability to sell water as a commodity. The wine industry is seen as a possible beneficiary of a transition to water markets, although the ability to access water in this way would vary greatly within the wine industry as well. A researcher of water policy in Oregon shared her opinion about water markets:

I worry about the commodification of water in that the ones with the money get the water, but I'm afraid too many people only understand the value of water, clean and otherwise, in dollars and cents.

Along with overall wine industry growth in the region, there is also a trend toward consolidation within the industry, with larger companies from outside the region buying and building wineries and vineyards in the Willamette Valley. The larger companies often have greater financial resources. The growth of the wine industry is combined with shifting practices that potentially use more water, like irrigation, increased yields of grape and wine production, and an increase in tourism activities. These changes are taking

place in the context of a region that has a growing demand for water resources from a range of stakeholders, and a projected climate future of increased water scarcity. The potential for the commodification of water and the creation of water markets raises concerns within the wine industry and within the larger region about equitable access to water:

Well, I think in the places where they have installed water markets and water has become a commodity that it only exacerbates any kind of inequality and accessibility issues in any kind of community. Water is life, and if you don't have water, you don't live.
-- State Water Resource Manager

The future of water policy and management is connected to the social fabric of the Willamette Valley wine region, including the sense of community identity and the shifting trends of economics, politics, and values.

4.3 The Willamette Valley and Climate Change

There is consensus among global climate scientists that the climate is changing and impacts are already being experienced around the world. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) states that warming is undeniable and continued emission of greenhouse gases will cause further warming and long-lasting changes throughout the global climate system (Jimenez et al, 2014). Climate change will have impacts on the Willamette Valley wine industry. The following section includes information and research findings that increase understanding about climate change impacts, including scientific information about future climate change scenarios, climate change considerations specific to the Willamette Valley wine region, and attitudes and perceptions described by key knowledge holders in response to interview questions regarding climate change and wine industry adaptation.

Climate Change Projections (Ecological Systems)

Temperature. The Willamette Valley in Oregon historically has had a temperate climate, but Oregon is already feeling the impacts of climate change. The current observed climate shows that Oregon continues to warm in all seasons. The Pacific Northwest region of the U.S. has warmed by 1.1°C since 1900. The years 2016-2019 were warmer than the 1970-1999 average. Climate models show the future climate in Oregon will continue to warm by 2.2-4.9°C by 2100 depending on global emissions rise (Mote et al., 2019). A recent climate futures study in the Clackamas River Basin (CRB), a tributary to the Willamette River, found warming trends as well. Modeling showed the average number of days below freezing in the winter months will decrease by 53% – 74% by the end of the century compared with the current climate. Hot days will increase in frequency; and the average number of days above 32°C will increase eight to twenty times compared with the current climate (Catalano & Loikith, 2019) (Figures 5, 6, and 7).

Figure 5. Average annual air temperatures simulated under Historical (green), Moderate (yellow), and Business-as-usual (red) emissions pathways 1950-2099. Solid lines indicate the median across models, and shading represents range across all model simulations (Catalano and Loikith, 2019).

Figure 6. Clackamas River Basin Average Frequency of Days Above 90°F 1950-2099 (Catalano and Loikith, 2019).

Figure 7. Clackamas River Basin Average Frequency of Days Below 32°F 1950-2099 (Catalano and Loikith, 2019).

Precipitation. Annual precipitation in Oregon is not projected to change in terms of amount, but models suggest modest decreases in summer precipitation and increases in winter precipitation (Figure 8). Extreme and heavy rain events could increase by ten percent in western Oregon by mid-century. Mountain snowpack is a natural reservoir for water in Oregon. Melting snow in the spring and summer seasons supplies surface water flow and recharges groundwater aquifers (Mote et al., 2019). Snowpack is predicted to decline significantly in winter months; instead precipitation will fall as rain and rapid runoff will occur in the winter, contributing to flood risks. Lack of snowpack storage will lead to water scarcity in warmer months (Mote et al, 2019). A joint research project between scientists at a number of Oregon universities used downscaled local climate models to project future water conditions in the Willamette Basin through 2100. The results of their study aligned with other findings about temperature and precipitation. They found that for every 1.6°C increase in annual mean temperature, there will be a roughly 15% decrease in summer flow in the lower Willamette River Basin (Jaeger et al., 2013). In addition, fire risk is projected to increase across the entire state, with large increases in the Willamette Valley (Mote et al., 2019).

Figure 8. Clackamas River Basin Average Precipitation 1950-2099 (Catalano and Loikith, 2019).

Climate Change and the Willamette Valley Wine Industry

In reality, planting and irrigation decisions will continue to change across the landscape, along with the climate. As one example, wine grapes are a sensitive crop that may be affected by climate change. The regional climatic conditions that produce an optimum quality are considered to be narrow and differ for each varietal, ultimately putting wine grapes at a heightened risk to climatic variations and change. Research has shown that some of the gradual, historical shifts in the climate (1948 through 2002) have been beneficial to some wine grapes currently grown in Oregon. However, the projected changes over the coming century may not continue to benefit wine grapes and could result in the migration of optimal conditions to more northerly regions that have traditionally been too cold for cultivation. While these anticipated changes may occur over a period as long as 50 years, Oregon's wine grape growers have begun considering adjustments to watering practices, varietal choices, and locations of vineyards. These decision points will continue to be made across the agricultural sector in the coming years.

-- Oregon Water Resources Department, 2017

The Oregon Water Resources Department (in the above quote) uses the example of the Oregon wine industry to highlight heightened risk from changes to regional climatic conditions and the need to make decisions about adaptation. In the research findings, all Oregon interview participants acknowledged that climate change is happening and it is going to affect the wine industry in the Willamette Valley. Certain risks arise in the region where historically wine grapes have not been irrigated beyond one to two years to establish new plants. With projected increases in temperature and more frequent heat waves and droughts in summer months, irrigation could become more common and access to irrigation water may become an important consideration in the Willamette Valley wine industry. A viticulturist from California whose company had recently purchased a vineyard in the Willamette Valley shared that he had engaged a climate modeling consultant to generate site specific future climate scenarios, with the main goal of understanding what their water and irrigation needs will be going forward. A viticulture researcher based in Oregon explained that there is still a big learning curve about irrigation when it comes to Willamette Valley soils. There is a lack of knowledge about what grapevines in the soil conditions of this region really would need in terms of irrigation, since it hasn't been researched in depth locally:

We really don't know. We know it's dry, we know we've got to do something about it, but we don't know what our soils are. We don't know how our soils are managing the water or how the plants are responding.

The viticulture researcher also raised the issue that localized information is needed beyond just quantity and timing of precipitation:

When you actually sit down and look at the data... we were very dry and at that time we were just forecasting out what it might mean ... how

should we manage our soils? Very few of the vineyards are irrigated. But that doesn't mean we don't care about water... people don't get it if they're from California, because they're like, just irrigate...well that's not the point. It's still water management.

A warmer climate can affect what type of grape varieties can be grown in the region. Pinot noir and cool climate-suited white grapes are predominantly what is planted in the Willamette Valley. A number of producers observed that at present, growers in Oregon are not considering planting new varieties of grapevines, but rather there is a shift toward a more technically-focused way of farming the existing Pinot noir grapes. One vineyard owner argued that climate change mitigation is still essential and can be achieved through farming practices that sequester carbon in the soil.

Attitudes About Climate Change (Social-Cultural Systems)

A number of climate change conversations in the Willamette Valley wine industry are centered on wine characteristics. There is the potential for hotter, drier weather to shift the current wine style of lower alcohol and higher acids, a more austere “Oregon-style” of Pinot noir, to a higher alcohol, bigger, bolder, “jammier” style of wine. Some producers are being proactive and securing fruit contracts from cooler vineyard sites, or even purchasing new sites with an eye on future conditions, where higher elevations could be desirable for their cooler characteristics. Many in the wine industry acknowledge and show concern that the last decade has revealed trends for long stretches of hot temperatures, and how it is a challenge to manage risk with a crop that is a monoculture and a decades-long investment. While some interviewees have found they need to shift their language around climate change with climate denier neighbors,

referring to “changing trends in temperature and rain patterns,” most find that the debate lies more in why climate change is happening, not whether it is happening. Others observe that the climate change conversation has shifted from trying to slow down climate changes through mitigation efforts, to planning for adaptation to inevitable changes. However, one vineyard owner shared her opinion that agricultural land should not be considered a sacrificial area when it comes to climate change, rather, viticulture in the region should play a big role in mitigation, using farming techniques to sequester carbon.

4.4 Water and the Willamette Valley²

In this section I introduce the story of water, institutions, and social systems in the Willamette Valley; including the quality and quantity of current water resources, Oregon water law, government oversight, how those in the wine industry access water, and attitudes about water and irrigation.

Current Water Resources (Ecological-Institutional Systems)

Seventy percent of the Willamette River basin is covered by forest, which has a large impact on hydrology in the region. In the coming decades, water demand is anticipated to increase with projected population growth, an upsurge of development, expansion of agricultural irrigation, and the need for *environmental flows*, i.e. leaving water in rivers and streams as habitat for fish, including federally-listed threatened and endangered species (Jaeger et al., 2013). In Oregon a number of state agencies are responsible for managing water, but two institutions are predominantly in charge of

² Information in this section is from detailed explanations in interviews with Oregon state agency staff and Oregon water law experts (lawyers and consultants).

quality and quantity. The Oregon Water Resources Department (OWRD) is responsible for administering water access and use through water rights, licenses, and permits, while the Department of Environmental Quality (DEQ) Water Resources Division is responsible for water quality standards. OWRD and DEQ Water Resources Division have different governance statutes from the legislature. According to a DEQ Water Resources Division employee, “Water quality and water quantity do not speak to each other much, because DEQ is not allowed to take into (account) the quantity aspect of water when they do their quality reviews.” Nonetheless, even though they are managed separately, water quality is directly related to water quantity, mainly because low streamflow concentrates pollutants. According to DEQ Water Resources Division, dissolved oxygen and algal growth are two of the most common water quality issues in the state, along with metals and pesticides. Harmful algal blooms are caused by cyanobacteria and can be related to agricultural runoff and water temperature, among other causes. Groundwater quality is at risk from failing septic systems and contaminants from industry and agriculture. Nitrate is one of the most common contaminants found in well water. DEQ Water Resources Division states that the Willamette Basin contains some of the state’s most challenging water quality issues; in their most recent basin assessment agricultural land use is the largest source of pollution in the most disturbed streams (DEQ, 2009). Another state agency, the Oregon Department of Fish and Wildlife (ODFW) is focused on protecting and improving water quality for fish habitat. Beginning in 1991, fifteen of the twenty-three species of salmon and steelhead, as well as eight non-anadromous fish species found in Oregon, have been listed under the federal Endangered Species Act (DEQ,

2020). In addition to pollutants, high water temperature is dangerous for fish, which is influenced by stream velocity, volume, flow, and groundwater inflow (Miller, 2007).

In the wine region of the Willamette Valley, government agency employees and grape farmers spoke about the common practice of subsoil drainage in agriculture fields, vineyards, and orchards. Subsoil drainage (the installation of drain pipes or tiles) removes water from soil that is too wet in the spring to begin farming. Although there are regulations that prohibit drainage of designated wetlands, there are no restrictions on subsoil drainage. Some worry the practice is negatively impacting aquifers by permanently moving water off the landscape, and contributing to water quality problems from increased velocity of runoff flow during rain events.

Willamette Valley Water (Institutional Systems)

Oregon water law is based on the *Prior Appropriation Doctrine*, which is a legal framework whose predecessor was the Mining Act in the western U.S. Prior appropriation has two main tenets: 1) *beneficial use*, which is the basis, measure, and limit of all rights to the use of the water, and 2) *priority-diversion*, which establishes priority dates, also known as “first-in-time/first-in-right.” The water right holder with the earliest priority date is the *senior user*, while those who obtain their right later are *junior users*. In the event that water use is restricted, senior users may use the full amount allowed, while junior users must hold back use. Oregon law requires that water is used at a specified place. Water rights are appurtenant, meaning they legally go along with a property sale unless the seller excepted the water rights from the deed. Oregon water law requires that a water right holder use the water designated or be at risk of losing the water right (Oregon Water Resources Department, 2018).

A complex web of institutions at multiple levels of government is involved in water law and legislation in Oregon. The federal constitution and government treaties pertain to water bodies that share jurisdictional borders (for example the Columbia River Basin, which encompasses land in Canada, Washington State and Oregon. As a water resource manager explained, the federal government also has treaties with sovereign Native American tribal governments dating back to the 1850s. Conflict between tribes and agricultural irrigators over water rights in Oregon continue to the present day, and have been adjudicated in federal courts, most notably in the Klamath Basin in southern Oregon.

The federal government regulates Oregon water through the Clean Water Act, the National Environmental Policy Act, the Endangered Species Act, the Reclamation Act (which regulates reservoirs for water storage), the Safe Drinking Water Act (which does not regulate groundwater wells), and the National Wild & Scenic Rivers Act (2% of Oregon's river miles are designated "wild and scenic" meaning they may not have dams). Federal agencies in charge of these regulations are the Environmental Protection Agency (EPA), the Army Corps of Engineers (USACE), the Bureau of Reclamation (BOR), the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the U.S. Geological Survey and the Bonneville Power Authority. Many other state, regional, and local institutions are in the web of influence over water decisions in Oregon. Municipalities, counties, state agencies, associations, leagues, water utilities, and lobbyists for industry and conservation groups all have varying amounts of influence over water decisions.

The OWRD is responsible for managing the supply of water to users. According to the OWRD, no new surface water rights are available; what water remains available for new uses in Oregon is groundwater, and the story of groundwater is shaping up to be complicated. The geography of Oregon is diverse with different climatic conditions in different parts of the state. Oregon has eighteen drainage basins, with the Cascade Mountain Range as the dominant feature dividing the wetter western part of the state from the drier eastern side. Agriculture accounts for eighty percent of groundwater use in Oregon. As of 2017 there were 17,000 irrigation wells in the state. Prior to 1955 there were no legal protections for groundwater in Oregon, and it wasn't until the 1990s that irrigators with new well water rights had to begin keeping track of how much water they used (Oregon Water Resources Department, 2018). Irrigators with rights established prior to that time period are not required to meter and monitor their water use. After paying for a use permit, which costs around \$2,000, the water is free. Water users would pay for electricity and maintenance for a well, but not for the water itself. Resources for water governance are allocated and spent at the state level. For example, according to the OWRD, only three of the eighteen groundwater drainage basins in Oregon have been fully studied by the state, at a cost of three-to-five million dollars per study, with each taking approximately five years to complete. Due to the lack of resources, groundwater in Oregon is still not fully understood. Some suggest the lack of progress in increasing understanding about groundwater is political in nature, and funding typically is made available only after a crisis has occurred. In 2016, the OWRD received \$555,000 dollars to study groundwater for two years, but the actual amount the department needs to complete a state-wide assessment is forty-five to seventy-five million dollars.

Irrigators can apply for a *Limited License* in order to establish a crop for up to five years in a water limited area, which is currently common practice for grape growers establishing new vineyard plantings. According to the OWRD, applying for a new water right can take five years or more to go through the permitting and certificate process due to an under-resourced department with a backlog. The state regulations also allow for ODFW and DEQ Water Resources Division to review any changes to surface water for potential negative impacts for fish, including instances where groundwater might interact with surface water. A number of exemptions to water rules are also available; for example capturing and reusing rainwater from a roof does not require a permit, which can be useful for irrigators without water rights. The Watermaster's Office, an arm of the OWRD, is responsible for oversight of water regulation in twenty Watermaster Districts. The Watermasters' duties include measuring flow and maintaining gauging stations, collecting groundwater data, and well and dam safety inspections. Watermasters regulate water use when there are shortages and users need to be cut off from supplies, plus they are expected to mediate disputes between water users. These twenty Watermasters are the direct contact for landowners, government agencies, elected officials, and water utility providers (Oregon Water Resources Department, 2018).

Some managers within the department believe they are purposefully put in an under-resourced position because powerful lobbying forces don't want water rights to be scrutinized for fear of possible redistribution. As it currently stands, irrigators will frequently file lawsuits against the state if their water access is cut off. The OWRD employees and lawyers specializing in Oregon water law believe that the future is going to be in water transfers. Water rights will be separated from land ownership, and water

markets will be formed to buy, sell and trade this resource, or as one water manager put it, “Water will be Oregon’s most important commodity.” An agency manager describes the challenge this way: “Unfortunately some of our statutes and some our rules didn’t always think ahead about the fact that there may not always be water available.” Concern is rising about who will have power to make decisions about water going forward. Again, an OWRD manager shared her concerns: “The climate is changing quickly...we try to make it equitable, but the problem is if you have the money you can be the loudest voice, and that’s unfortunate.”

Wine Industry Water Access (Institutional-Ecological Systems)

Access to water as a vineyard or winery owner is determinant on geographical location. In areas with available groundwater, property owners can use 15,000 gallons a day of groundwater for domestic use, which can be compared to 350 gallons a day allowed in the state of Nevada where there are serious water shortages. In addition, up to 5,000 gallons a day can be used for industrial or commercial use. Water use outside of these exempt uses, like irrigation, necessitates a groundwater right permit. According to a water consultant who frequently works with wine industry clients:

What people are doing is applying for new ground water rights. Surface water is generally not available for new uses during the irrigation season [...] if they're wanting to do a winery, a tasting room, then they're getting a groundwater right.

Another way water access varies can depend on access to an irrigation district, for example, Washington County in the north of the Willamette Valley has the Tualatin Valley Irrigation District (TVID). TVID obtains water from a large reservoir, Hagg Lake, that was constructed in the mid-1970s by the U.S. Army Corps of Engineers (USACE).

The reservoir is owned by the federal Bureau of Reclamation (BOR) and managed by the county for drinking water and agricultural irrigation. Landowners can buy in to a reliable water source at an affordable rate. In contrast, in neighboring Yamhill County to the south, very little county-wide irrigation infrastructure exists, making access to reliable irrigation water less common. Although there are a few small irrigation districts in the county, most landowners either hold historic surface water rights, or attempt to obtain groundwater rights. Many of the Willamette Valley wine grape growing areas, including the Chehalem Mountain AVA, Ribbon Ridge AVA, Yamhill-Carlton AVA, and the Eola-Amity Hills AVA, have basalt aquifers with very little available water. One vineyard owner on Ribbon Ridge drilled eleven separate wells on his property without successfully finding a reliable source of water.

Willamette Valley Attitudes About Water (Social-Cultural Systems)

They put in ... a bunch of reservoirs and they started sucking the water out of the ground. And the neighbors complained that their wells started going dry. She says they don't really use groundwater. It's mostly surface water. So I don't really know the truth there, but that is the perception.
--Willamette Valley Viticulturist

Attitudes about water availability among respondents ranged from “not concerned” to “very concerned.” Although the general perception is that Oregon has wet weather, interview participants in the wine industry, academics, politicians, water consultants, water lawyers, and resource agency employees all observed this misconception about the abundance of water in western Oregon. A number of wine industry participants shared that the reality of obtaining a water right was not as straightforward as they would have anticipated. Other interviewees who had moved to Oregon from regions in California where water is scarce were less stymied by the

bureaucratic process, finding it less onerous than their previous experiences. Many participants had concerns about the growing demand for water. Population growth in the Willamette Valley, connected with growth in the Portland Metro region, means municipalities are working to secure access to drinking water that will meet current and future demands. Some in the agriculture sector are concerned about the ability to access adequate amounts of water in the future; while others who hold senior water rights express fears about losing access to water should current laws be restructured. A viticulturist shared his perspective on water access in the Willamette Valley:

It seems like everybody is scared. Water rights are getting more difficult. Or there is more regulation...what I find is there is not availability of information. So you don't know. You don't know how to get a permit (or) what is right and what is wrong.

A winemaker and grape grower who has participated in a number of industry technical committees over the years explained that he has given talks to his peers in the wine industry, emphasizing that water could be a limited resource for the future of their industry and urging them to begin to address the issue now before it is too late. He expressed difficulty in getting people to care. There is a divergence of attitudes within the wine industry; for many it doesn't feel like a pressing issue yet, and for others it is a critical issue that should not be overlooked.

Values about water also vary; to some water is a precious commodity and a finite resource to be intrinsically valued, and they reject the idea that water should be bought and sold. Others believe water should be put to use to grow crops in order to promote and sustain agriculture in the region. One viticulturist expressed his view of the value of water: "It's a waste to let it run down the stream into the ocean." For other farmers, too

much water on their land is a problem and they promote subsurface drainage practices. For many there is an absence of engagement around water at all; as one rural resident put it: “If all of your life, you've turned the faucet and something happened, if you've flushed the handle and it all went away... life is good.” Her farm is located in a groundwater deficient area that is experiencing a large amount of vineyard plantings on neighboring properties. A number of these properties are owned by foreign and out-of-state investors from South Africa and California, and her concern is that the new ownership doesn't understand the finite nature of water. She describes her upbringing on the farm:

Growing up here, there is a little spring which supported (our) household...and in the summer it went dry. Which meant Dad would go someplace, fill a couple of old milk cans with water and flush the toilets twice a day. We were sent to the neighbors for bathing, and Mom hauled the laundry into town and used the laundromat. And until you don't have it, you have no idea how valuable water is.

A manager at the OWRD framed the different attitudes about water availability this way: “I find that people, until they are right on the precipice of dire straits, don't tend to act proactively.”

Wine Industry Specific. Wine industry attitudes about water fall roughly into four camps. It is important to note that these groupings of philosophies and approaches are not fixed, and the practices of a number of producers span the boundaries of these farming approaches.

1) On one end of the continuum are producers who are deeply concerned about promoting and sustaining ecosystem health through their farming practices. These producers followed practices of regenerative viticulture (Rhodes, 2017), or organic and biodynamic approaches. These practices can include planting cover crops, using compost,

forgoing tilling, restoring habitat, and abstaining from using synthetic chemicals in an effort to build healthy soils and watersheds. The regenerative viticulture approach also considered that economic sustainability did not depend on continuous business growth, but rather in finding approaches to farming, labor, and business that supported both ecological system and human health outcomes.

2) Some in the industry choose their farming and winemaking methods based solely on their ideas about making high quality wine. These farming practices can include choosing not to irrigate, “dropping fruit” (meaning removing some clusters of grapes from vines before they mature to help improve the quality of the remaining grapes), hand picking the crop, and using native yeast instead of commercially purchased yeast for the fermentation process. Philosophy influences these choices, but so does economics. It is more expensive to produce wine this way, but the wine can often be sold at high price points.

3) There is a large contingent of producers who farm conventionally. This third approach to farming can include tilling between rows to reduce weed pressure, watering plants when necessary, using synthetic fertilizers, pesticides, and fungicides when necessary, and using commercial yeasts.

4) The fourth camp is most concerned with efficiencies and higher yields. To achieve this outcome, these farmers may opt to use irrigation to increase fruit production, machine harvest their crops, and employ technologies in the cellar for increased water and energy efficiency. Efficiencies and economies of scale allow these producers to market more wine at a cheaper price. Although over-generalized, there is the assumption that small scale producers lean toward the “high quality” approach and that the larger

producers, many with ownership outside the region, opt for the “high efficiency” approach.

Willamette Valley Attitudes About Irrigation (Social-Cultural Systems)

Attitudes and approaches to irrigation in the wine industry in the Willamette Valley are changing as the industry itself changes. These different approaches and philosophies have been fiercely debated; as one winemaker put it: “It has been a bone of playful contention between camps of winemakers.” Historically, growers in the Willamette Valley did not irrigate their vineyards, only hand watering for the first year or two for vine establishment. Although a number of factors influence the decision to irrigate, cultural practices are a strong influence. California producers have irrigated for decades, so when coming north to establish vineyards in the Willamette Valley the installation of an irrigation system is just a normal part of the process for them. In some cases, interviewees reference climate change projections of drier, hotter summers as factors in deciding to install permanent irrigation. Other producers do not believe *Vitis vinifera* (wine grape vines) should be grown in the region if you have to irrigate. A number of these like-minded producers have formed an organized group called the Deep Roots Coalition, where members commit to not irrigating. Described by a member:

This is a group of producers that's committed to *terroir* in the wines, but there's also this environmental thing. And the water stuff is real and we're really up against it. The reality of that is really, really profound, which is kind of scary. And I know it's going to change everything.

Members of the group shared their concern that some owners of currently dry-farmed vineyards are talking about retrofitting their properties for irrigation. Once this shift begins to take hold, a number of Willamette Valley grape growers expressed their belief

that it will be difficult to ever walk it back or reverse the trend in the future. Producers use the California wine industry as an example:

So you've got sugar production, so you can hang more fruit, so you can be more profitable. And then next thing you know, there's a whole industry built around irrigation. There's all the materials, the pipes, and once you go down that road?...The inertia sets in for irrigation when it wasn't really even necessary. Even went so far as to develop a rootstock that stayed close to the surface. So it was actually designed to grow laterally instead of vertically, which is really kind of insidious if you really think about the meaning of wine and how that totally obliterates the idea of terroir.
– Willamette Valley Winemaker

Others reject the belief that irrigation is negative for wine industry outcomes, and believe it might even be necessary given current and future challenges:

There are some people with a philosophy. Which is great, but based on no really scientific truth. And they don't have water, because they decided to not make the investment. So they say that not irrigating your vines is the right thing to do. I disagree, but that's my personal philosophy. I'm not going to fight philosophies. - Willamette Valley Viticulturist

Newcomers to the Willamette Valley from California are already moving forward with installing irrigation systems, which illustrates the potential shift from dry-farming to irrigation in the coming decades:

It seems to be the type of question people don't ask in Oregon. For us in our experience it's one of the first questions that we ask when we are looking at a vineyard or a property, is where's the water coming from? What's the price and where is the water coming from? We are thinking decades ahead. The amount of money we are investing out here, we are not going to see a dollar of that for seven or eight years, which we are used to when it's part of our business plan. But you do have to be very thoughtful in your decision-making process. You can't rush into anything. And that's where the water discussion has come from for us here. I don't really care about today. It's twenty years from now that I want to be prepared for. Which maybe we'll need it later or maybe we won't. We don't know. Maybe we'll have a nice beautiful reservoir that's great for fishing, but we never use the water at all.
-- Willamette Valley Viticulturist working with Californian Owners

4.5 Analysis and Conclusion

In this chapter I presented background information and research findings related to how water governance in the Willamette Valley creates opportunities and barriers to wine industry climate change adaptation. This research confirmed my assumption that water demand will continue to increase while water availability will decline, due to an increase in consumption from the growing wine industry, regional populations, other industries, and tourism; combined with climate change impacts. On a regional level in the context of climate change and water, scarcity relates to the amount of water in the system of rivers and streams, but it also relates to social and institutional systems. Access to water rights, the cost of irrigation, infrastructure, and regulatory flows all are connected to water availability. So water scarcity can come from a change in climate and hydrology, as well as from human actions. Scarcity arises when demand increases while available quantities diminish. Communities of people are often making choices about water in response to institutional directives (Jaeger et al., 2013). With climate projections for hotter, drier growing seasons and less winter snowpack, the external driver of climate change will impact regional ecological systems, but will increasingly be a community risk management problem as well (Amos, 2007).

In the Willamette Valley water governance is a top-down structure, where federal legislation and mandates along with state legislation, is managed and overseen by state-level government agencies, primarily the Oregon Water Resources Department and the Water Resources Division of the Oregon Department of Environmental Quality. The top-down structure does allow for consideration of the “big-picture” of all water stakeholder needs, but also results in lack of community participation in decision making which could

exist in an alternative management model such as common pool resources (Cavalcanti et al., 2010; Ostrom, 1990). The state agencies lack human and financial resources, which some interview participants purported is intentional because it benefits certain groups, for example senior water rights holders. Inadequate resources results in a lack of oversight to monitor and enforce regulations, as well as stymying scientific inquiries that lead to a greater understanding of water availability, especially groundwater in the case of the Willamette Valley.

In the Willamette Valley entrenched legal regimes (Arnold, 2014), like the prior appropriation doctrine, have resulted in an unevenness of who can access water resources. Senior water rights holders have little incentive to redistribute their long held ability to use water, which poses challenges for holders of junior water rights. The Willamette Valley wine industry exists within a context of a community and region where water resources are shared by numerous stakeholders. Future conflict can arise as water needs increase for these stakeholders, including municipalities, industry, agriculture, recreation, and environmental flows. This combination of entrenched legal regimes and an increase in water demand will likely result in a future of water rights shifting to a commodity market system. Many interview participants, including those working for the OWRD, see a future in Oregon where water rights are decoupled from land ownership and there is an increase in the buying, selling, or trading of water rights and use permits. This raises concerns about disenfranchisement of those with less financial means; this shift to water markets could exclude these stakeholders from water access (Strang, 2016).

In the context of addressing current challenges around water resources in the Willamette Valley, as well as future projections for a growing demand for water in the context of a more variable and uncertain water supply, wine regions will have to continue to adapt. The research revealed that those within the wine industry in the Willamette Valley have a range of attitudes and approaches to water resource and climate change planning and management; some producers didn't consider it an issue in the region, while others discussed that water access and climate were major deciding factors about investing in particular vineyard sites. The research also highlighted that there are a variety of climate adaptation approaches around water, which fall into four main categories: 1) increase water use, 2) reduce water dependency, 3) mitigation, and 4) engage in institutional change. Each of these adaptation approaches are connected to ISED framework systems. For example, "increasing water use" is connected to social values, such as choosing to irrigate for higher grape production; ecological necessity like frost mitigation; and institutional systems pertaining to the ability to procure a permit to use water.

These adaptation approaches are dependent on economic resources and/or social values related to sustainable farming, winemaking, and hospitality operations. The trend of outside investment and corporate consolidation in the Willamette Valley in recent years may be creating a faction in the wine industry that will be better resourced to adapt to water challenges that arise as part of climate change. I had assumed the businesses most likely to plan long-term for future water-related climate challenges were those who were relocating to Oregon from outside areas. Businesses that largely had bigger, more corporate management structures than the majority of small-scale operations historically

making up the wine industry in the Willamette Valley. The research data did confirm that due to greater access to resources, these larger businesses will have the ability to adapt to climate change challenges by being able to invest in infrastructure, potentially buying water through future water markets, and investing in technological approaches to conservation in farming and cellar operations.

A number of interview participants expressed a need to increase thinking and planning across institutional, social, and ecological systems. One viticulturist spoke of the interconnectedness of watersheds and hydrologic systems in regions where agriculture is an integral part of these systems, and institutions and individuals have the opportunity “to harm or to help.” Another winery owner and viticulturist called her community to action to improve ecosystem and watershed health, and to consider regional planning in agricultural landscapes:

It's going to hopefully dawn on people that watersheds are real. What happens in that watershed, in the soil, directly affects the quality and quantity and access to water in that watershed. Everything that we do locally affects something more systemic. And we've got to start landscape level planning for this kind of thing, because we could be storing so much more water. Agriculture has to be a part of that. If it is just a straight up acres to acres thing...we've got the vast majority of the landscape under agriculture. So there could be a tremendous effort made to increase (water) access, increase quality, increase flow, that's where that conversation is going to have to go.

In the next chapter, I introduce and present findings for the second case study wine region in Tasmania, Australia. Mirroring the format of this chapter, I use Arnold's (2014) ISED framework to examine the institutional, social, and ecological systems in a real-world example.

Chapter 5. Case 2-- Tasmania, Australia

5.1 Introduction

In this chapter I introduce and present findings for the case study of the wine region Tasmania in Australia. Similar to Chapter 4, I use Arnold's (2014) ISED framework to examine the institutional, social, and ecological systems in a real-world example; organizing the themes (codes) from the key knowledge holder interview data into the three ISED systems, and present background information and findings in three main sub-sections: 1) Introduction to Tasmania, 2) Tasmania and Climate Change, and 3) Water and Tasmania. Matching the analysis process in Chapter 4, the sub-sections also include information sourced from policy documents, government agency publications, and academic research. The "Introduction to Tasmania" sub-section provides background information including the history, demographics, geography, and wine industry trends in the region; while also examining the political and economic contexts of the region related to water resources and the wine industry. Interview responses from key knowledge holders about political will, water resources, power and influence, and government-business enterprises informed the understanding of the political context regarding water and climate change in Tasmania. Main themes emerging from the Tasmanian political context include: water is deemed a commodity managed by economic market forces; the transfer of control of water to private management; and concerns about trust and transparency between local communities and top-down government agencies. The economic context of water, climate change, and the wine industry in Tasmania was derived from interview responses related to themes (codes) about economics, power and

influence, decision making, and the wine industry. These themes highlight the commodification of water driving wine industry growth through increased irrigation capacity due to irrigation scheme development, while also examining the water access disparity between large corporate wine industry owners and smaller, less-resourced producers. The second sub-section, “Tasmania and Climate Change,” considers future climate change projections on the island, including results from models of future scenarios for temperature and precipitation. In addition, this sub-section more closely examines climate change considerations specific to the Tasmanian wine industry, as well as attitudes and perceptions among interview participants regarding climate futures. Finally, the sub-section “Water and Tasmania” provides background information about the history of water access and legislation on the island, as well as current governance structures for allocating water rights and use, water quality considerations, and the ways the wine industry is likely to access water in the various sub-regions on the island. This sub-section draws from key informant interview data around attitudes and perceptions to water, where findings highlight trends such as: irrigation is critically important for economic growth on the island; issues regarding who can access water through irrigation schemes; and the focus on two main stakeholders when it comes to water-- the economy and the environment. The main findings that emerge from the synthesis and analysis of the research data using the ISED framework are: 1) climate change will result in challenges around water resources in Tasmania, but changes will differ depending on geographical location on the island; 2) current water governance in the region is a top-down structure that includes federal and state funding and mandates; 3) water is valued as a commodity that can increase economic growth on the island, which has resulted in the

intensification of irrigation scheme development; 4) lack of government resources and a political focus on economic growth has transitioned water management to a neoliberal, for-profit, government-business enterprise model; 5) climate and reputation are contributing to an influx of wine industry investment from larger companies on the mainland of Australia; and 6) those within the wine industry have a range of attitudes and approaches to climate change planning and management, but the importance of water is undisputed.

5.2 Introduction to Tasmania

History, Demographics and Geography

Tasmania is a small island state one hundred and fifty miles south across the Bass Strait from the mainland of Australia (Figure 9). It has a small population of half a million residents and an isolated location (Australian Bureau of Statistics, 2016). Nearly half of the island is natural protected areas including national parks and World Heritage Sites (Tasmania Parks and Wildlife Service, 2013). A large part of the island's population, over 40%, lives in the greater Hobart area in the south of the island, which is also the state capital (Australian Government, 2017). Prior to British colonization in the early 1800s, the island was inhabited by Aboriginals for over 40,000 years. The British permanently settled on the island and established a number of penal colonies. The Aboriginal population was nearly eliminated within thirty years of colonization by the spread of infectious disease and violence, named a genocide by historians (Boyce, 2010; Clements, 2013; Ryan, 2012). Today the population of Tasmania is the most ethnically homogenous in Australia, with the majority of its residents having British descent (Encyclopedia Britannica, 2017). A large portion of the population is over retirement age,

and approximately a third of Tasmanians are reliant on government support for their income (Australian Government Department of Social Services, 2017). Historically, the main industries of Tasmania were mining, forestry, and other resource extraction, in addition to agriculture and fisheries. These industries have been in decline in recent years, and the service sector is growing (Encyclopedia Britannica, 2017). Tourism is on the rise in Tasmania, with 1.19 million visitors in 2016 (Tourism Tasmania, 2017). Tasmania is home to a number of unique animals like wallabies, ringtail possums, Tasmanian devils, wombats, platypuses, and echidna (Encyclopedia Britannica, 2017).

Tasmania is a mountainous island, with high mountains in the west, and a series of parallel northwest-southeast ridges and valleys and plateaus that slope gently southeastward. There are two large river systems on the island, the Derwent in the southeast and the South Esk in the northeast. The Central Plateau has more than four thousand lakes, with a landscape similar to northern Canada or Finland. Soils in the west are acidic, poorly drained, and low in fertility. There are fertile areas in the northwest, northeast, and southeast of the island, with alluvial soils in the drainages. Most of the population lives on the east side of the island, as the west is largely a protected natural area (Encyclopedia Britannica, 2017). The soils of the wine regions vary greatly from north to south. The Derwent Valley in the south has sandstone and schist; further northeast in the Coal River Valley there are peaty alluvial and sandy soils. To the north in the Tamar Valley, the soil is gravelly basalt on a clay and limestone base (Wine Australia, 2017).

Figure 9. Tasmanian Wine Regions (Wine Tasmania, 2020).

Tasmanian Wine Industry Trends

As of 2020, Tasmania had one hundred and sixty wine producers and approximately two hundred and thirty vineyards, planted on nearly five thousand acres. Commercial production of wine on the island began in the 1950s (Wine Tasmania, 2020). Tasmania is located between forty-one and forty-five degrees south in latitude, similar to the locations of the Willamette Valley and Burgundy, France in the northern hemisphere. The island is still considered a young wine region compared to larger regions in South Australia, Western Australia, and New South Wales (Winetitles, 2010). Tasmania is a very small region, producing less than 0.5 percent of Australia's national wine grape production, although Tasmania has been experiencing strong growth and vineyard

expansion in recent years (Winetitles, 2010). The growth of the industry from 2013-2017 resulted in twenty-five percent more vineyard plantings (Wine Tasmania, 2017). Increased consumer demand for cool climate grape varieties like Pinot noir and a growing awareness of Tasmanian wines have positioned the region to be a premium wine producer. Values of Tasmanian wine grapes are at least four times the national average, with bottles retailing over thirty Australian dollars (Winemakers Federation of Australia, 2013). While the majority of mainland wine producers have had issues with oversupply and declines in returns on investment in exports in recent years, Tasmanian wine has had returns 2.5 times higher than the Australian average (Lewis et al., 2015). Most producers in Tasmania sell their wine through cellar doors (tasting rooms) and directly to restaurants. A small number of wineries sell to the mainland, and even fewer export internationally. The state of Tasmania is legally classified as one region for geographical origin indication purposes. The wine sub-regions on the island are concentrated in the central and eastern areas with less rugged terrain than the west (Figure 6) (Lewis and Grimmer, 2015). The wine sector employs approximately 1,400 full time equivalent positions and attracted nearly 250,000 visitors to its cellar doors in 2016, approximately twenty percent of all of the island's visitors. Along with vineyard and winery expansion, there has been growth in new business in packaging, bottling, restaurants, and tourism infrastructure (Wine Tasmania, 2017).

Tasmania-- Political Context (Institutional-Social Systems)

Tasmania is a state in the Australian federation, and is governed by elected members of four main political parties: Labor, Liberal, Greens and Independent (Tasmanian Electoral Commission, 2020). The residents of Tasmania are represented in

the federal parliament by senators and representatives. In addition to the state government, Tasmania has twenty-nine local government areas responsible for land planning, waste management, and infrastructure (Davies, 2010). Both state and local governments use the system of multi-seat proportional representation through elections with ranked voting (Encyclopedia Britannica, 2017). Tasmania has had ongoing citizen debate and conflict over natural resource extraction, like mining and logging, as well as dam construction for hydro-electric power (Davies, 2010). Along the spectrum of opinions about politics in Tasmania, a number of interview participants spoke of distrust in the political process, with concerns about poor transparency and a lack of public participation in government decision-making; while conversely, others felt that due to the small size of the population there was ample opportunity for individuals to personally influence their local and state politicians. One example is local farmers coming together to agitate and lobby for new irrigation schemes. A number of participants, including those working for larger companies, reported that they have an easy time working with agencies and regulators. Industry groups, such as the Tasmanian Farmers and Graziers Association, Wine Tasmania, Tas Agriculture and Tas Dairy sit on water planning committees and are involved in the process of developing water management plans. Outside observers and those within government agencies highlight how priorities and resources can shift depending on who is in power politically. According to agency employees, this has resulted in a shrinking budget and less staff for the state level Tasmanian Climate Change office in recent years when the Liberal Party had control. A shortage of resources at DPIPW has slowed the progress of watershed assessments in the forty-eight catchments on the island, which is required by the state water legislation.

From within the government agency there was a hope that industry could take “as much lead as the government” or that “they lead before the government is forced to regulate” when it comes to environmental issues. An employee of the government water agency explained current political priorities under a Liberal Party government, and raised questions about the future of economic and industry growth within the Tasmanian water context:

It is complicated, but look there is definitely political will I think in Tassie. There has been a strong economic driver in terms of growing the value of agriculture tenfold by 2050, it's one of the key policies. But I think that is hand in hand in terms of a water strategy and sustainability. A key outcome of the last election was for a rural water use strategy. So we are working on developing that rural water use strategy, which is a bit of a future looking approach given all of the changes in terms of what a governance role is, as well as other stakeholders. How are we going to adapt and be ready for what is happening very quickly in terms of dealing with climate change? Dealing with growth and value? Are we reaching limits of further extractive water use, therefore that growth and value is going to have to be driven by other means?

Tasmania-- Economic Context of Water and Wine (Institutional-Social Systems)

The growth of the Tasmanian wine industry is connected to outside investment and climate change considerations, but it is also influenced by the high value of wine grapes on the island. The economic imperative is there to transition agricultural land into higher value crops like grapevines, and the ability to transition is reliant on access to water. Vineyard proximity to irrigation schemes has become very valuable. One winery owner discussed his recent decision to purchase more vineyard land:

Water...seasons don't seem to be getting wetter, they seem to be getting drier, and water security in Australia in general-- and Tasmania is not exempt from that-- is a very important thing. Security of water. We purchased a property up the road about 20 kilometers and part of the value of that property is its 100 megaliter water rights, which came with the

land. Without that water right it would be almost worthless to us, so it adds huge value to the land.

Government agencies assist the wine industry in expanding through enterprise mapping projects, where soil types, irrigation schemes, and climate change projections can be mapped, overlaid, and assessed for suitable grape growing parcels. Access to capital has a big influence on who can invest in land with water rights, water infrastructure, and develop new vineyards in prime water locations. As in Oregon, consolidation and outside investment is a trend in the Tasmanian wine industry. The “Race to Tassie” continues with large corporations and investment groups moving into Tasmania including big names like Treasury Wine Estates, Brown Family Wine Group, Yalumba, Accolade Wines, Hill Smith, Fogarty Wine Group, and Kreglinger. These larger companies have the resources to invest in irrigation schemes, pay for water infrastructure, and buy water on the water market if necessary. Access to these financial resources is not always possible for small producers. One outcome of outside corporate investment is the shift to commodity wine grapes. It can make more financial sense for larger companies to grow the grapes in Tasmania, press the juice, and then ship it in tanker trucks on the ferry to the mainland to be made into wine at their existing facilities. This trend shifts Tasmanian wine away from its traditional identity as a locally made product most often sold on the island to local consumers and visitors. The irrigation schemes have placed a monetary value on water, where if one chooses to irrigate, one must pay for the asset. This is a shift for many Tasmanian farmers, who previously paid nothing for water. Many interviewees anticipate the cost of water will rise as costs to maintain infrastructure persist.

5.3 Tasmania and Climate Change

You hear about drought and you think Western Queensland, Western New South Wales, but the east coast farmers in Tassie are now in drought and crying out. And they want the same level of support that the rest of the country does and so forth. It's just different... there is a blind spot. So, number one, we think we have bountiful water but we don't. Number two, we think our water is pristine and clean, but it is actually not. So the Derwent River, it is one of the most polluted rivers from a heavy metals perspective in the world.

-- Tasmanian Conservationist

Climate change increases the likelihood of severe, inescapable, and irreversible impacts for people and ecological systems (Jimenez, 2014). Outcomes for ecological systems are linked to risk, vulnerability, and adaptive capacity in the Tasmanian wine regions. A number of factors can make wine regions vulnerable to negative impacts of climate change (see Table 1 in Chapter 2). This section provides published scientific research on projected future climate changes in Tasmania, specific considerations for the Tasmanian wine industry regarding climate change, and attitudes about climate change that emerged from the interview data.

Climate Change Projections

We base our allocation policies around...the 'dry climate' future scenario, and across Tasmania ... projections of future scenarios. I think we are really seeing those changes. We are really well on our way to meeting those drying projections, and even exceeding them in some catchments. I think there's certainly, internally and across water planning, we are hearing a need for those projections to be updated already. A couple of years ago we had probably record floods, that was within six months of a period of record drought. So it's the variation that people are struggling to adapt to and the changes in what were considered to be fairly reliable rainfalls.

-- Water Resource Manager, Tasmania

Temperature. All areas of Australia are experiencing hotter than average temperatures, hotter summers with longer heatwaves, changes in the intensity of rainfall, and more

frequent bushfires (Lereboullet et al. 2013). The projections show that climate change is going to become progressively more significant than natural variability in weather, with strong warming trends that accelerate towards the end of the century (Harris et. al 2020). In 2010, the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC) at the University of Tasmania modeled climate futures for the island, providing fine-scale climate projections using downscaled climate models based on a high greenhouse gas (GHG) emissions scenario and a low emissions scenario. Climate information was generated from 1961 to 2100. The historical data shows that the average temperature in Tasmania has increased by more than 0.5°C since 1950, and this was typically an increase in nighttime temperatures. By 2100, temperatures are projected to increase by 1.6°- 2.9°C depending on GHG emissions levels. The highest temperatures are likely to happen in the northeast and interior of the island. Heat waves and multiple days with high temperatures are projected to increase (Figure 10). Spring and autumn months have large projected increases greater than 4°C (Grose et al., 2010). Heatwaves are anticipated to occur four times more frequently than current conditions (White et al., 2010). Bushfires are a historic and current occurrence in Tasmania, and according to an ACE CRC report, it is expected that fire danger will roughly double over twice the area of land by the end of the century (Fox–Hughes et al., 2015).

Figure 10. Increase in frequency of heat waves throughout the century (ACE CRC, 2010).

Precipitation. Total annual rainfall is not projected to change under high or low GHG emissions scenarios by 2100, but rainfall patterns from season to season are anticipated to change significantly (Figure 11) (ACE CRC, 2010). Surface water flow is projected to decrease significantly in the central highlands which can have impacts on localized water catchments, and impacts on hydro-electric generation capacity. Due to changes in future precipitation some agricultural regions in the interior Midlands and Derwent Valley (north of the main city of Hobart) may receive more surface water flow (Bennett et al., 2010). Frequency and severity of extreme weather events is anticipated to increase, with the intensity of rainfall heightening flood risk. Coastal communities will experience more frequent storm surges and sea level rise (Antarctic Climate and Ecosystems Cooperative Research Centre, 2010).

Figure 11. Extreme rainfall events will happen more frequently by the end of the century (ACE CRC, 2010).

Climate Change and the Tasmanian Wine Industry

Most producers in Tasmania currently irrigate their wine grape crops. While there is not a prediction for less rainfall on the island with future climate scenarios, there will be differences in intensity and timing which can increase uncertainty about water reliability for summer irrigation. Drought projections and water supply are concerns in the region. With shifts in when rain events occur, there can be challenges around negative impacts to crops with the new arrival of summer rains. Disease pressure from summer precipitation is ranked as a high risk in the wetter regions (Harris et al., 2020). In a wine region historically known for a short growing season, where it can be challenging to fully ripen the grape crop in a cool year, there is some hope that warming trends will have a positive impact with a potential for a longer growing season (Harris et al., 2020). On the other hand, grape growers express concern about warmer winter temperatures resulting in earlier bud-break on the vines, making them more susceptible to spring frost. The frequent occurrence of bush fires and resulting smoke taint impacting the grape crop is

also a serious concern on the island. A Tasmanian winemaker said that prescribed burns are done in and adjacent to wine regions on the island to limit the severity of bushfires, and the timing of these burns historically has conflicted with the timing of grape growing season.

Wine industry interview participants and the Australian media highlight that outside investment in the Tasmanian wine industry is going to continue to contribute to its growth. A number of larger companies on the mainland of Australia have invested in vineyard land and existing wineries in Tasmania. These companies are experiencing hotter and drier conditions in their current mainland locations and in anticipation that trends will accelerate with climate change, companies with resources invest in Tasmania. All the research shows that climate change impacts will happen on the island too, but by comparison they could be less disastrous than in other Australian wine regions.

Attitudes About Climate Change (Social-Cultural Systems)

Climate change is pretty well accepted in the state agencies as something that is happening and requires planning. As an island state with many coastal towns and cities, sea level rise is a concern, but also the impacts of weather variability and long term changes in climate on agriculture. According to some, social buy-in regarding climate change is not “there yet.” Within the wine industry the general observations range from “climate change is massive and no one is paying attention,” to larger wine companies purposefully coming to Tasmania to invest in a region with a cooler climate than the mainland as a reaction to climate change. Climate change considerations vary based on scale as well. As a small industry, with many independent operators, many winery and vineyard owners don’t have the time or infrastructure for long range planning. As one

small producer put it: “it’s happening but I don’t have the time to think about it right now. I’ve got to spray the vineyard and sell the wine in the same freakin’ day.” For the larger producers, some have the resources to plan for the long term. For example, one large company based in Victoria, Australia bought a number of vineyards on the island, which started a trend the press coined the “Race for Tassie.” Large companies with holdings in regions with high risk from heat, drought, and bushfire have decided the cooler climate in this state is a good long term investment. The head viticulturist from one of these companies explained his company’s considerations:

So as a business, we take a very long term view. The board is certainly very accepting of climate change scenarios, and they have all their decision making around capital expenditure. And that was part of their rationale behind coming to Tasmania in the first instance. Of course there was commercial opportunity, but we were looking to expand and we had climate change as a lens through which the decision was being made.

Similar to Oregon, wine grape producers are also concerned with how climate change may change the style of their wines. One winemaker believes the time for action is now and has already secured grape contracts from growers with the coolest sites she can find. She questioned whether the Tasmanian wine industry still wants to be known for the cool climate styles of wine for which they have built a reputation, and if so, then new locations on south facing slopes, different vine clones, and different vine rootstocks will be necessary. She explains:

Rootstocks can shift your maturity, they can delay ripening, they can shift your water uptake and your ability to survive in low water situations. So maybe there are solutions when we are looking at new regions that are low water.

Recognizing an industry need, both government and institutional bodies have engaged in Tasmania-specific climate research, including Wine Australia, the industry group funded

by producers and the federal government, investing in regional-scaled climate modeling and interviews with local grape farmers and winemakers. A multi-year study was conducted by the Climate Futures research group at the University of Tasmania produced a “Climate Atlas,” which is an online tool for producers that shows climate change projections for the grape growing sub-regions on the island and identifies “pathways to adaptation” (Harris et al., 2020).

5.4 Water and Tasmania³

In this section I introduce the story of water, institutions, and social systems in the Tasmania; including the quality and quantity of current water resources, Tasmanian water legislation, government oversight, how those in the wine industry access water, and attitudes about water and irrigation.

Current Water Resources

Tasmania contains twelve percent of Australia’s freshwater resources across only 0.85% of Australia’s land area. Forty percent of the state, mainly in the west, is designated protected public land, but much of the valuable freshwater resource on the island is unprotected on private land in the interior and east (Landcare, 2020). The Environmental Protection Authority (EPA) is the state agency responsible for setting water quality objectives for Tasmania based on the state Water Quality Management (1997) legislation. Similar to Oregon, a separate state agency is tasked with managing water quantity; in Tasmania this is the Department of Primary Industries, Parks, Water and Environment (DPIPWE). One state agency manager observed that once the

³ Information in this section is from detailed explanations in interviews with Tasmanian state agency staff and University of Tasmania water resource researchers.

responsibility of drinking water management changed from smaller regional water districts to a statewide entity, TasWater, in 2013, the approach to managing pollution has shifted from a “whole-catchment” emphasis to more of an engineering approach, where they “try to solve the problem at the plant, rather than throughout the catchment.”

In an interview, a government-business enterprise biologist and an operations manager brought up the emergent trend of the intensification of industry in Tasmania, which has led to negative water quality impacts; they referred especially to the aquaculture industry. In addition, Tasmania has experienced a large amount of federal and state investment in recent decades for irrigation infrastructure on private agricultural land, thus increasing opportunities for more water-intensive farming and resulting in an increase in nutrient concentrations and algal blooms. In 2018 the Tasmanian State Legislative Council conducted a formal review in response to citizen concerns about another government-business enterprise, Tasmanian Irrigation, which is responsible for constructing and managing irrigation schemes on the island. During the review, a representative from the Anglers Alliance Tasmania shared a complaint about the decline in water quality with the increase in agriculture. A water manager at DPIPWE connected the mismatch of the water legislation in Tasmania in regards to water quantity and development with ecological outcomes:

Another issue in Tassie, in terms of the impact on rivers, is that the water legislation deals just quantitatively with water (while) a lot of the water access is managed in most catchments. The impacts of land use change and diffuse impacts on water quality in particular are potentially not dealt with through water planning. While we are implementing sustainable water access, we still see the condition of rivers across the state declining.

Another water quality concern in drier areas of Tasmania is salinity in soil and water. Climate change and land management practices impact salinity. Currently, approximately thirty percent of the state has conditions where evaporation exceeds rainfall in most months. Instead of being washed out, incoming salt in rainfall accumulates in the soil, groundwater, or bedrock below. Poorly managed irrigation, construction of dams, land cover change, and recycling effluent water can all increase salinity (DPIPWE, 2007).

Many interview participants in government, conservation, and viticulture observed that Tasmania has had a decline in water availability in recent years. Water use restrictions are becoming a common experience in Tasmania in the summer months, with certain regions like the east coast particularly hard hit by a multi-year drought.

Tasmania Water (Institutional Systems)

At the time of federation, the states in Australia retained control of their water resources. In the mid-1990s the Council of Australian Governments (COAG) which is comprised of the Premiers of all the states, the federal Prime Minister and the Chief Ministers of the territories, came up with a series of reforms aimed at efficient water delivery. Water flows across jurisdictional boundaries on the mainland, and in the 2000s the combination of drought and overconsumption of water for agriculture uses in the Murray-Darling Basin resulted in dire environmental and economic impacts in multiple states. The federal government at the time, potentially with ambitions to have more influence over the states, formed the National Water Initiative (NWI) which established the National Water Commission (NWC) as an independent federal statutory body (Australian Department of Agriculture, Water, and the Environment, 2020). As one

interviewee described the only way the federal government can influence or interfere with state water is: “one: throw buckets of money at it, or two: regulate for endangered species.” In this case the federal government went with the former. Using the two billion dollars in profits from the privatization and sale of the government telecommunications company, the “Australian Government Water Fund” was created. The fund gave money to the states for water management. The NWI focused on water as an economic imperative and had the goal of establishing water markets in order to allow for water to “flow” to its highest value use. Markets meant water was tradeable and separate from land ownership. In order to get the federal money, states were required to assign water rights, monitor water use, and invest in irrigation infrastructure. Academic and government agency interview participants described that prior to the NWI, water rights were less structured in Tasmania. Even though the state government had passed water legislation in 1999 with the Water Management Act (WMA), which regulates the taking of water for specific uses and sets fees for water licenses, as recently as 2005 water was unmetered on the island (Tasmanian Legislation, 2020). In accordance with the NWI, DPIPWE is required to complete water resource assessments and management plans for the forty-eight catchments on the island. According to DPIPWE managers, only a handful have been completed to date, and therefore most regions have yet to implement metering or monitoring. Some within DPIPWE have concerns that water was hugely over-allocated during the process of assigning new rights. Under the WMA decisions about water resources are managed by non-governmental “water entities” including local councils or private companies or trusts, which are formed based on geographic location on the island. In order to use water, including storing water in a reservoir, an individual or company

must obtain a *water license*, which specifies the location allowed for taking water. One also must obtain a *water allocation*, which is the amount of water a licensee can take during a given time period. If a property fronts a river or stream the owners automatically have *riparian rights* which enables unlimited water take for domestic use without a license; however, all irrigation water requires a license and an allocation. Both water licenses and allocations can be transferred to someone else temporarily or permanently with approval by DPIPWE (DPIPWE, 2020).

For much of its history, Tasmania has had a small population, and water was considered plentiful enough. Farmers could take water from a nearby waterway or capture and store it in small reservoirs on their farms during rain events. Groundwater is not extensively used in irrigation in Tasmania, partially due to high variability in water yield and quality. DPIPWE estimates that less than five percent of groundwater is in use (DPIPWE, 2020). According to academic researchers, farming regions on the island historically had local irrigation collectives, which would form to share the cost of building and maintaining a dam between a few neighboring farms. At the end of the 1920s the first hydro-electric dams were constructed in the wetter, more mountainous west side of the island. The Hydro-Electric Corporation became the first water regulator in the state and eventually they held all water rights upstream of the dams, which is a significant portion of all the freshwater in Tasmania. Large investments have gone into shifting water management from local control to state institutions. The major state institutions are TasWater, Tasmanian Irrigation (TI), Hydro Tasmania, and DPIPWE. TasWater is largely responsible for all drinking water and wastewater management, but also plays a role in irrigation. TasWater is jointly owned by the regional councils and the

state government (TasWater, 2020). TI is a government-business enterprise, which is a hybrid of a private, for-profit company and a government institution. TI often negotiates water leases from Hydro Tasmania. TI also works directly with farmers to design, build, and maintain irrigation schemes in various regions around the eastern side of the island (Tasmanian Irrigation, 2020). One result is that a large amount of water is moved from the wetter parts of the island to the drier areas, which has significantly altered the agricultural landscape. Farmers, agency managers, and academics agree that the irrigation schemes have resulted in the planting of more water intensive crops, including wine grapes. In Tasmania, as in most of Australia, nearly all of the vineyards are irrigated during the growing season. To date, irrigation investments have been significant with a big emphasis on increasing production and growing the economy of Tasmania. A key policy on the island is to grow the value of agriculture tenfold by 2050, and that aligns with the goal that the capacity of TI will double in ten years (DPIPWE, 2020). Currently there is water trading in Tasmania at the local and regional scale within a basin or irrigation scheme, but nothing formalized at the state level. Some in DPIPWE are eager to increase the capacity of water markets because with growing populations and agricultural expansion, the demand for water is also growing.

Wine Industry Water Access (Institutional-Ecological Systems)

Access to freshwater is dependent on geographical location in Tasmania, where significant differences are found in the wine subregions around the island. In a number of areas irrigation schemes have been developed by Tasmanian Irrigation (TI), and these schemes source water through agreements with Hydro Tasmania (Hydro) or TasWater, or they can be run under their own water licenses. In certain areas on the island there are

private recycled water programs which transport processed residential and commercial wastewater to agricultural areas via pipes and pumps. These private companies can be situated under the management umbrella of TasWater, although some of the recycled water schemes have had challenges due to salt intrusion during king tides, which requires that systems are shut off and therefore not completely reliable. Significant interest is growing in developing new recycled water projects, particularly in the most heavily populated areas in and around Hobart. Some farmers, in the Derwent Valley for example, have access to municipal water, which they can use for agricultural irrigation. Others have riparian irrigation licenses with properties abutting rivers and streams. A number of farmers construct dams and reservoirs on their farms, either diverting surface water, capturing rainfall, or storing irrigation scheme water for summer use. It is common for neighboring farms to share infrastructure like reservoirs and pumps, and all forms of water access require permission from DPIWWE.

Tasmanian Attitudes about Water (Social-Cultural Systems)

When asked about water availability in Tasmania, many interviewees were quick to point out that the island has lots of water, it just tends to not be in the place they need it. One interview participant opined that attitudes about plentitude are in direct contrast to scarcity in regions on the mainland, and that compared to the mainland, Tasmania does receive more annual rainfall. The issue with water availability is the wide variability in accessing water throughout the island. Most of the rain falls on the remote western half of the island. The areas where people live and farm in the central and east of the island experience much drier conditions.

Water is thought of as a critical resource for improving the economic future of Tasmania, a value that emerged in interviews with producers and government employees. The formation of government-business enterprises like Hydro and TI advance the mission of economic growth through the control and use of water. Multiple interview participants highlighted that with forestry and mining in decline in the past decades there is a perception from residents and politicians that the island state needs to “catch up” with the mainland economically, and to do this will require modernization and the production and export of goods. Agriculture is a large part of the economic growth vision. On the homepage of the TI website its mission is directly referenced: “Helping to Grow the Wealth of Tasmania” (Tasmanian Irrigation, 2020). In order to grow the economy as quickly as possible, one researcher I interviewed noted that approaches tend to be short-term: “A drive for efficiency precludes what are the ways we can make an effective design process. The attitude is ‘let’s just do it. Let’s just get it done. And we’ll worry about the problems later. We’ll sort them out as they emerge’.” Another interviewee described that the view of water as an economic good began with “hydro-industrialization” on the island. Development of hydroelectric generation on the island was to carry Tasmania into the future:

Otherwise Tasmania is always seen as this little cousin who relies a lot on the mainland for benefits...so much of the population relies on welfare money. Hydro-industrialization was seen as getting Tasmania into much more of a developed thing. So now those in government, but also the general population have the perception quite deep in their psyches that water equals power generation and Hydro Tasmania owns the water, like: “It’s not my water, it’s not our water. It’s already Hydro’s water”.

Farmers with historic riparian rights can take issue with newer top-down government rules. Prior to increased state government oversight in water access in this

century, farmers largely were able to use the water they needed. If a farmer owned land next to a waterway they had rights to extract water. Now there is a tension with the top-down government management structure. As one water researcher explained:

People are farming on properties where their father, grandfather, great grandfather always just extracted. No one asked how much ... people weren't farming so intensively, so people weren't stressing. But now you have all these rules and different players. It's becoming far more intensive. It's driving an increase in use even from people who traditionally didn't need it. I have spoken to a very large farmer in Tasmania who says, "I do not extract anywhere near what I am licensed to extract. If I were to extract the whole thing the river would stop, but I wouldn't do that. It's my river. I live here. I grew up here. Why would I do that?"

When considering cultural influences in the region, one can ask who is missing from decision-making about water and how do social values perpetuate this? One response from a water researcher pointed out that water in Tasmania, and in the whole of Australia, is often approached from only two standpoints; irrigation and the environment. General citizens agree that these are important stakeholders, but they often don't realize that they themselves are also stakeholders in water outcomes. The Tasmanian water researcher wondered, do people care? Should people care? Should people care about the concentration of capital? Are the people who are marginalized so disempowered that they can't care? Multiple participants also expressed that the big "elephant in the room" for water management in Tasmania is the Aboriginal population. One interviewee described that people working in the water management department know they need to engage with the Tasmanian Aboriginal population, but it is not happening for a number of reasons. For one, the state water legislation does not require it, and secondly, there are very few Aboriginal people remaining on the island and they are already very disempowered. The department may also find it "frightening to engage" because a very different worldview

around the ownership of water. Although the genuine intention may be there on the part of the state, there is a deep mismatch and big barriers exist to not only meaningful, but any engagement.

Finally, with a number of irrigation schemes the water comes out of a pipe, which removes the user from experiencing the conditions where the water comes from. The farmer does not see the river banks, or the water levels or flooding or impacts on riparian vegetation. Without seeing the water there can be less of a sense of ownership over the larger watershed impacts of extraction. In interviews with environmental conservationists, academics, government agency employees and grape farmers, I found agreement that environmental conservation values for water bodies in Tasmania are focused on the protected wilderness areas in the west, rather than on agricultural regions.

Tasmanian Attitudes about Irrigation (Social-Cultural Systems)

Irrigation is critically important. And frost management is critically important here. Very much so in the south and the east. They are really troubled by the lack of water.
-- Tasmanian Winemaker

In contrast to the Willamette Valley, nearly every wine grape grower in Tasmania irrigates their vineyard. Many in the industry believe you should not be planting a vineyard unless you have your water source “completely sewn up.” A number of producers see the potential for future expansion of vineyard plantings into new areas on the island like the Midlands, which currently has a lot of sheep grazing, and expansion will require the development of new irrigation schemes. Others interviewees were skeptical; one viticulturist pointed to problems with irrigation schemes on the mainland and wondered why Tasmania would want to follow down the same path. Whether

respondents express concern or indifference about irrigation schemes is usually dependent on where they are located on the island. In talking to producers in the Derwent Valley, north of Hobart, there was very little concern. These producers were connected to the TasWater municipal drinking water system, and they were able to use this water for irrigation, winery operations, and hospitality. They found the water to be cheap and reliable, and they did not need to participate in an irrigation scheme. Other producers in the grape growing regions in the drier Coal River Valley and the east coast were eager to have extensively-developed and well-managed irrigation schemes, which has not been the outcome for everyone to date. Location also results in a difference of opinion about government involvement in water management. In regions where water is more available many farmers are lobbying for more localized community self-regulation of their irrigation schemes, while in areas where water is scarce, there is a desire by many for more government oversight to ensure fairness of access.

5.5 Analysis and Conclusion

In this chapter I presented background information and research findings related to how water governance in Tasmania creates opportunities and barriers to wine industry climate change adaptation. As in the Willamette Valley, this research confirmed my assumption that water demand will continue to increase while water availability will decline, due to consumption from the growing wine industry, regional populations, and other industry. Climate change will impact regional ecological and human systems on the island, with projections of hotter growing seasons, and more extreme climate events like drought and heavy rainfall. Wine sub-regions in different locations on the island will experience climate change differently, so adaptation planning is geographically

dependent. The top-down water governance structure in Tasmania includes federal legislation, funding, and mandates, as well as state-level legislation, management, and oversight. Federal funding, coupled with social values about the economic role of water in growing the state economy, has resulted in the development of irrigation schemes for agricultural use around the island. The creation of a for-profit, government-business enterprise to oversee irrigation scheme development and management has led to concerns about lack of transparency and loss of local control over water resources (Bakker, 2003). Other neoliberal models of public-private partnerships control access to the majority of water on the island, namely the hydroelectric company, Hydro Tasmania (Higgins & Cocklin, 2012; Pietz, 2002). Similar to Oregon, the state agencies lack human and financial resources, which results in the inability to conduct scientific research to increase understanding of watersheds on the island. Insufficient resources at the state level also results in inadequate oversight to monitor and enforce water regulations.

As the wine industry on the mainland of Australia has experienced extreme climate conditions in recent years, there has been an influx of investment from large companies purchasing wineries and vineyard land in Tasmania. Those within the wine industry have a range of attitudes and approaches to climate change planning and management, but the importance of water is not disputed. Nearly everyone irrigates and all winery owners need water for production. As water access continues to be dependent on geographical location and irrigation schemes; larger, corporate entities with more financial resources will be more likely to be able to buy water and water-accessible vineyard land, which may lead to inequities within the wine industry. Adaptation strategies are focused on securing water infrastructure, and making viticulture decisions

regarding suitable cultivars, rootstocks, and grape varieties for withstanding future climate scenarios. In addition, a number of producers are not engaged with climate adaptation planning at all, mainly because the issue has not become dire, and time and financial resources are needed elsewhere in their businesses (Moser & Ekstrom, 2010).

In the following chapter, “Chapter 6. Case Study Narratives: Climate Change and Water Governance in Wine Regions,” I expand on the themes that emerged from the research findings in Chapters 4 and 5 about the Willamette Valley and Tasmania in five narrative vignettes. These stories organize the research themes into the institutional, social, and ecological systems framework; and provide real-world examples of the interactions between these systems as they relate to water resource governance and climate change adaptation in wine regions.

Chapter 6. Case Study Narratives: Climate Change and Water Governance in Wine Regions

6.1 Introduction

The Willamette Valley and Tasmania need clean, reliable water supplies. The wine industry needs water for grape farming, wine production, and hospitality; and both regions need water for residential and commercial use. Water is a critical part of the landscape that helps shape regional identity, including agricultural landscapes, open spaces, and regional species like salmon in Oregon and giant freshwater crayfish in Tasmania. Water contributes to how people experience these regions, as places where residents and visitors relax and recreate. In the previous two chapters, Chapters 4 and 5, I presented research findings and made the argument that long term regional resiliency is dependent on the cultural, political, and economic factors that influence decisions, plans, trends, and outcomes regarding water resources. In this chapter I share five narrative vignettes situated in the case study regions based on themes emergent from key informant interviews. The first vignette, “Power and Control: How Climate Adaptation is Reliant on Hydro Tasmania Decisions,” examines how access to water resources has shifted to a government-business enterprise and how that could negatively influence equitable access to water. The second vignette, “The Web of Oregon’s Regional Water Infrastructure Governance,” provides an example of how top-down governance structures and entrenched legal regimes can limit local control over water decisions. The third vignette, “Bringing Water to Dry Land: Tasmanian Irrigation, Transparency, and Local Management,” presents the recent history of government-business enterprise run irrigation scheme development on the island resulting in citizen concerns about lack of

transparency, and local control of water for agricultural purposes. The fourth vignette, “East Coast Struggles: Oversight, Corporate Influence, and Conflict,” shares multiple themes in Tasmania about outside, corporate wine industry growth; challenges with the lack of communication between state and local government authorities; and severe water shortages impacting a range of stakeholders. The final vignette, “Establishing a Vineyard in a Willamette Valley ‘Critical Groundwater Area’,” tells the story of one grape farmer’s experience encountering challenges while attempting to secure groundwater rights, while recognizing larger regional challenges around water resources, enhanced by fragmentation of authority between government entities, and lack of human and financial resources. This chapter highlights similarities in the case study regions regarding challenges with top-down governance structures, current and future challenges about water access and availability, and fragmented authority that lack transparency and adequate resources. The vignettes also illustrate differences between the two regions, mainly the different approaches to irrigation water infrastructure development and the neoliberal structures of water management through for-profit government-business enterprises promoting the cultural value of water as an economic good.

6.2 Power and Control: How Climate Adaptation is Reliant on Hydro Tasmania Decisions

Most grape growers rely on irrigation to farm in Tasmania, and they access irrigation water from government-business enterprises, typically TI or TasWater. The hidden giant in the story of water governance is Hydro Tasmania (Hydro), a government-business enterprise that controls most of the water on the island. In 1929, the Hydro Electric Corporation became the regulator of water on the island. At that time just over

200,000 people lived on the island (the current population is over 500,000 with more than one million visitors a year) and demand for water was quite low. In the 1950s the Tasmania Water Act was passed which allocated all water upstream of the hydroelectric dams to the Hydro Corporation. With the passage of the 1999 Tasmanian Water Management Act, Hydro now holds a special, non-consumptive license. Hydro operates an extensive system of large dams and reservoirs in the remote, mostly uninhabited western mountains on the island, and Hydro's right to use the water is protected by the act. Hydro has entered into arrangements to transfer (i.e. temporarily sell) portions of their water rights to commercial uses as licensees. Some of these licensees are individual farmers and often the licensee is TI. Access to water from Hydro is one of the reasons TI can build their large irrigation infrastructure projects in certain parts of the island. TasWater is responsible for delivery of drinking water to towns and cities as well as some irrigation schemes, and also relies on water transferred from Hydro.

DPIPWE is responsible for regulating water quantity for the state with the mandate to provide government oversight for reasons of human and environmental health. Questions have arisen about oversight, transparency, and control between and within Hydro and DPIPWE. A manager at Hydro agreed:

Hydro Tasmania for historical reasons has a very light regulatory regime. We are very lucky in that regard. We work very hard to keep that regulatory regime by going above and beyond what is required.

In order for DPIPWE to transfer any water titles, they must seek the consent of Hydro. One researcher described the potential conflict in the power structure with Hydro having full control of so much water: "It is deep in the psyche of the agency (Hydro) that they have the power and control of water in the state and it shows in their interactions with the

government.” A Hydro manager stated, “Water is becoming increasingly important for the Tasmanian economy.” The purpose of Hydro selling water allocations is to make money, and the value of water has proven to be higher in the past for agriculture than for energy generation. Recently Hydro has run into trouble selling water during drought conditions when water levels are low, and irrigators had to be cut off. One grape farmer described a scenario from a recent hot, dry summer growing season:

There were some water issues that emerged last season, where the state of Tasmania ran out of water to some extent. Someone just kept turning the tap on until they realized that the dams were running empty.

Another farmer expressed anger over the amount of control Hydro has over water in Tasmania:

There is major conflict between Hydro and the irrigators. They are the biggest on the block and basically they don’t give a sh*t about anyone else.

As a Hydro manager explained, Hydro sets their price for water in May based on projections of possible profit from electricity generation. In the last four-to-five years water prices have increased threefold, and Hydro doesn’t think Tasmanian farmers will accept that steep of a price hike. Hydro also sells electricity to the mainland of Australia, transporting it by cable under the Bass Strait. Hydro’s manager speculated about a future scenario where climate change impacts increase water scarcity on the mainland resulting in Hydro selling water for more profit to the mainland. Part of the challenge of water in Tasmania is that management and regulatory frameworks are fragmented. Water quality is regulated by the state agency the Environment Protection Authority (EPA), while water quantity is regulated by DPIW. Land use is the jurisdiction of both local

councils and the state, and water catchment health is managed by Natural Resource Management (NRM) groups. According to one interview participant the NRM groups are “statutory bodies that have no teeth.” Ultimately Hydro, with the most control over water resources, may end up holding the most decision making power in the future as the demand for and cost of water continues to rise. As a for-profit government-business entity they have to answer to shareholders’ expectations and financial targets, which could increase the existing unevenness in access to water among Tasmanian wine grape growers and create a higher potential for inequity.

6.3 The Web of Oregon’s Regional Water Infrastructure Governance

A narrative that came from a number of interviewees in the Willamette Valley was a shared opinion that an investment in a regional water storage and delivery infrastructure project would be one way to help farmers, including grape growers, have a sustainable, reliable water source in the face of climate change. As it turns out, the Willamette Valley does have a regional water storage system, a series of thirteen reservoirs from dams on the Willamette River and its upper tributaries, which is a complicated mix of federal, state, and tribal institutions engaged with decision making about Willamette River water. The 1938 Federal Flood Control Act authorized construction of the dams by the USACE, who continue to be responsible for dam operation. A separate federal agency, the BOR, holds all of the water rights from these reservoirs, which are administered by the state’s Oregon Water Resources Department (OWRD). These water rights are held exclusively for agricultural irrigation, and an act of Congress would be needed to change their use. According to an OWRD manager, only

five percent of the stored water is currently under contract and used by irrigators. The reservoirs allow for operation of the hydroelectric turbines for energy generation; and they are popular recreational destinations for boaters and anglers. There is a growing demand from other stakeholders to expand the uses of the reservoir water. As the population continues to grow in the region, municipalities are looking to the reservoirs as a source of drinking water, and flow in the river is also critical habitat for federally-listed endangered species of salmon and steelhead. Along with the desire of multiple stakeholders to access that water for new purposes, conflict has arisen. As one interviewee put it: “there is a big fight for water between municipalities and agriculture.” Even though the irrigators have been using a very small amount of the water, they fear losing access when there may be an increase in need in the future. Some farmers expressed concern that municipalities have a strong capacity to participate in decision-making, but irrigators are a more diffuse group and their voices may not be heard. An ongoing feasibility study that began in 2004 is being undertaken by the USACE and the OWRD to evaluate the Willamette Basin’s water use and water needs, and to determine necessary changes to existing management. The process began with a federal institutional review by the Corps Deputy Commanding General for Civil Engineering and Operations and the United States Department of Commerce National Oceanic and Atmospheric Administration (NOAA Fisheries), which is responsible for the endangered species listings for anadromous fish. Calculations have shown that thirty percent more water is needed than is available to meet all the competing demands with NOAA Fisheries estimating that fish protection alone needs almost all of the available water in the basin. In their review, the USACE recommended a reallocation of the annual storage, with

nearly 160,000 acre feet to go to municipalities and industry, around 330,000 acre feet to remain available for irrigators, and 1.1M acre feet to remain in the river for fish conservation. A state agency review is required, and if approved, the plan will then go to a review by a series of federal agencies and the United States House of Representatives for final approval. For irrigators, access to the reservoir water would still require significant investment in infrastructure to transport and locally store water. As one OWRD agency employee put it: “Three decades have passed. Attempting to solve water rights is a very slow process.” Decisions require weigh-in and approval from a large contingent of institutions at a range of levels, resulting in a timeline that stretches decades. Climate change is a serious and pressing challenge to water availability, and it is yet to be determined whether and how the web of governance can adapt in a way that is more nimble and timely.

6.4 Bringing Water to Dry Land: Tasmanian Irrigation, Transparency, and Local Management

With the influx of funding from Australia’s National Water Initiative in the early 2000s, TI was formed to consolidate planning and management of irrigation schemes at the state level. According to TI, prior to its establishment there was a combination of government institutions overseeing local and regional irrigation schemes (including the Rivers and Water Supply Commission, the Tasmanian Irrigation Board, Tasmanian Irrigation Schemes, and a variety of locally-run schemes.) TI is a government-business enterprise and has built fourteen irrigation schemes since 2011. To participate in an irrigation scheme, farmers pay up front infrastructure costs and commit to buying a certain allotment of water annually. As of 2018, there were nearly 1,700 active irrigation

and delivery rights through TI schemes. TI manages their own water licenses, as well as contracting water through TasWater and Hydro (Tasmanian Irrigation, 2020).

When it was originally set up TI's premise was to build schemes with a team of water professionals and handle the complex water regulatory environment in the state. The original plan was to then hand management and execution of the schemes back to the local communities. This did not come to pass; instead TI changed their statement of corporate intent and in addition to developing schemes, they also became owners and operators. Local communities did not have the choice to manage their own schemes which resulted in conflict. Concerns around this lack of local control, combined with other complaints about costs, and lack of transparency and oversight, resulted in a Tasmanian Parliamentary Inquiry in 2018. Evidence was solicited from the public through a website and three public hearings in Launceston in the north of the state, with the CEO and board members of TI in attendance.

A number of the wine grape growing regions on the island are served by TI schemes, particularly the dry Coal River Valley region, which has had significant growth in vineyards in recent years with new access to irrigation water. Three irrigation schemes have been developed in the valley, but the first two did not result in successful outcomes of water delivery. A third scheme was developed, and the farmers thought it was intended to correct the problems with the first two schemes, but instead the third scheme was filled quickly with a group of new farmers. Each scheme has a representative committee to liaison with the staff at TI. I met with a prominent grape grower in the Coal River Valley, who has been involved with two of the three irrigation scheme developments in the area, and he confirmed: "there are a few sore heads for stage one and two... we are still trying

to break down barriers and get the committees together.” As one Coal River Valley farmer put it:

Recent years have seen a continual restriction on water use during the summer period because of availability of water quota...this has led to frustrations by existing operations since more water rights have been sold than the existing scheme can handle...there is no doubt that our Coal River Stage II scheme has been badly managed.

Wine industry thinking on irrigation schemes is mixed; many see it as an opportunity to expand the area where they can viably grow grapes. One winemaker said that she has a “forceful belief that they will need to bring irrigation water to new sites in the Midlands that are higher elevation and south facing.” South-facing sites are cooler in the southern hemisphere, and the Midlands are an agricultural subregion that is not currently farmed for grapes. Her reasoning is that climate change is going to have “a massive impact” on where grapes can be grown on the island. Others express concern when looking at the problems that have arisen with irrigation schemes on the mainland of Australia; and one viticulturist interview participant questioned, “Why did Tasmania choose to replicate them?”

One critique of the process of rolling out the irrigation schemes addressed in the parliamentary inquiry was a lack of informed discussions with the larger population. Instead, decision making was happening closely between the agriculture industry, government, and TI. According to some producers, the transparency in the process “left a lot to be desired.” Other concerns voiced by irrigation scheme participants during the parliamentary inquiry included unreasonably high corporate and administrative costs, lack of transparency about finances, and lack of transparency about water allocations and volume of flow. The CEO of TI defended the role of her institution, arguing that

centralized independent management of schemes is the most cost-effective and reliable approach in the long run (Parliament of Tasmania, 2018). The local chair of the committee for one scheme countered:

We would run it better than they (TI) would. We're in touch with what's going on day to day so we can (defuse) problems a lot quicker than they can, before they escalate. We know the individual crops in the district and what needs what and can manage water delivery to those individual needs a lot more efficiently than they can. We know that such and such down the road might have an onion crop that needs watering today (Parliament of Tasmania, 2018).

The inquiry's findings confirmed that TI holds a monopoly on “large-scale, off-farm irrigation services” in Tasmania, and that there were a number of legitimate concerns. Water costs are not consistent across schemes, which leads some customers to deduce that they are subsidizing other schemes. Information is not publicly available regarding water allocations and flow volumes, and self-management of water access would provide greater flexibility to irrigators. The recommendation for improving the current situation is that TI should facilitate “a clear pathway for each scheme to determine its own future” and to ensure “transparency, accountability and responsiveness to users, and make relevant information publicly available” (Parliament of Tasmania, 2018). How this was to be operationalized or overseen was not addressed by the Parliament.

6.5 East Coast Struggles: Oversight, Corporate Influence, and Conflict

The east coast is a grape growing region in Tasmania that has experienced firsthand the challenges of climate change and irrigation schemes. The east coast TI irrigation scheme filled quickly with participants including many vineyard owners. Significant costs were paid up front by farmers to construct the scheme, but a number of

years have passed and there has yet to be reliable availability of water. Given its location far from the wet western mountains, and far from the large rivers in the central part of the island, this scheme is reliant on rainfall to increase flow in a small river to the point where they are permitted to fill the reservoir, but the rain has not materialized. When I asked one producer what type of planning is being done for the future if they don't get rain, her response was direct: there is no other plan. I asked if the irrigation scheme will stay permanently on hold until there is water, and she answered:

It will stay on hold until we get enough water to fill a 3,000 megaliter dam. And then hopefully we will have enough water in it to get us through two seasons. And then hopefully it will rain.

The east coast subregion is a smaller wine region, but it receives a very large number of visitors every year. The drive from the island's major city of Hobart is only two hours and visitors find beaches, small coastal towns, and a very popular national park. The east coast is sparsely populated with year-round residents, and like much of the agricultural areas on the island it is a sheep grazing region. According to residents the population balloons from 600 to 5,000 in the summer. The region is very dry and has been experiencing drought conditions for a number of years. The east coast is highly vulnerable to bushfires, and climate conditions have put pressure on the health of coastal and intertidal ecosystems. Water concerns are high on the agenda for both residents and farmers on the east coast. Friction exists between local input to decision making about water and state level oversight. Conflict also arises between neighbors around illegal water pumping from rivers already at very low flow rates. The local council is made up of elected councilors, who along with local mayors and natural resource managers juggle the needs of farmers, residents, businesses, tourism, and the natural environment all in the

context of serious water shortages. At the state level, DPIPWE issues licenses and permits for water use and during dry periods commonly issues orders to curtail water use. In the community, some residents, politicians, and local government employees perceived a lack of transparency and communication from the state agency, and a lack of state level involvement with local efforts to address the issues. While visiting the east coast, I attended a meeting of the local council's Natural Resource Committee, which was made up of natural resource managers, elected councilors, local farmers, grazers, oyster farmers, bushfire officials and others. The agenda of the day included addressing challenges facing water managers in the area. One observation was a need to look at the carrying capacity of water resources for tourism. The opinion was that state politicians heavily promote tourism for state economic benefits, and they do so without public consultation. Demand for water increases exponentially on the east coast in the summer due to tourism. One community representative on the committee commented that the problem was "too many vineyards." Another council member suggested that "water restrictions should be part of our culture." Some residents perceived that DPIPWE gives large corporate entities special access to emergency water allocations from rivers with low flows in the area. They felt these large companies get special treatment because they cater to tourism and boost the state economy, while local residents and small farmers are negatively impacted by the water overconsumption. Many participants in the meeting, and others I interviewed in the area, were concerned about a lack of oversight and enforcement by DPIPWE to ensure that new licensees did not negatively impact water availability for existing downstream users. One councilor added that in their area "water management equals a black hole."

The story of east coast vineyard owners C. and R.'s experience in recent years illustrates some of the challenges that can arise with a lack of useful institutional engagement when it comes to water. C. and R. bought a small vineyard that was originally planted in the 1960s, the first in the area. The couple bought the neighboring property and expanded their vineyard holdings. C. and R. farm the grapes themselves, along with part time help from their university-age son. Water is needed in the vineyards for irrigation, but also to mitigate damaging spring frosts that are typical to the area. Overhead sprinklers are used for frost mitigation and drip irrigation is used for watering vines. C. and R. invested in a new \$150,000 dam on their property and still needed to pay for a pump and pipes. The water came from the Swan River, plus they bought into the east coast irrigation scheme, which was still not online due to lack of rain. C. and R.'s backup plan was to buy water from their neighbor who has a larger dam. I met C. and R. on their vineyard property where they also have a home and a converted barn for the tasting room. The couple could usually be found tending the vineyards, but they head to the barn if someone comes up the driveway for a wine tasting visit. During my visit C. received a text message from DPIPWE on his cell phone. It was an automated message that informed him they would have to limit pumping from the river due to low flows. My visit was in the beginning of the summer; and there would likely not be any rain to replenish the river flow until late fall, if then. C. shared that the message instructed him to pump two of the seven days in the week, and to meter and monitor his use. He expressed frustration at the lack of details or clarity in the message. How much could he pump for two days? Currently any water he pumped directly from the river is unmetered and that is the case for everyone on the east coast pumping from rivers. DPIPWE only requires

metering pipes that are part of irrigation schemes. C. expressed that this type of communication was common from the department, and although it is his desire to follow the rules, he is frustrated because the rules are not always clear. His main concern is his neighbor, who continuously pumps from the river to irrigate vineyards and to irrigate pasture using large pivots. Residents in the area have become worried about their riparian rights which provide them domestic drinking water. The fear is that overpumping by a few is causing shortages for the rest. As one local councilor put it: “no [name withheld] doesn’t have [to curtail water use], but he is seven generations here. Some have a god given right that they own half into the river... that was there before the regulations. It’s a huge issue now. This is going to become more frequent here on the coast.” The result has been that local growers on the east coast are getting together to ask DPIPWE for more oversight and to require that everyone meter their water use. C. and R. expressed that even though it is a close community, there is a bit of an “I’ve got to protect my patch” attitude, instead of collaborating to try to benefit all. C. and R. remain very concerned about water, including drinking water, and are unsure of the long term sustainability of grape farming in the area.

6.6 Establishing a Vineyard in a Willamette Valley “Critical Groundwater Area”

The story of J.’s farm brings to light the limitations individual grape farmers can encounter at the farm scale related to both geology and water law. His story connects to long term regional water needs, and highlights the disconnect between county planning departments and the state water resources department. J.’s story also illustrates the kind of creative yet costly work-arounds farmers come up with in the face of water scarcity and regulations. In recent years J. and his wife bought their rural property in a wine grape

growing region in the central Willamette Valley. J. had owned and farmed a successful vineyard for over two decades in the north part of the region and when they sold it the couple decided on the new venture further south. The area is home to many high quality vineyards, and J. knew it held lots of potential. He would plant grape vines- Pinot noir, Chardonnay, and Riesling, plus he was enthusiastic to begin a new project- a cider apple orchard. The house on the site had been there for a few decades and had a residential use well established. J.'s plan was to drill a new well for irrigation which requires a permit from the OWRD. When J. went to the OWRD office to talk with the Watermaster he learned his property fell within a "Critical Groundwater Area," which means no new uses were allowed. Apple trees and new grapevines need water. So J. petitioned the OWRD for a temporary five year permit to use groundwater to irrigate his trees and establish his vineyard. After an eight month wait he learned he was denied. J. found out he would not be allowed *any* water for commercial purposes. He raised the issue with the Watermaster, pointing out that he is a farmer and how is he supposed to farm without using any groundwater for commercial purposes? According to J., the Watermaster responded: "That's not our problem. We don't have anything to do with zoning, that's the county. So you're going to have to talk to the county." When J. approached the county they responded that they don't regulate water. As J. puts it: "So you're stuck between two agencies that simply won't communicate about it."

J.'s property is on a county road at the top of a ridge. A number of five acre residential lots have been developed on this road over the last five years. Access to water on the ridge is mainly by groundwater wells. The aquifers on this ridge are the perched basalt typical to the region. Many soils in the sub regions of the Willamette Valley are

made up of basalt flows. Lava flows covered large areas throughout the region, and there are over a hundred and fifty layers of flows that formed cracked basalt rock, each nearly one hundred feet thick. Between the basalt layers are thinner layers of loose volcanic rubble and ash. Water can seep in and fill the cracked spaces in the basalt, and travel between layers through the loose material (Oregon State University, 2020). Snowmelt has no impact on the aquifers in J.'s region, as elevations are typically too low to accumulate winter snowpack. Aquifer recharge, if any exists, must come from rainfall. When J. got to talking with his neighbors, he realized he was not the only one with water issues in the area. The OWRD rules allow a property owner to pump water from one aquifer only. Due to cost, most people drill their well into the first, most shallow aquifer. The OWRD rules allow each property 5,000 gallons per day of unrestricted water for domestic use. A few neighbors on the road told stories of noticeable reduction of water in their wells in recent years. One neighbor who has owned his property for four years was "playing by the rules" according to J. and drilled his domestic well into the first aquifer, but two of the four years his well went dry. As J. puts it: "There is proof positive we have a problem...already." J. indicated that it appears the aquifer is overtapped, but the OWRD does not have the resources to study the issue. According to a researcher at Oregon State University:

We scientists know very little about groundwater. The groundwater models are really early. They're getting better, but it is not totally clear. I mean, we might say, yeah, there's an aquifer or there's groundwater, but we're not clear about the amount.

One issue raised by J. is the disconnect between the law carried out by the ORWD, and the actual use on the land, which is connected to county zoning rules. This concern came

up from multiple constituents, including local elected officials, employees of the OWRD, representatives of environmental conservation organizations, and academic researchers.

J.'s opinion reflects the challenges of the entrenched legal regimes like prior appropriation, when it comes to water governance in the region:

We feel it's imperative that the county and the water resources board get together about any development. I don't care if it's a house that has to access a domestic well or it's a winery or it's a vineyard. We all have to play by the same rules, and they need to be applied evenly over whomever is doing the development. It's unreasonable to say that everyone who got here first gets all the water. That's nuts. I think what we've got is a broken system that is being supported by law...it doesn't make sense in the face of looking at the future. If we are really going to solve our issues of water going forward, we've got to get away from these artificial boundaries. Water doesn't know property boundaries...water works in basins and drainages. That's how we need to start. We need to start by addressing our water problems in our drainage basin. We need to be assessing what our long term needs are.

Upon learning that he would not get access to groundwater, J. decided on a new approach. He was permitted to take water from the roof, which is an exempt use in Oregon water law. J. decided to design a closed-loop system where he could capture water and generate energy, which came with considerable cost. He purchased eight large cisterns from a company in California and had them trucked up to Oregon. When I visited the farm, the storage pond was under construction, with equipment on site, and a tremendous amount of dust due to dry and windy summer weather. The water will be captured from the roofs on the property and piped with gravity to the pond down the hill. The pipe will be fitted with a turbine to capture the energy from the flow. That turbine, combined with a small wind turbine to be installed on site, will provide the energy to

pump the water back up the hill to the holding tanks where it will be used for farming, and wine and cider production operations.

6.7 Analysis and Conclusion

In this chapter I presented five narrative vignettes that illustrate themes from the research and situate them in real-world contexts. The vignettes provide examples of the interactions between the institutional, social, and ecological systems in the wine regions as they relate to water resource governance and climate change adaptation. In both regions top-down water governance structures have impacted regional outcomes. In Tasmania there was a push to technological approaches to resource management for economic gain, like in Pietz's (2002) "Technology Complex" theory, where natural systems are transformed by mechanical elements to control river flows for hydroelectric production or irrigation schemes. The neoliberalization of water management (Bakker, 2003) is illustrated in the government-business enterprise model adopted by Tasmania in the cases of Hydro Tasmania and Tasmanian Irrigation. In this model, concerns around communication and transparency arose among water users; particularly as irrigation schemes in Tasmania shifted from local and regional decision making to the state-level government-business enterprise Tasmanian Irrigation, as presented in the vignette "Bringing Water to Dry Land."

In the case of the Willamette Valley, entrenched legal regimes and fragmentation of authority are highlighted as barriers for water access. In the example of water storage on the Willamette River, federal control of large water storages minimized state and local choices around water access and use. In the case of J.'s farm, lack of communication and misalignment between state-level water resource management and county-level planning

and development processes impacted water availability and access. In Tasmania, the increase in state government oversight regarding water use permitting, lead to conflict with citizens accustomed to less regulation.

One challenge facing all policymaking institutions is the need to make decisions about water while often lacking data, science, and information. Both Tasmania and Oregon are hindered by a lack of institutional resources that would allow for adequate staffing and funding for research and data collection. Without the full picture of water availability, current water use, and projected future water needs, institutional decision makers have to act with blinders. In the Willamette Valley this became apparent when overallocation of groundwater rights resulted in water shortages; while at the same time entrenched legal regimes like the prior-appropriation doctrine have resulted in an unevenness in who can access water. Lack of resources, and potentially a lack of political will, is also credited for challenges with enforcement of current water rules.

As presented in Chapter 4 and 5, the climate continues to change in both regions as water demands rise, and the wine industries grow. Those within the wine industry have a range of attitudes and approaches to water resource and climate change planning. In Chapter 7, I consider in more detail the barriers and opportunities to climate adaptation approaches; and offer a number of recommendations derived from lessons learned in the Willamette Valley and Tasmanian wine region case studies.

Chapter 7. Discussion and Conclusion

7.1 Discussion and Recommendations

In my research I examined the drivers influencing climate change adaptation through water resource governance in global wine producing regions, including Oregon's Willamette Valley and Tasmania, Australia. My research determined that climate change will affect both regions with changes in temperature, precipitation, and extreme weather events impacting water resources. At the same time the wine industry continues to grow and evolve in both regions, where clean, adequate water supplies will be a critical for good social, economic, and ecological regional outcomes. My research adds to the broader climate change discourse in the wine industry by going beyond viticulture and technological solutions; and elevating the need to examine the relationships between ecological, institutional, and social systems in order to better understand climate adaptation options in regional contexts. My observations and analyses test the utility of the ISED framework in the context of climate change and water governance, using the framework to determine barriers and opportunities for adaptation.

Key findings about social drivers for water outcomes in wine regions include the importance of attitudes and values. Similar to findings by Moser and Ekstrom (2010), I found a diversity of attitudes among key knowledge holder interview participants about the risks of climate change in each region, ranging from the lack of directly felt impacts to those in the wine industry, to self-interest focusing on farm scale and personal wine business outcomes, to a sense of the daunting scale of the problem. The social memory of place, referenced by Barthel et al. (2013), was present in the range of attitudes about the perception of availability of water in both regions historically known for rainfall and

cooler temperatures, but with changing conditions due to climate change. In both regions the inconsistency in perceptions around the abundance or scarcity of water of those in the wine industry, resulted in an unevenness in who is participating in discussions and decision making about water policy and management. Another key finding about social drivers impacting water decisions was the predominant attitude in the Tasmanian wine industry, government agencies, politicians, and government-business enterprises that the value of water is economic; where water use benefits the wine industry and the state economy. In the Willamette Valley the research revealed variability among wine industry businesses that were actively planning long term for water resources. For example, in the Willamette Valley many stakeholders believed that water conservation is primarily a problem for irrigated vineyards. With drier summers and an increasing number of vineyard investors from out of the region, the number of irrigated vineyards is increasing, resulting in equity concerns about water access in a region without coordinated irrigation infrastructure. In contrast, perceptions about water availability in Tasmania were tied to one's geographic location and access to historic riparian water rights, or to government-business entity-managed irrigation schemes. In both regions, outside investment and corporate consolidation is creating a faction of the wine industry that will be better resourced to adapt to water challenges that arise as part of climate change.

My research encountered another approach, regenerative viticulture, which is connected to social values and puts forth an alternative vision for resiliency in the face of hotter, drier, and more variable climate futures. This approach is not focused solely on economic or industry growth, but rather on finding farming methods that promote sustaining the ecological and social systems of the region (Rhodes, 2017). Regenerative

viticulture integrates grape farming into more biologically and agriculturally diverse systems, promoting watershed health and biodiversity, while also considering sustainable labor practices, all of which can result in an increased resilience to climate shocks.

Based on my findings about the interrelationships among the social, institutional, and ecological systems in my case study wine regions, I will now discuss the barriers to more adaptive solutions and highlight some of the opportunities identified by my interviewees and me to overcome the barriers.

Barriers

Top-down governance structure

Both the Willamette Valley and Tasmania have top-down structures of governance for water resources which allows for “big-picture” state-wide decision making about water, but also results in a to barrier for local and individual engagement. In Tasmania, state management of water, combined with federal money and legislation, has resulted in technological and engineering approaches to water resource adaptation in the form of irrigation schemes in place of conservation or mitigation strategies. Management of irrigation schemes by the state-level, government-business enterprise, Tasmanian Irrigation, resulted in concerns about the lack of local decision making and transparency about financial costs to farmers. In the Willamette Valley top-down water governance also resulted in a lack of local control or participation in water decisions. One vineyard owner shared his experience in submitting a water use application to the state water department, followed by months of waiting to learn the outcome: “It’s a big black box to us... it’s just a large regulatory agency, so we put our applications in and we just wait. You learn to be very patient.” In top-down governance structures, entrenched legal

regimes, like legislation, regulation, and litigation (Arnold, 2014), can be challenging for adaptive management in the face of uncertainty like climate change, and can take long time frames to change.

Fragmentation of authority

The cross-jurisdictional boundary reality of water management in both wine regions, combined with the fragmentation of authority, can contribute to negative outcomes for water access and water quality. Fragmentation of authority refers to different agencies and levels of government responsible for water quality, water quantity, planning, and development. In Oregon and Tasmania, challenges arise around coordinating policies and reconciling missions, mandates, and timelines. Various entities represent the needs and desires of different interests groups, and interests are not always reconcilable. An example of fragmented authority in the Willamette Valley can be found in J.'s narrative (Chapter 5). The conflict arises when the county planning department approves residential or commercial development without consideration of available water resources, because that authority lies with the state water resources department. In Tasmania, a conflict arises between the interests of two authorities, for example, when the local council on the east coast of the island struggles with lack of water availability and prolonged drought, yet the state government, motivated by economic outcomes, encourages an influx of water users in summer months through the promotion of tourism. These examples highlight some of the challenges of addressing climate change adaptation when coupled with the complexity of government, which Urwin and Jordan (2008) describe as a lack of clear definition about institutional roles, responsibilities, and the best scale to address problems.

Lack of resources

The lack of financial and human resources and political will, can contribute to barriers to climate change adaptation outcomes. In both regions, under-resourced government agencies have resulted in lapses in the collection of scientific data regarding water resources, which impacts the ability for informed decision making about management by those with regulatory oversight. In the Willamette Valley limited resources have resulted in the lack of data collection about ground water availability, resulting in the overallocation of use permits, which has resulted in water shortages for agriculture and residential water users. According to a water department manager, under resourcing may not be neutral, but an attempt by some interest groups, including agriculture lobby groups, to maintain the status quo of water access and use. In Tasmania, one could argue, in the absence of a well-resourced government, water resource control and management was “outsourced,” as described by Lane (2003), to for-profit government-business enterprises, in this case Tasmania Hydro and Tasmanian Irrigation. In the face of limited financial and human resources, both regions have experienced challenges with monitoring and oversight of regulation enforcement regarding illegal water takings and pollution abuses.

Equity issues and the potential for maladaptive adaptation outcomes

As Arnold (2104) described, some institutional decisions can promote the resilience of certain systems while having maladaptive outcomes for others. In the context of social systems in Tasmania, where water is considered an “economic good,” and federal and state agencies, along with government-business enterprises, promote water markets to allow users to buy, sell, and trade water as a commodity, there is the risk

of increasing inequity in accessing water. Interviewees in Tasmania expressed concern over the potential for water license speculation, and control of water access ending up in the hands “of the highest bidder.” Employees of the water resource department for the state of Oregon, along with water lawyers and researchers, shared the view that water markets are likely the future of water access for Oregon and the Willamette Valley.

Water markets could move forward, in the context of the prior-appropriation where most water rights are already allocated, resulting in water right holders gaining the option to sell or lease their water to others who have the ability to pay. Other equity issues that arise when considering water access in wine regions are the ability to afford to buy land with associated water rights, or the ability to invest in water storage infrastructure. In Tasmania some maladaptive adaptation outcomes negatively impacted ecological systems, one example being increased soil salinity connected to an irrigation scheme in the Coal River Valley wine region.

Opportunities

There are a number of clear and sometimes conflicting approaches to adaptation, some realized and others potential, that are being made by wine industry stakeholders to address water needs and climate change in wine regions. One adaptation approach is to increase water use, this may mean increasing irrigation because of reduction in precipitation; increased spraying for pests, molds, or mildews brought on by changes to the climate; increased use of water for mitigating extreme heat or frost in the vineyard; or for cellar or hospitality operations in the context of an increase in sales or tourism. A second adaptation approach is to reduce dependency on water through changes in farming approaches, such as implementing techniques like cover crops that retain soil moisture; or

changing viticulture decisions, such as selecting drought tolerant cultivars or choosing heat tolerant grape varieties. A third approach is to focus on mitigation through reduction of greenhouse gas emissions, which can be achieved through changes to farming and wine production operations like a switch to renewable energy in the cellar, or using no-till practices in the vineyard to sequester carbon in the soil. And finally, those in the wine industry can engage in institutional change through political or community activism, serving on advisory boards, or participating in education and outreach efforts to inform policy decisions. Table 8 provides a detailed snapshot of adaptation actions. Some adaptations will likely improve outcomes for the management of a sustainable water resource system, and others may be maladaptive, reducing the long-term viability of water resources.

Table 8. Wine Industry Water Resource Adaptation Actions

1. Mitigation		
<i>Description:</i>	<i>Barriers:</i>	<i>Opportunities:</i>
Reduce greenhouse gas emissions to slow climate change, including carbon sequestering farming practices; changes in energy sourcing & consumption; purchasing carbon offsets.	<p>Institutional barriers include fragmentation of authority & entrenched legal regimes.</p> <p>Social barriers include necessity to change farming or production operations; costs.</p>	Engage with boundary organizations for education and voluntary financial incentive programs.
2. Increase water use		
<i>Description:</i>	<i>Barriers:</i>	<i>Opportunities:</i>
Maintain current level of production in farming and winery operations; increase crop yields; expand winery operations; plant new vineyards; build new wineries; increase tourism infrastructure like tasting rooms, accommodations, and dining infrastructure.	Water becomes more scarce when and where it is needed; uneven access to water based on geographic location and institutional water appropriation/ available water rights; cost to participate in water markets or irrigation schemes.	Possibility to buy/lease water from water markets; build water infrastructure to store or move water; potential for state redistribution of water rights.

3. Reduce water dependency through changes to viticulture options, farming techniques, and/or cellar operations

a. Regenerative viticulture & whole-systems management approach

<i>Description:</i>	<i>Barriers:</i>	<i>Opportunities:</i>
Use farming approaches that reduce dependency on added water without need for technological or synthetic inputs. Promoting production and farming methods that focus on sustaining ecological and human health and sustainable economics, but not continuous economic growth.	Lack of widespread knowledge about this farming approaches; mismatch with social value of using water as an economic driver to promote business growth.	Long term cost savings; engage with boundary organizations for education and voluntary financial incentive programs; increase resiliency by reducing reliance on technology or outside inputs like synthetic chemicals or imported water.

b. Maintain status quo for current vineyard & cellar production outcomes

<i>Description:</i>	<i>Barriers:</i>	<i>Opportunities:</i>
Maintain current vineyard crop a production outcomes through a variety of actions including: selection of clones and rootstock site selection; use viticulture research to increase understandir of vines and soil conditions; buy to irrigation schemes (Tasmania)	Cost; lack of resources for funding or distribution of research findings; geographic and financial barriers to participating in irrigation schemes.	Engage with boundary organizations for education and access regarding latest research findings; look to other wine regions for adaptation strategies in the face of different climate conditions.

c. Technological approaches

<i>Description:</i>	<i>Barriers:</i>	<i>Opportunities:</i>
Using technological approaches, for example soil moisture sensors, recycled water schemes, efficiency technology for irrigation or cleaning in the cellar.	Upfront costs; lack of resiliency if technology fails or becomes outdated/obsolete.	Increased efficiencies can result in long term cost savings; positive ecological conservation outcomes (for example, recycled water schemes).

4. Engage in institutional change

<i>Description:</i>	<i>Barriers:</i>	<i>Opportunities:</i>
Could include political involvement, membership in lobbying organizations, grassroots organizing, or stakeholder coalition-building to: institute or expand water markets; limit development to reduce demand for resources; re-allocation of water appropriation; promote policy for water conservation; advocate for improved ecological outcomes.	Fragmentation of authority; lack of resources to engage; entrenched legal regimes; potential for maladaptive adaptation promoting the resilience of some systems over others, for example, water markets could lead to water speculation or monopolies of control.	Engage with boundary organizations; participate in a multi-disciplinary/multi-institutional group; influence systemic change that could benefit the wine industry and the public good; influence long term thinking for long term challenges like climate change.

Recommendations

Multi-disciplinary/multi-institutional approach to tackle complex problems

Collaborative efforts to include a diverse range of stakeholder voices is one opportunity to address complex problems like water resources and climate change. For example, the Oregon Water Resources Department puts forth a goal to form a “nexus” of water governance that brings together considerations for land use planning, infrastructure, permitting, field research, environmental health, public health, and funding (OWRD, 2017). Local engagement and local planning is an opportunity to build capacity in communities to work with state and federal agencies, while ensuring local goals and values are sustained. In one example in Yamhill County in the Willamette Valley, an elected county commissioner has convened a multi-stakeholder group to consider long range planning for water in their region. In a grassroots effort, irrigators in a sub-region of Tasmania successfully lobbied their state political leaders to address citizen concerns about loss of local control of irrigation schemes and other issues with the state level government-business enterprise in charge of irrigation infrastructure and management. These types of efforts align with Sabatier’s (1988) public policy research regarding *advocacy coalition frameworks*, where groups of people from different sectors, not merely government agencies, interest groups, and legislative committees, but also researchers, policy analysts, and journalists, come together to generate and evaluate policy ideas (Jenkins-Smith & Sabatier, 1994).

Engagement with boundary organizations

One opportunity to improve relationships between social systems and institutional systems is to engage and enhance the role of *boundary organizations*. Boundary

organizations refers to collaborative efforts to engage at the intersection of policy and science, often with the goal of the joint construction of knowledge, and informing decision making and policy outcomes (Guston, 2001; Van den Hove, 2007). Boundary organizations, which can include non-governmental organizations, research initiatives, or universities, among others, could be useful for communicating science, conducting outreach, and educating policymakers, politicians, and wine industry producers. An example of boundary organization engagement in wine regions is the nonprofit organization based in Portland, Oregon called Salmon Safe. Salmon Safe partners with the agriculture sector, including the wine industry, on a certified eco-label program for agricultural products. In this case Salmon Safe has a peer-reviewed accreditation program that ensures agricultural and manufacturing practices protect watershed health, and in exchange companies can use labels for promotional purposes (Salmon Safe, 2020).

Redistribution of water rights

In both Oregon and Tasmania there was mention in interviews with water managers, grape farmers, and water researchers about the need to consider changing the legislation that allows those with historic or senior water rights to use the most water. The interviewees questioned the fairness and equity of the current laws. Both regions are experiencing a growing need for water for expanding residential populations, critical wildlife habitat, and the demands of agriculture and industry; at the same time, climate change is projected to reduce water availability. In the Willamette Valley, the prior appropriation doctrine of “first in time, first in right,” results in unevenness in who can access water in the region and who will have their water use restricted during times of shortage. In Tasmania, historic water rights holders are exempt from certain water use

restrictions, creating conflict among neighbors during droughts. Although the need to address the redistribution of water rights was discussed by interviewees in government, research, and the wine industry, it would likely be a slow process due to entrenched legal regimes and stakeholder opposition. The slow timing of the process could be a mismatch with the urgency of climate change risks.

Outreach, education, and incentives

One finding of my research was that many individual grape farmers and vineyard owners do not engage with issues of water governance in their regions beyond their personal situation, and many are not considering long term planning for climate change challenges. One opportunity to expand the level of engagement within the industry is through outreach, education, or incentives. An example in Tasmania is the Australia's Wine Future project, which was jointly funded by the wine industry and the government. For this project researchers created models to determine regional-scale climate change scenarios through 2100, and worked with industry stakeholders to tailor outcomes expressly for their needs. The project resulted in an online atlas that stakeholders can access to understand specific climate trends for growing conditions in their sub-region in Tasmania which can inform short and long term planning decisions (Harris et al., 2020). Another education-related adaptation opportunity for wine regions is to consider their future climate scenarios, then look to other wine regions currently experiencing those conditions in order to learn from their adaptation strategies. For example, if Tasmania's future climate includes more frequent summer rainfall, they can look to Australia's Hunter Valley wine region in New South Wales, where these climatic conditions have been experienced and adapted to for decades (Harris et al., 2020).

Engage in institutional change

At the individual or wine industry level, there is the opportunity to engage in institutional change to impact climate change adaptation outcomes. This engagement could include political involvement through running for office or supporting particular candidates in elections, membership in lobbying organizations, grassroots organizing, or stakeholder coalition-building, which could influence the creation or expansion of water markets; limits to residential, commercial or agricultural development to reduce demand for water resources; re-allocation of water rights; promotion of policy for water conservation; or advocacy for improved ecological outcomes. Industry lobbying organizations do exist in both regions, with the Oregon Wine Board advocating at the state level for the Willamette Valley wine industry, and the industry groups Wine Tasmania and Wine Australia operating with similar missions for the Tasmanian wine industry.

Mitigation

While a number of strategies to deal with climate change have shifted focus from mitigation to adaptation, the Intergovernmental Panel on Climate Change emphasizes that both mitigation and adaptation are essential for climate change risk management. Mitigation slows the rate and magnitude of climate change, allowing for enhanced capacity to plan for and manage risk (Denton et al, 2014). The wine industry has the ability to reduce greenhouse gas emissions to slow climate change through actions like carbon-sequestering farming practices, changes in energy sourcing and consumption, and purchasing carbon offsets. Regenerative agriculture promotes carbon sequestration through no-till practices, the planting of cover crops, and restoration planting on vineyard

properties. These farming practices, called “carbon farming,” sequester and store carbon in the soil and in the plants instead of releasing it into the atmosphere (Montgomery, 2017). One example of mitigation efforts in the Willamette Valley is a program created by the Oregon Wine Board, the “Carbon Neutral Challenge,” which provides information, support, and incentives for participating wineries.

7.2 Conclusion

The research findings suggest that climate change will result in challenges around water resources in the Willamette Valley, including for the wine industry. The current water governance in the region is a top-down structure operating with entrenched legal regimes. Diverse stakeholders with increasing water needs can lead to conflict about access to water resources in the context of a hotter, drier climate, and population and wine industry growth. The combination of entrenched legal regimes and an increase in water demand will likely result in a future of water rights shifting to a commodity market system; where water users will need to have the financial means to buy water and infrastructure.

Climate change will also impact water resources for the wine industry in Tasmania, but the challenges will differ depending on geographical location on the island. The top-down water governance structures in Tasmania have shifted decision making away from local control in recent decades, resulting in concerns about transparency and trust. Federal funding and mandates resulted in the development of a state-wide water allocation system with licensing of use permits. Federal mandates also resulted in the development of irrigation infrastructure to move water around the island and increase agricultural production. Societal values in Tasmania equate water use to the

opportunity for economic growth on the island, which has resulted in the intensification of irrigation scheme development. The lack of state government funding, along with a political focus on economic growth, has shifted water management to a neoliberal, for-profit, government-business enterprise model, where the hydroelectric company and the irrigation system developers hold control over much of the water resources on the island. Water users, including those in the wine industry, pay for access and use of water resources. Climate change and a good reputation for quality are contributing to an influx of investment in the wine industry from larger companies based on the mainland of Australia, which is contributing to a transformation to a more corporatized regional wine industry. Financial resources will continue to influence who can access water resources dependent on location, the ability to successfully lobby for infrastructure, and pay for licenses and water. As in the Willamette Valley, those within the wine industry have a range of attitudes and approaches climate change planning and management; but in Tasmania the importance of water for irrigation and wine production is undisputed.

The research findings show barriers to climate change adaptation in both regions, including top-down governance structures, the fragmentation of authority, the lack of financial and human resources in government management and oversight agencies, issues with equity in access to water, and the potential for maladaptive adaptation outcomes. The need for more economic resources to survive as a wine business in a changing climate will contribute to further consolidation and the influx of larger corporate business entities, resulting in future wine industries with a less diverse economic and cultural fabric. On the other hand, in Tasmania and the Willamette Valley, research findings also identified opportunities to explore climate adaptation in alternative ways; like:

regenerative viticulture practices, engaging with boundary organizations in research and innovation, actively participating in actions around institutional change to affect water governance and long-term planning efforts; all of which could result in a more nuanced and diverse wine industry.

Currently, in both the Willamette Valley and Tasmanian wine regions, the dominant climate change conversation is focused on planting different grape varieties adapted to warm climates, increasing irrigation, and planting vineyards in new sites with suitable future climate conditions. My research contributes new understanding of the importance of considering how relationships between institutional, social, and ecological systems influence climate change adaptation. The ISED framework proved to be useful in organizing and structuring the themes (codes) that emerged from the research data. The framework accommodated analysis aimed at understanding both the complexity of systems and the relationships between systems. One example of this analysis can be found in the Tasmanian case study: Tasmanian Irrigation is an institution existing as the result of federal policy and funding, but also as the result of a society with values equating water with economic growth opportunity. Tasmanian Irrigation greatly influences climate change adaptation outcomes for the Tasmanian wine industry, but these outcomes are dependent on the relationship between the social and institutional systems. The ecological systems are also crucial in this example, because as the narrative vignette “East Coast Struggles: Oversight, Corporate Influence, and Conflict” illustrated in Chapter 6, without adequate rainfall some of the Tasmanian Irrigation schemes will not operate. The ISED framework assisted in my analysis and understanding of the relationships both within and between the institutional, social, and ecological systems.

This research demonstrates there is value in using the qualitative methods research approach of case studies and thematic analysis using the ISED framework to increase understanding and inform individual and regional decision making. This approach can be useful in the context of other global wine regions grappling with climate change and water resources; but also for other issues such as land use, labor, fire risk, or others. In addition, this research approach can have utility outside of the wine region context, and can contribute to building more complex understanding in all areas tackled in social-ecological systems research, like forest management, urban habitat biodiversity, fisheries recovery, etc.

In the agricultural wine region context, the wine industry exists as part of a community and region where water resources are shared by numerous stakeholders. There are opportunities for those within the wine industry to engage in conversation as an industry, and with policymakers and community stakeholders to determine immediate actions and long-term regional climate adaptation planning. These actions can explore how to benefit the wine industry while also minimizing harm to the larger community, and promoting overall ecosystem resiliency.

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Appendix A. Exploratory Research Design

In 2016 I conducted a series of exploratory research trips to wine regions around the globe, where I interviewed a broad set of key knowledge holders in order to better understand issues, attitudes, and perspectives on a wide range of themes impacting human and natural systems. I visited wine regions in Napa Valley, California; the Western Cape of South Africa; the Yarra Valley and Mornington Peninsula in Victoria, Australia; and Tasmania in Australia. I conducted forty-seven semi-structured interviews with wine industry professionals, academic researchers, and professionals or government agency representatives in planning, climate change, water resource management, and environmental conservation (Table A). I used open-ended research questions in the early phase of this research, which informed future research phases (Yin, 2009). Interview participants answered a series of questions around three themes: 1) Social and ecological impacts of wine industry growth on water resources; 2) The role of land use planning decisions in wine regions; and 3) Attitudes and experiences regarding global climate change including planning and adaptation. These research trips included site visits and tours of wineries, vineyards, and water infrastructure projects like dams and reservoirs in each region. I wrote detailed memos following each meeting and transcribed the interview audio. After conducting interviews, memo-ing, transcribing and reading through the data, I interpreted fourteen main patterns (themes) across the dataset. I used Atlas.ti software to assign codes to segments of text in each transcript. The fourteen emergent codes were: adaptation, climate change, communication, consolidation, environmental impacts, growth, labor, identity, legislation/regulation, technology, transformation, viticulture considerations, water and weather. I used the results of the

exploratory research to inform the development of a focused research question in the comparative case study phase of the research.

Table A. 2016 Exploratory interview participants: Napa Valley, CA; Western Cape, South Africa; Victoria, Australia and Tasmania, Australia.

Key Knowledge Holders	Napa	South Africa	Victoria	Tasmania
Wine Industry- Winery and Vineyard Owners, Winemakers, Viticulturists, Marketing Representatives	8	8	6	6
Academic Researchers	1	2	2	3
Professionals or Government Agency Representatives- Planning, Climate Change, Water Resource Management, Environmental Conservation	5	2	2	2
Total- 47	14	12	10	11

Appendix B. Comparative Case Study Interview Guide

1. General themes around water in [Tasmania/ the Willamette Valley]
(stakeholders/users, quantity, quality, climate vulnerability)
2. Water access and use (water rights, where is the water coming from, seasonal or annual variation, how is it being used, etc.)
3. What are the key agencies, institutions, industries “at the table” making decisions about water? Who is missing from the table?
4. Any current or potential future conflict regarding water? Between agricultural sectors, environmental conservation, other industries, municipalities?
5. Any current or future cooperation or opportunities regarding water?
6. Is there sufficient access to and sharing of information about water and/or climate change for stakeholders in [Tasmania/ the Willamette Valley]- including policies, initiatives, science?
7. Is there political will (desire, means, power) to address issues regarding water resources and/or climate change?
8. Potential future scenarios for water governance or regional outcomes for water in [Tasmania/ Oregon]

Appendix C. List of Codes and Sub Codes

1. Attitudes and Perceptions
2. Climate adaptation
 - Barriers
 - Opportunities
 - Geography
 - Strategies
3. Climate change
4. Decision making
 - Who?
 - Who's missing?
 - How are decisions made ?
5. Government regulatory body
6. Economics/Money
7. Environmental concerns
8. Government business enterprise/public-private partnership
9. Irrigation
 - Geography
 - Access
 - Cost
 - Source water
 - Water markets
 - Problems
 - Opportunities
 - Future
 - Infrastructure?
 - Land use/land cover change
10. Legislation or Regulatory Frameworks
 - Federal
 - State
 - Local
11. Oversight
12. Policy and Management Plans- Water Initiatives/Management
 - Federal
 - State
 - Local
13. Political Will
14. Power and Influence
15. Private Property Owners(considerations)
16. Relationships/Communication
 - Who is missing?
 - Conflict?
17. Research
18. Sharing Information or Data

19. Transformation

- Political
- Economic
- Social
- Environmental or Institutional

20. Water

- Water as an economic good
- Water access
- Water rights
- Attitudes and perceptions
- Water quality
- Water quantity
- Environmental considerations

21. Weather/Climate Variability

22. Wine Industry

- Scale
- Ownership
- Location
- Risk/Vulnerability
- Decision making
- Sharing/accessing information?