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Thinking Outside of the Organisational Box

How Private Firms Can Invest in Nature-based Solutions at the Watershed-level to Manage Agricultural Water Risks in California's San Joaquin Valley

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Embarking on a two-year graduate journey has been one of the most rewarding experiences of my life. It has been a lifelong aspiration to play a role in the protection of Earth's awe-inspiring natural resources, and I feel so grateful for the opportunity to learn from a global community of passionate sustainability enthusiasts, and work with innovative solutions in academic and practical settings. Let there be no mistake, this master's programme was challenging. As a wise member of Batch 27 once said "you will have good days and bad days when studying at the Insti". I want to first acknowledge some of the most beautiful people I have ever had the pleasure of meeting: my amazing batch. What would I have done without this incredible support system guiding me through the good and bad days? I am so thankful for each and every one of you and am beyond excited for the lifelong friendships we will enjoy together. I would like to also thank Batch 27 for their wisdom and advice, and Batch 29 for being so incredibly involved in planning and running this past year's events and activities. To the IIIEE faculty and staff, thank you for sharing your expertise and working to support our Batch through personal and academic challenges. I am forever grateful for my advisor, Professor Kes McCormick, whose cutting-edge research into nature-based solutions first inspired me to apply to the Environmental Management and Policy Programme. Additional thanks to the practitioners who took time out of their schedules to participate in my research. Their invaluable perspectives were fundamental to the findings of this thesis. Finally, I would like to acknowledge my loving family, friends and amazing partner who waited patiently for me to return home from my European adventure. Beginning with my childhood participation in a wetland construction project, I have had a life-long fascination with nature-based solutions. Therefore, it is with great pride that I present the results of my graduate thesis research on private engagement with nature-based solutions for agricultural water risk management.

Abstract

Nature-based solutions (NBS) can provide a range of benefits to tackle acute sustainability challenges in an enduring and cost-effective manner. Increasing recognition of the value of these solutions has led to their adoption across the globe. However, a majority of NBS projects are implemented with public funding, though the participation of the private sector is vital to achieve comprehensive operationalization. While private firms may be motivated to invest in NBS to support their philanthropic or corporate social responsibility (CSR) goals, it is imperative to demonstrate the material value of these solutions to promote significant private engagement. Through a review of relevant literature, a risk management motivation was identified as a potential driver of private investment in NBS. California's San Joaquin Valley, with its pressing water scarcity challenges and immense, water dependent agricultural industry, served as an ideal context for a case study to explore the potential for private firms to employ NBS to address their water quantity risks. The reviewed literature also revealed the benefits of adopting a watershed-level approach for water stewardship; thus, the risk management capacity of watershed restoration was selected as a specific NBS category for analysis. Through qualitative interviews with relevant practitioners, and a review of secondary data sources, this thesis aims to demonstrate the business case for NBS by analysing the capacity of select watershed restoration measures to mitigate water risks for private firms with agricultural assets in the San Joaquin Valley. The specific water quantity risks impacting the agricultural sector in this region, and the risk management capacity of watershed restoration measures to mitigate these risks, were analysed using two theoretical frameworks to answer the posed research questions: (1) What are the water quantity risks impacting the agricultural sector in California's San Joaquin Valley region? and (2) What is the water risk management capacity of watershed restoration when employed by private firms with agricultural assets in California's San Joaquin Valley?. In the analysis section, data findings and existing empirical knowledge were synthesized to create a framework to guide future research and practical efforts in this area. Finally, the identified drivers and barriers for private sector engagement with watershed restoration projects as risk management strategies are outlined in the concluding section of this paper.

Keywords: water scarcity, agriculture, private sector, risk management, nature-based solutions, watershed restoration, San Joaquin Valley, water security, value

Executive Summary

Introduction

Nature-based solutions (NBS) are a trending remedy to many modern sustainability challenges. As such, there is ample research about these interventions and an abundance of regional projects utilising the natural services they provide. Currently, most of the funding for NBS projects comes from public sources. However, there is a growing interest in private sector involvement as government budgets become strained.

To incentivize private sector participation, it is essential that firms recognize the value of investment in NBS projects. Although reputational or philanthropic objectives can drive such investments, presenting the true value of engagement with NBS requires the demonstration of direct material benefits. Perhaps the most tangible dynamic in the relationship between the environment and the private sector is industrial natural resource consumption, where the presence or absence of specific resources can directly impact the financial performance of firms.

Water scarcity is most notably pronounced within the agriculture sector. The San Joaquin Valley offers an excellent opportunity to investigate the private sector's reliance on natural resources due to the region's immense, water dependent agricultural industry and acute water scarcity challenges.

Figure 0.1. The San Joaquin Valley (depicted in colour)

Source: Created by the author using data from Hanak et al. (2019). Map base layer sourced from USGS (2005)

The results of a review of relevant literature revealed growing trends and potential benefits for private firms to adopt risk management motivations and watershed-level approaches for investment in NBS to combat water scarcity. These findings were synthesised into a three-step framework, including novel concepts (to the left) and traditionally employed approaches (to the right). Figure 0.2 illustrates this framework, which helped to guide the data collection and analysis.

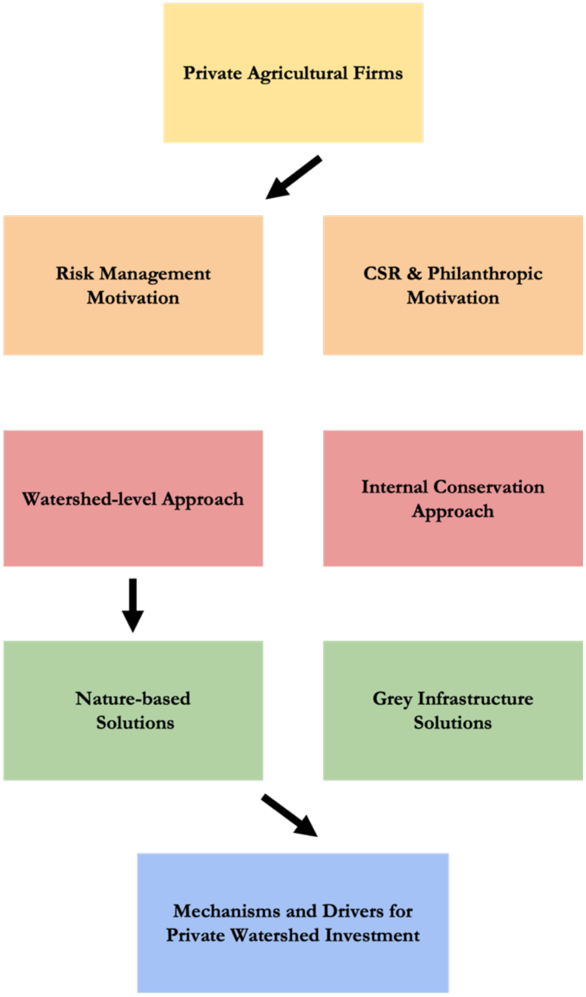

Figure 0.2. The Three Steps for Private Engagement with Water Stewardship

Source: created by the author using relevant themes from the literature review

Problem definition

The problem definition identified for this thesis is twofold. First, there is the practical issue of water scarcity within the San Joaquin Valley which has contributed to severe risks to the viability of the region's agricultural industry. Second, the potential of NBS to address this water scarcity crisis has been gravely underexplored. There are clear deficiencies in both practical examples of private engagement with NBS for water security and topical case studies within the existing body of research.

Aim and Research Questions

The aim of this research is to demonstrate the business case for private investment in NBS by analysing the capacity of select watershed restoration measures to mitigate water risks for firms with agricultural assets in the San Joaquin Valley. To support this aim, two research questions have been formulated:

RQ 1: What are the water quantity risks impacting the agricultural sector in California's San Joaquin Valley region?

RQ 2: What is the water risk management capacity of watershed restoration when employed by private firms with agricultural assets in California's San Joaquin Valley?

Research Design, Materials and Methods

Because the research questions require a focus on a specific problem context, a qualitative, descriptive, single case-study design has been chosen to answer these questions. First, a review of relevant literature was conducted to establish major themes, knowledge gaps and industry trends. Next, a collection of secondary data sources, including documentation and archival records, were examined. Finally, to gain an understanding of the private sector's perspective of water risk and the risk management capacity of watershed restoration projects, primary data was collected through interviews with relevant practitioners. Data from these sources was then analysed through an inductive Thematic Content Analysis (TCA).

Theoretical Frameworks

Two theoretical frameworks were employed to analyse the collected data.

To support RQ 1, a Risk Assessment Factor Framework, derived from Ronco et al. (2017), was selected. Figure 0.3 below illustrates the three factors within this framework: hazard, exposure and vulnerability.

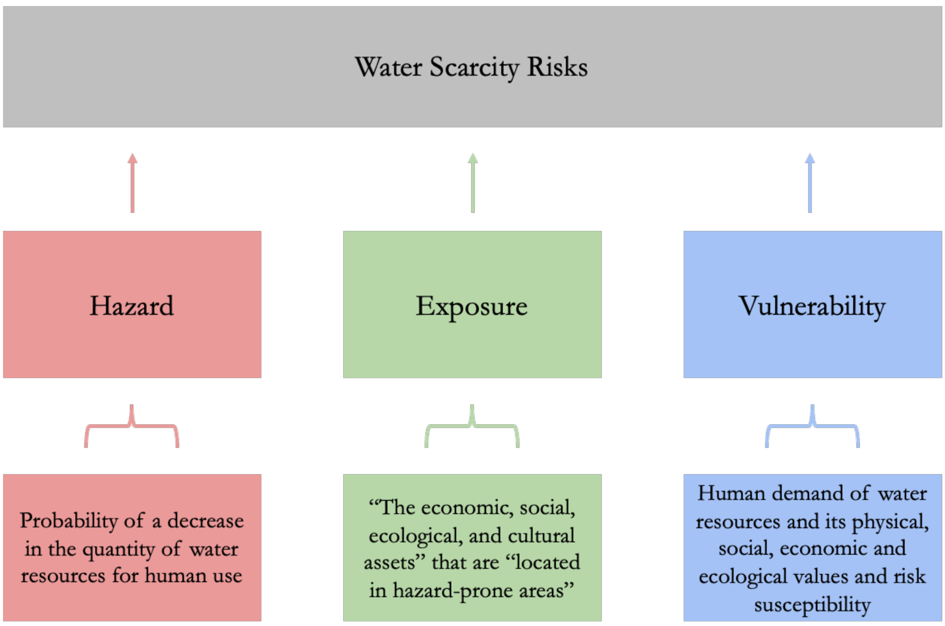

Figure 0.3. Risk Assessment Factor Framework

Source: Created by the author, based on risk assessment factors presented in Ronco et al. (2017)

To answer RQ 2, Risk Management Capacity Factor Framework, taken from Jaffe et al. (2010), was utilised including three factors: availability, access and timing. Figure 0.4 illustrates this framework below.

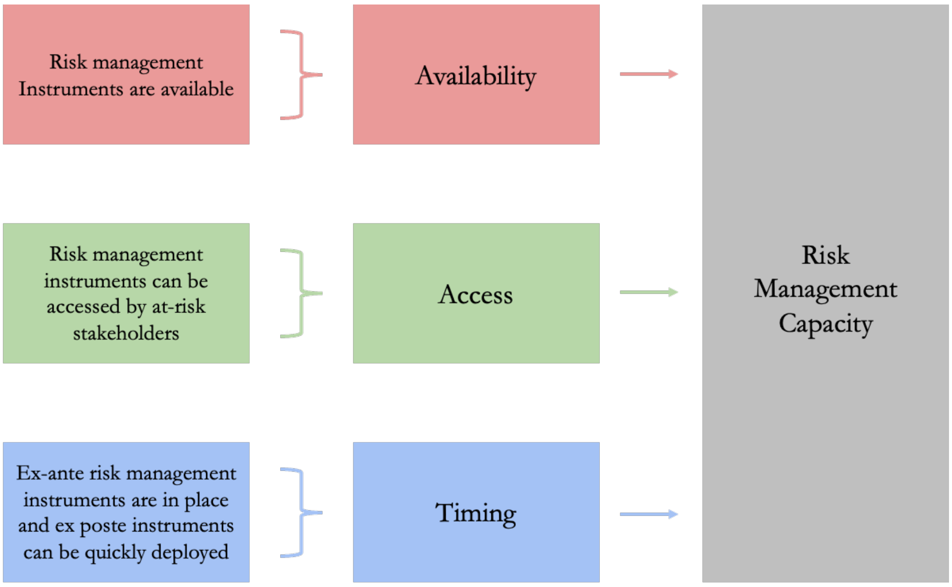

Figure 0.4. Risk Management Capacity Factor Framework

Source: Created by the author, based on risk management capacity factors presented in Jaffe et al. (2010)

Findings and Results

A summary of the answers to the two research questions, achieved through the application of the aforementioned theoretical frameworks for data analysis, is presented below.

RQ 1: What are the water quantity risks impacting the agricultural sector in California's San Joaquin Valley region?

Hazard

The probability of a decrease in the quantity of water resources for agricultural use in the San Joaquin Valley is increased by clear physical, regulatory and reputational risks. Physical risks include natural phenomena (droughts, wildfires and increasing temperatures) and anthropogenic activities (groundwater overdraft and urban water supply competition). Regulatory risks (conservation regulation, the Sustainable Groundwater Management Act and water fee increases) as well as reputational risks (stemming from consumer and investor perception) furth contribute to a substantial water risk hazard.

Exposure

Firms with agricultural assets in the San Joaquin Valley, the communities they support and the ecosystems they compete with, represent the exposed assets located within the hazard prone San Joaquin Valley.

Vulnerability

Because of the agricultural sector's reliance on freshwater resources, firms within the San Joaquin Valley are especially vulnerable to water risks. Consequently, the communities supported by the agricultural industry, as well as the ecosystems within the valley, are also vulnerable to risks associated with decreasing freshwater supplies.

RQ 2: What is the water risk management capacity of watershed restoration when employed by private firms with agricultural assets in California's San Joaquin Valley?

Availability

Source watersheds and fallowed agricultural land within the San Joaquin Valley are in critical need of restoration. Furthermore, there are a range of available avenues, partnerships and mechanisms which contribute to the availability of watershed restoration projects that can serve as risk management instruments. Specific restoration measures which have been identified include meadow, forest and stream restoration (within source watersheds), as well as wetland construction and the conversion of agricultural land (with the San Joaquin Valley floodplain).

Access

Several barriers, including value realisation, lengthy return on investment (ROI) timeframes, perceived risks in NBS investment and the fragmented nature of restoration projects, may inhibit private access to watershed restoration for water risk management. Conversely, drivers, such as novel financial mechanisms, multistakeholder partnerships (MSPs), government incentives and demonstrated examples of successful restoration projects, could help to promote private sector access to watershed restoration projects.

Timing

To adopt a proactive approach to risk management, private agricultural firms with assets in the San Joaquin Valley should look to invest in local watershed restoration before key landscape features are further degraded or developed in a nonstrategic manner. Issues, related to the long-time frame of natural processes, may reduce the capacity of restoration projects to mitigate agricultural water risks in an ex-post manner.

Conclusions

The following list summarises the major barriers and drivers associated with private investment in the identified watershed restoration techniques, to address agricultural water risks.

Barriers

1. A high risk perception associated with NBS and watershed restoration investment

2. A lack of technical or scientific know-how to support investment in restoration projects

3. The long-time frame for the full realisation of restoration projects which rely on natural processes

4. Most NBS and watershed restoration projects are implemented in a fragmented manner at smaller scales, while the true benefits of such solutions are realised at larger, comprehensive scales

5. Private firms often view water as a public good, and have largely failed to attribute adequate value to this natural resource

6. The private sector has traditionally adopted philanthropic and CSR motivations for water stewardship investment, and an understanding of the material risks associated with freshwater scarcity is lacking

Drivers

1. Government collaboration and MSPs can allow for investment risk sharing and reduction

2. Third party experts, including NGOs, landowners and government agencies, can fill knowledge-gaps and provide technical support for private firms looking to invest in watershed restoration

3. The large areas of watershed land in need of restoration within the San Joaquin Valley, and the collection of existing restorative projects and actors in the region, provide an opportunity for private firms to invest now to mitigate future water risks in an ex-ante manner

4. Adopting a watershed-level approach for private water stewardship will allow for a realisation of the full range of benefits associated with restorative NBS

5. With growing corporate, consumer and investor concern regarding global freshwater scarcity, the need for a private firm to adopt a risk management motivation for water stewardship investment will be promoted by the introduction of novel frameworks, monitoring schemes, financial incentives and competitor "peer pressure"

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Abbreviations

TCA - Thematic Content Analysis

CSR - Corporate Social Responsibility

NBS - Nature-based Solutions

PWS - Payments for Watershed Services

PES - Payments for Ecosystem Services

ROI - Return on Investment

NGO - Non-government Organisation

PPP - Public-private Partnership

CVP - Central Valley Project

MAF - million acre-feet (of water)

SGMA - Sustainable Groundwater Management Act

ESA - Endangered Species Act

IBTs - Inter-basin Water Transfers

FRB - Forest Resilience Bond

Multi-stakeholder Partnership (MSP)

GSA - Groundwater Sustainability Agency

1 Introduction

Nature-based solutions (NBS) are a trending remedy to many modern sustainability challenges. As such, there is ample research about these interventions and an abundance of regional projects utilising the natural services they provide. NBS can provide sustainable alternatives to grey infrastructure by addressing a wide range of environmental problems in a financially sound and resource-efficient manner. Currently, most of the funding for NBS projects comes from public sources. However, there is a growing interest in private sector involvement as government budgets become strained. Though many techniques for operationalizing private engagement with NBS have emerged in recent years, the share of private NBS investment remains insignificant. To incentivize private sector participation, it is essential that firms recognize the value of investment in NBS projects. Although reputational or philanthropic objectives can drive such investments, presenting the true value of investment in NBS requires the demonstration of direct material benefits. Perhaps the most tangible dynamic in the relationship between the environment and the private sector is industrial natural resource consumption, where the presence or absence of specific resources can directly impact the financial performance of firms.

Freshwater is a fundamental element of industrial and agricultural operations. In the past, this natural resource has been seen as a "public good", and private firms have taken water resources for granted by failing to recognize their actual economic value (Hoekstra, 2014). Nevertheless, as the global threat of water scarcity has become more pronounced in recent decades, private firms have begun to recognize the finite nature of this resource. In a 2012 survey, the World Resources Institute found that 53% of responding Fortune 500 companies "had experienced detrimental water-related business impacts" (Reig et al., 2013). With changing weather patterns and increasing drought conditions resulting from changing climates, private firms will likely experience further freshwater scarcity, posing a direct threat to their resilience and profit-making.

Water scarcity is most notably pronounced within the agriculture sector. Seventy percent of global freshwater consumption is attributed to agricultural uses, and consequently, this sector has been at the forefront of interventions for water stewardship (PRI, 2018). The resilience of agricultural-dependent companies (such as those in the food and beverage, or garment industries), as well as many national and regional economies, hinges on available freshwater for agricultural production (The World Bank, 2020). A prime example of this reliance can be seen in California's San Joaquin Valley, "the most productive agricultural region in the United States" (California Natural Resources Agency, 2022). This fertile region has become "ground zero" for water scarcity problems stemming from severe drought, wildfires, decreased snowpack and groundwater overdrafts (Hanak et al., 2019). Given these pronounced water scarcity challenges and the region's extensive agricultural production, the San Joaquin Valley offers an excellent opportunity to investigate the private sector's reliance on natural resources.

The initial aim of this thesis research was to ascertain incentives for private sector engagement with nature-based solutions for freshwater security, or how can private firms be incentivised to invest in NBS for freshwater security? Through a review of relevant literature, it became clear that large-scale private investment in nature-based solutions requires risk management motivations and a watershed-level approach. Agricultural firms' dependence on freshwater resources creates a strong incentive for such firms to invest in solutions that safeguard their access to freshwater. With a growing understanding of the role of NBS in combating water scarcity challenges, the material value of investment in these solutions may be more clearly demonstrated. Consequently, the specific context of the San Joaquin Valley, with its urgent water-related challenges and expansive agricultural industry, has been selected to serve as a case study to examine the potential for private sector engagement with NBS.

1.1 Problem Definition

The problem definition identified for this thesis research is twofold. First, there is the practical issue of water scarcity within the San Joaquin Valley which has contributed to severe risks to the viability of the region's agricultural industry. Second, the potential of NBS to address this water scarcity crisis has been gravely underexplored. There are clear deficiencies in both practical examples of private engagement with NBS for water security and topical case studies within the existing body of research.

1.1.1 Practical Problem

Introduction to the Context

The San Joaquin Valley is situated within California's Central Valley region and lies between the Sierra Nevada Mountain Range (to the east) and the California Coastal Range (to the west) (Hanak et al., 2019). The San Joaquin Valley is composed of two watersheds: the San Joaquin River and Tulare Lake Hydrologic Regions (Hanak et al., 2019). Though the Sacramento River Watershed makes up the northern segment of the Central Valley, it is not part of the San Joaquin Valley and will therefore not be included in the scope of this study. Figure 1.1 depicts the San Joaquin Valley region (colorised) within the state of California. This specific area was selected for study because of its severe water scarcity crisis and the substantial size of its agricultural sector.

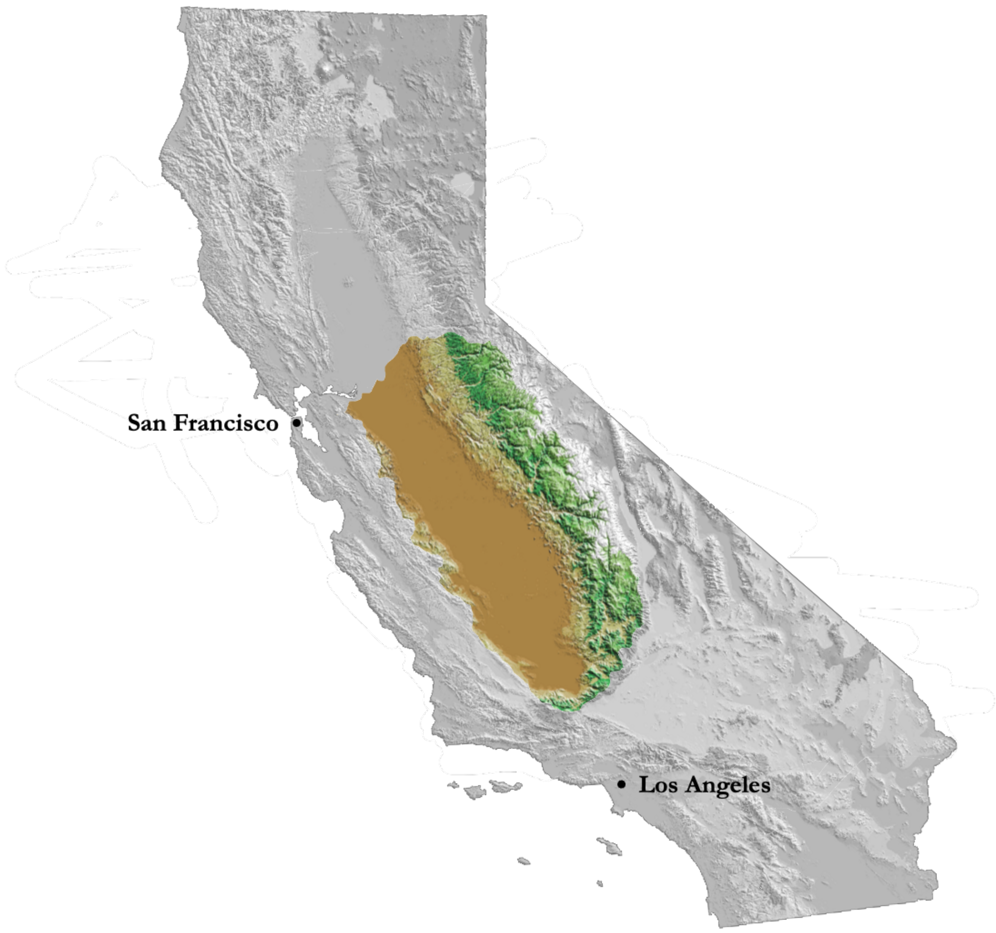

Figure 1.1 The San Joaquin Valley

Source: Created by the author using data from Hanak et al. (2019). Map base layer sourced from USGS (2005)

Natural Hazards

The water scarcity problem in the San Joaquin Valley is a growing environmental and economic crisis that requires timely and innovative interventions. Natural phenomena, driven by climate change, have created a freshwater deficit in the region. These phenomena can be broken down into four types; (1) wildfire, (2) drought, (3) flooding and (4) decreased snowpack. In 2020, wildfires cost the state's wine industry $3.7 billion through the destruction of vineyard assets (Gartner et al., 20). Along with cropland destruction, wildfires can also have direct effect on water quality and quantity by introducing pollutants and sediments to waterways (Buckley et al., 2014). Specifically, wildfires within the Sierra Nevada region, the source of 60% of California's water supply, threaten to disrupt the natural flow of freshwater resources (Buckley et al., 2014).

California's prolonged drought periods are a leading cause of the San Joaquin Valley's water scarcity crisis. As of 2022, "most of the State is under severe drought conditions with approximately one-third of the state under extreme or exceptional drought conditions… The Exceptional Drought area is mostly located in the San Joaquin River and Tulare Lake Hydrologic Regions" (California Department of Water Resources, 2022). Though California has received some relief through the torrential rain brought about by atmospheric rivers (October 2022 - March 2023), concerns about the fluctuation between dry and wet periods prevail (Toohey, 2023). Participant 3 pointed out this "recent surplus of water" but emphasised the need for "predictable sources of water" for agricultural stability (Interview 3, 2023).

Paradoxically, the recent atmospheric river conditions have presented another water risk for California: extreme flooding events. Dry, hydrophobic soil created by years of drought conditions has made the San Joaquin Valley particularly vulnerable to flooding during times of excessive rainfall. Within the larger Central Valley region, it is estimated that volumes of flood water could increase fivefold between 2022 and 2072 (Bardeen, 2022). Although the recent excess of rain ushered in the end of some drought restrictions, these fluctuating weather conditions have highlighted the unreliable freshwater flows within the state (Toohey, 2023).

A final natural hazard that has impacted water supplies within California is the depletion of snowpacks within the headwater regions of major watersheds. California's climate is rapidly warming, leading to decreased snowfall and earlier spring melt (Bardeen, 2022). "Roughly a third of the state's annual [freshwater] supply is stored as snowpack that melts during the spring and early summer when water demands are high" (Public Policy Institute of California, 2016). Without a gradual snowmelt that provides water flow during dryer periods, water scarcity in the San Joaquin Valley will continue to increase dramatically (Public Policy Institute of California, 2016).

Agricultural Sector

Output from the San Joaquin Valley's agricultural sector comprises half of California's total annual crop yield (Escriva-Bou et al., 2023). As of 2018 "4.5 million acres of cropland were irrigated in the region, using 16.1 million acre-feet (MAF) of water" (Escriva-Bou et al., 2023). Economic outputs from this agrarian region include greater than $24 billion in direct crop revenue, while $34 billion in food and beverage revenue is dependent on crops from the San Joaquin Valley (Escriva-Bou et al., 2023). The economic dependence of the region on agriculture cannot be overstated; nearly one-fifth of the region's population is employed in the agricultural sector (Hanak et al., 2019).

The region's reliance on agriculture and the occurrence of natural hazards driven by changing climatic conditions has created an accelerating water scarcity crisis. Water scarcity explicitly impacts crop irrigation, a major driver of freshwater withdrawals in the San Joaquin Valley (Hanak et al., 2019). In support of crop irrigation, "Chronic overpumping of groundwater has dried up wells and damaged infrastructure (Hanak et al., 2019). Additionally, water imports from other regions, which utilise a series of canals, aqueducts and other grey infrastructure to supplement the groundwater supply within the valley, are also running low (Bland, 2022).

Water scarcity impacts will continue to have severe effects on the agricultural sector within the San Joaquin Valley. Due to groundwater overdraft, large segments of farmland within the region will need to be fallowed or come out of production. Escriva-Bou et al. (2023) estimate that, in the worst-case scenario, "nearly 900,000 acres of farmland would be fallowed, almost 50,000 jobs would be lost, and regional economic activity would decline by 2.3 percent". Additionally, more than $7 billion dollars in lost agricultural revenue could occur in the coming decades due to the fallowing of farmland in the San Joaquin Valley (Fresno State California Water Institute, 2020).

Research Problem

Through a review of existing academic articles and grey literature, several key points have emerged which justify the academic relevance of the chosen thesis topic. Though there is growing enthusiasm for NBS, and a surplus of successful project examples across the world, a vast majority of NBS projects have been fully funded by public sources, with very little participation from the private sector. Unsurprisingly, there is limited research about the role of private actors in NBS projects, and most research on this topic has been conducted within the context of the European Union. Several relevant studies have called for further exploration of this topic outside of Europe (Mayor et al., 2021).

To successfully combat the San Joaquin Valley's water scarcity crisis, innovative solutions must be explored that offer viable alternatives to groundwater pumping and severely decaying grey infrastructure[1] (Fresno State California Water Institute, 2020). Research has indicated that NBS, or natural infrastructure, could be one innovative alternative to dilapidated infrastructure. "Economic analysis has demonstrated that in some cases, natural infrastructure can supply the same quantity and quality of water at lower costs" (The World Bank, 2020). The ability of nature-based solutions to support California's water security goals was affirmed by Governor Gavin Newsom in 2020, who "outlined a comprehensive and results-oriented agenda to expand nature-based solutions across California through Executive Order N-82-20" (California Natural Resources Agency, 2022).

As revealed by the literature review in Chapter 3, there is a serious deficiency in private engagement with NBS. To realise the full array of water security benefits which may be achieved through scaled-up NBS projects, supplemental funding from the private sector is vital (Dhyani, et al., 2021). To encourage mainstreaming of NBS with private sector support, it is essential to emphasise the business case for NBS (Watkins et al., 2019). The goal of this research is to demonstrate the business case for NBS by illustrating the material value of privately funded NBS projects to promote water security.

Specifically, this thesis will address four major research gaps in the existing literature. First, there is substantially insufficient academic literature and practical examples of private engagement with NBS. Secondly, most of the research into NBS has been conducted within Europe, and further research is needed to understand dynamics within other continents (Kooijman et al., 2021). Third,

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[1] Also referred to as built infrastructure; includes dams, canals and pumping stations

a majority of NBS projects have been implemented within an urban context, and further studies about the potential for rural application are needed (Kooijman et al., 2021). Finally, NBS initiatives within the private sector often fall within corporate social responsibility functions, driven by philanthropic motives rather than economic value (Watkins et al., 2019). Therefore, a case study, focusing on business rationales for privately funded NBS within the context of rural North America, was selected to address these four identified research gaps.

Aim and Research Questions

As previously stated, the initial aim of this research was to identify incentives for private sector engagement with nature-based solutions to achieve water security. Through the literature review and preliminary research (including the completion of a thesis proposal assignment), the aim of this thesis was further refined based on identified knowledge gaps and considering the acute water scarcity crisis in California. The reviewed literature revealed that a risk management motivation and watershed-level approach are likely the most effective channels for private investment in NBS to promote freshwater security. The updated research aim for this thesis is to demonstrate the business case for private investment in NBS by analysing the capacity of select watershed restoration measures to mitigate water risks for firms with agricultural assets in the San Joaquin Valley.

To fulfil this research aim, a description of major water risks impacting the studied population is needed. This can be achieved through the application of research question (RQ) 1:

RQ 1: What are the water quantity risks impacting the agricultural sector in California's San Joaquin Valley region?

As RQ 1 describes the practical problems impacting the studied region, the next logical step is to study potential interventions through an analysis of selected risk mitigation measures. This is satisfied by RQ 2:

RQ 2: What is the water risk management capacity of watershed restoration when employed by private firms with agricultural assets in California's San Joaquin Valley?

Scope and Delimitation

To set the scope of this case study, several factors were considered. First, a geographic boundary for the study was selected. Because the initial aim of the research was to better understand private engagement with NBS, and most of such research has been conducted within Europe, the author chooses to focus on regions outside of this continent. Several locations were considered for this thesis, including Bengaluru, India. However, initial exploratory research of this region revealed significant barriers to obtaining sufficient data. Ultimately, the author identified California's San Joaquin Valley (USA) as a viable case study context with acute sustainability challenges.

The issue of water scarcity impacting the San Joaquin Valley is a widely publicised sustainability issue, especially within the United States. Several articles refer to this region as "ground zero" for implementing water stewardship actions (Hanak et al., 2019). Furthermore, the variety of land types that comprise the valley's watersheds suggest that many different types of NBS can be utilised to achieve the valley's water security objectives; thus, offering a unique opportunity to study and compare these different NBS techniques (Fresno State California Water Institute, 2020). Another important justification for selecting this particular scope stems from the ability to fill another predetermined research gap: a majority of NBS research has been conducted within urban settings (Kooijman et al., 2021). Focusing on a larger, mostly rural region, will allow for a new perspective within NBS literature, and could provide insights into large-scale NBS investments which are more likely to attract private-sector investors (Mayor et al., 2021).

A second scoping consideration pertains to the temporal boundaries of the case study. The primary deliberation here involved the selection of data sources. Only sources published after 2010 were selected, as these were determined to be sufficient for addressing the contemporary and dynamic nature of the selected sustainability dilemma. Nevertheless, because water scarcity conditions and potential mitigating measures are reliant on historical and current conditions, collected data includes information from a period between the early nineteenth century (when the valley began to be developed for agricultural use) and the present day (Austin, 2022).

Third, scoping considerations were given to the particular type of private firms which were to be studied. The decision to focus on private sector firms with agricultural assets within the San Joaquin Valley was straightforward, as agriculture comprises most of the world's freshwater use (PRI, 2018). Because the agricultural sector within the valley is so dominant, and due to the reliance of the sector on rapidly depleting water resources, this particular scoping decision was based on a need to identify a private sector group with high natural resource use operating in a resource-starved location (Escriva-Bou et al., 2023). By establishing this dependency and urgency, the value of investment in NBS can be more clearly demonstrated. Additionally, land use by the private agricultural sector within the valley has directly contributed to a loss of watershed assets, leading to a depletion of the freshwater flows they provide (California Natural Resources Agency, 2022). This has resulted in an urgent need for restorative NBS projects within the valley, creating ample opportunities for private-sector NBS investment.

The final scoping consideration involved the selection of specific NBS interventions that could contribute to water security within the San Joaquin Valley. The first decision, to focus on watershed-level restoration, was justified by the literature review, found in Chapter 2. Once this decision was made, specific NBS techniques were identified through the collected data and can be broken down into two general categories. These are (1) watershed restoration within the San Joaquin Valley floodplain, such as wetland construction or stream-bank improvement, and (2) restoration of the various headwater regions that drain into the Valley, including forest, stream and meadow restoration.

Ethical Considerations

Several ethical considerations for this thesis have been contemplated. First, the intent of this research will be to uncover mechanisms to increase the water security of communities that rely on agriculture within the San Joaquin Valley and should not be used to promote profit-making over the interests of those affected by water shortages. Though the outcome of this thesis will be an identification of value-based business incentives for encouraging private sector participation, the core function of NBS should always be the promotion of human health and environmental protection. Finally, secure data storage and the proper credit and citation of sources will be duly applied. All collected data will be stored in the author's password-protected device and within Lund University's Google Drive and Microsoft Office cloud databases, where the author is the sole account owner.

Participation in the study will be fully voluntary, and the identity of participants will be protected unless otherwise requested (Creswell & Creswell, 2018, pg. 152). All study participants were provided with an overview of the purpose of the study prior to their participation (Creswell & Creswell, 2018, pg. 49). Furthermore, interview participants were given an Informed Consent Form (see Appendix I) which detailed their rights and outlined the purpose of the study. According to (Creswell & Creswell, 2018), such forms should include:

1. Identification of the researcher
2. Identification of the sponsoring institution
3. Identification of the purpose of the study
4. Identification of the benefits of participating
5. Identification of the level and type of participant involvement
6. Notation of risks to the participant

This form did not include information pertaining to numbers 4 or 6 above. It was determined that no notable risks would be created by participation in interviews, as the identities of participants would be kept completely confidential. Furthermore, participants were informed of the potential benefits of participation through initial emails, phone calls and LinkedIn direct messages which conveyed the relevance of the thesis topic to their own professional or academic work.

Finally, this research has been conducted independently, and, apart from guidance and advice by faculty at the International Institute for Industrial Environmental Economics, no organisation, firm or institution has had any major influence over the outcome of this thesis. No external organisation or actor has funded this thesis project in any way. Finally, the design of this thesis project was reviewed using questions to determine if the research warranted a review from an ethics board at Lund University. Based on this, it was determined that no such review was required for research conducted in pursuit of this thesis.

Audience

The intended audience for this thesis shall be policymakers, private sector actors, NGO representatives and researchers who are seeking solutions to water scarcity risks or focusing on the potential of NBS to contribute towards various water security goals. These may include actors working directly within the studied context, or others who may be able to draw useful conclusions for similar work outside of the San Joaquin Valley. Target audiences working directly within the San Joaquin Valley could include California state government officials, representatives from conservation groups, sustainability teams working for agricultural companies, and decision makers for larger corporations with supply chain reliance on the San Joaquin Valley, among others. It is hoped that the outcomes of this research will provide useful guidance for actors to explore NBS for water risk management, and establish a detailed illustration of the specific conditions, barriers and drivers that are present in the San Joaquin Valley.

Outline

Chapter 1 (Introduction) - This chapter commences with an overview of the research topic and selected context, followed by a description of the practical sustainability problem and identified research problem. Next, the aim and research questions are presented followed by the scope and limitations, ethical considerations and intended audience.

Chapter 2 (Literature Review and Theoretical Framework) - Here, a comprehensive literature review is presented, where research gaps and the current state of knowledge regarding the initial research topic are explored. Furthermore, two theoretical frameworks to guide the data analysis, drawn from the literature review, are outlined in Chapter 2.

Chapter 3 (Research Design, Materials and Methods) - In this chapter, the methodology and design of the thesis are presented, followed by an explanation of data types, data sources and analysis methods to collect and process data. Additionally, reliability and validity considerations are described in this chapter.

Chapter 4 (Data Presentation and Analysis) - In Chapter 4, qualitative data from primary and secondary sources are presented under headings that correspond with the thematic categories identified in the initial data analysis.

Chapter 5 (Discussion and Recommendations) - Here, the findings of the research are analysed through the two theoretical frameworks presented in Section 2.2. A synthesis of thesis findings and existing knowledge is then presented. Limitations to the research design and methodology are also discussed in Chapter 5.

Chapter 6 (Conclusions) - In this chapter, key takeaways from the research and concise recommendations are presented.

2 Literature Review and Theoretical Framework

The purpose of this chapter is to present the contemporary knowledge and current conditions related to the initial research topic; incentives for private sector engagement with nature-based solutions for water security. The first segment of this chapter serves as a literature review, where only academic articles and research papers have been considered. This literature review illustrates the current "state of affairs" related to private water stewardship and private engagement with NBS. The methodology employed for Chapter 2 can be found under Section 3.2 in the subsequent Chapter.

Literature Review

Here, the results of a review of relevant academic literature are presented. Please see Section 3.2 below for an explanation of the methodology used to conduct this review. The identified literature can be broken down into four general categories; (1) literature about motivations for private sector engagement with water stewardship, (2) literature about approaches for private sector investment in water security, (3) literature pertaining to NBS theory and (4) literature related to the current state of private sector engagement with NBS. The literature review will first be organised into these four broad categories. The emergent coded themes identified in the literature review are presented as subheadings under each of these four broader categories.

Motivations for Private Sector Engagement with Water Stewardship

The following section describes the motivations that drive private sector engagement with water stewardship measures. The two thematic categories presented here are (1) reputational considerations and (2) water as a material risk. These two categories encapsulate the majority of identified motives driving private sector investment in water stewardship.

Reputational Considerations

Traditionally, private firms have adopted sustainable agendas as a form of marketing to address "evolving societal views" on various environmental issues (Debaere & Kapral, 2021). Indeed, the issue of water scarcity is a prime example of a pressing concern that has already begun to impact consumer behaviour. It is no surprise then that a primary motivation for private water stewardship comes from reputational considerations (Debaere & Kapral, 2021).

According to Dumont-Bergeron & Gramlich (2021), many private firms "are not only water-dependent but also voracious when it comes to freshwater consumption". Most notable are firms in the agriculture sector, which are responsible for 70% of global freshwater consumption (Dumont-Bergeron & Gramlich, 2021). Private firms within water-dependent sectors are at the forefront of negative consumer opinion considering growing water scarcity challenges across the globe (Dumont-Bergeron & Gramlich, 2021). Because water has long been considered a public good, private companies have been able to undervalue and overconsume this natural resource without any real reputational consequences (Debaere & Kapral, 2021). However, as the link between private sector consumption and growing water scarcity has become increasingly clear to consumers, private firms have been forced to address their water use through various corporate social responsibility (CSR) and philanthropic measures (Debaere & Kapral, 2021).

Water as a Material Risk

While reputational concerns have driven many private firms to employ water stewardship practices, managing "financially material risks" is the most powerful motive to encourage private engagement with water stewardship (Reig et al., 2019). This is because a private firm can directly attribute risk management investments to its material risks, comparing the costs of implementing a risk management strategy with costs related to the impacts of the identified risks. Because private sector investments rely on a "realistic" return on investment (ROI), approaching corporate water stewardship from a risk management perspective allows for an attribution of monetary value to freshwater resources (Debaere & Kapral, 2021).

"Risk is the possibility that an event will occur with a potentially negative impact on the achievement of a farm or firm's performance objectives and/or on the successful functioning of the overall supply chain" (Jaffe et al., 2010). There are three major categories of water risk which have been identified in the reviewed literature. These are physical, regulatory and reputational risks (Reig et al., 2013). Reputational risks have been described in the Reputational Considerations thematic category above. However, because private firms generally separate their risk management and marketing operations, and because reputational considerations were identified as the most common motivation for private sector water stewardship, this type of risk was assigned a separate thematic category in the literature review.

Regulatory risk impacts stem from water pricing, sanctions and water rights (Dumont-Bergeron & Gramlich, 2021). Changing regulatory requirements and increasing water prices can be expected as freshwater continues to be unsustainably consumed (Jaffe et al., 2010). Paradoxically, a lack of proper regulation may present physical risks for certain private firms, as competing companies consume depleted freshwater resources without restraint (Dumont-Bergeron & Gramlich, 2021).

Physical water risks arise from issues pertaining to water quality and quantity (Dumont-Bergeron & Gramlich, 2021). However, this thesis will primarily focus on risks arising from water scarcity. According to Hoekstra (2014), "The growing scarcity of freshwater due to rising water demands and a changing climate is increasingly seen as a major risk for the global economy". Freshwater scarcity can contribute to water stress, which is "the ability, or lack thereof, to meet human and ecological demand for freshwater" (Dumont-Bergeron & Gramlich, 2021). For private firms, physical water risks can manifest in supply chain sourcing issues, operational disruptions and other material impacts (Dumont-Bergeron & Gramlich, 2021).

Despite growing water risks and risk awareness, private sector water stewardship actions are lacking "because frameworks to assess, record, and report are neither globally adopted and widespread, nor locally suited" (Dumont-Bergeron & Gramlich, 2021). To bridge this gap between awareness and action, it is important to collect qualitative information about the "impact of water risk on supply chains, production infrastructure, and distribution systems" (Dumont-Bergeron & Gramlich, 2021). Understanding and valuing water risks is essential to promoting sustainable freshwater consumption in the private sector, and private firms should incorporate water risks into their business strategy (Dumont-Bergeron & Gramlich, 2021).

Approaches for Private Sector Investment in Water Security

In the previous section, motivations for private sector engagement with water stewardship have been identified. This section describes approaches or mechanisms through which private firms engage with water stewardship activities. Under this general category, four thematic categories were uncovered. The first is the concept of a Watershed-level Approach, where water risks are considered as part of a larger hydrologic system. The second thematic category is CSR and Philanthropic Activities, through which a majority of private water stewardship measures are implemented (Debaere & Kapral, 2021). The third thematic category, Multi Stakeholder Initiatives, includes Public-private Partnerships (PPPs) and other collaborative strategies to achieve shared water goals (Reig et al., 2019). Finally, thematic category four, Impact Investment and Payments for Ecosystem Services (PES) summarises the specific investment mechanisms through which private firms can contribute to external water stewardship interventions and natural resource management.

Watershed-level and Internal Conservation Approaches

Water stewardship activities implemented by private firms can be categorised into two classes: internal and external measures. It is far more common for a firm to implement internal best practices for water conservation, where both water use and mitigation measures fall directly within the firm's organisational boundaries (The World Wildlife Fund, 2011). For example, a company may install more water-efficient appliances in their production line, or a farm may utilise precision irrigation practices to conserve water (Escriva-Bou et al., 2022). However, looking beyond the internal "fence line" allows a private firm to address water risks that may stem from events or phenomena outside of their organisational control (Reig et al., 2019).

It should come as no surprise that a majority of literature pertaining to private sector water stewardship discusses internal water conservation practices, as these measures represent the majority of private water stewardship action (The World Wildlife Fund, 2011). Yet, freshwater resources are extracted from broad hydrologic systems, and internal action may not be sufficient to fully address a firm's water risks. "Reducing your water footprint by 20% — while commendable and even necessary — won't insulate your business from major water supply disruptions caused by droughts or wildfires" (Gartner et al., 2022). Several reviewed articles introduce the concept of a watershed-level approach to water stewardship (this is also referred to as "catchment" or "basin" management). Holistic water risk management can be most effective when restorative efforts focus on the broader watershed "as a combination of social and ecological forces" (Christian-Smith & Merenlender, 2010). The most noticeable watershed-level concern is the disruption of the ecosystem services provided by "natural infrastructure", that are disrupted by excessive urban and agricultural development (Varshini, et al., 2022). A loss of natural infrastructure, such as wetlands, can "weaken resilience to rapidly changing climate conditions and ultimately hinder economic development" (Wilson & Browning, 2012). Private firms are impacted by risks resulting from natural phenomena and should therefore look to manage these risks by focusing on natural infrastructure. While the conventional response to water scarcity concerns has been an investment in "grey infrastructure", watershed improvement can function as a "critical complement" to built infrastructure projects for water security (Wilson & Browning, 2012).

Perhaps as a consequence of this novel perspective, there is a growing interest in watershed-level investment within the private sector (Reig et al., 2019). The literature presented two specific examples of this, where The Coca-Cola Company (Coke) and Nestlé S.A. (Nestlé) have invested in wetland restoration projects in high-risk watersheds within their supply chains (Debaere & Kapral, 2021). Though these actions are relatively small in scale, and most likely initiated by marketing or reputational considerations, the mere presence of such private investment may create a snowball effect where watershed restoration is legitimised by a demonstration of successful projects. Indeed, several reviewed articles have highlighted a "growing interest in financial investment in water" (Debaere & Kapral, 2021).

CSR and Philanthropic Activities

As is likely the case in the examples of Coke and Nestlé investing in watershed restoration, many privately funded external water stewardship endeavours occur through the CSR or philanthropic objectives of a firm (Mulongoy & Fry, 2016). While reputational and even some regulatory risks can be addressed through CSR or philanthropic actions, adequate water risk management may require a private firm to view watershed restoration as a strategic measure (Mulongoy & Fry, 2016). Constructing a single-built wetland within a high-risk watershed may promote a healthy brand image, but it will do little to address a firm's physical water risks brought about by changing climatic conditions and watershed deterioration. Debaere & Kapral (2021) conclude that "Voluntary initiatives or investments are of limited scale and scope". Proper water risk management requires the integration of restoration practices within the strategic focus of a firm.

It is important to note that CSR policies rely on the worldviews and perspectives of consumers (Debaere & Kapral, 2021). This means that the profitability of CSR is determined by consumer demand, and a CSR policy is only sustainable as long as its profitability is guaranteed by this demand (Debaere & Kapral, 2021). The logical consequence here is that CSR activities are based on public perceptions and not scientific or strategic considerations. True risk management should be guided by evidence-based identification of "adequate ways to prevent and mitigate risks" (Dumont-Bergeron & Gramlich, 2021).

Multi-stakeholder Initiatives

As previously demonstrated, water is a shared resource, and initiatives to tackle water challenges benefit from a shared approach. A prime example of a multi-stakeholder initiative is a PPP, where the efficiency and innovation of the private sector are combined with the resources and capacity of government agencies to achieve common goals (Debaere & Kapral, 2021). Where government agencies have traditionally relied on command-and-control measures, it may be more cost-effective to invite private firms to participate directly in environmental protection initiatives (Debaere & Kapral, 2021).

Multi-stakeholder initiatives, whether through PPPs or other collective action networks, allow for a sharing of multidisciplinary knowledge, technological innovations and other resources amongst private and public entities with shared water goals and challenges (Dumont-Bergeron & Gramlich, 2021). The pooling of resources in this manner ensures the sustainability and legitimacy of water restoration projects. Legitimacy is promoted by the inclusion of impacted stakeholders in project decision-making and administration (Dumont-Bergeron & Gramlich, 2021). These benefits may explain why collective action approaches are rapidly growing in the restoration field. For example, Kang et al. (2023) report a "fivefold" increase in the number of collective action payments for watershed services (PWS) programs "between 2005 and 2015" (Kang et al., 2023). It is important to note that collective action does not come without its share of drawbacks. The "complexity of actor composition" often creates conflict among the stakeholders participating in multi-stakeholder initiatives (Toxopeus & Polzin, 2017).

Impact Investment and Payments for Ecosystem Services

While many private firms may not have the technical expertise or land rights required to directly restore watersheds, they can contribute to watershed restoration through various funding mechanisms. These mechanisms are collectively referred to as impact investments, which are ventures specifically designed to produce environmental benefits (Debaere & Kapral, 2021). While impact investments encapsulate the myriad of financial pathways for investment in environmental projects, payments for ecosystem services (PES) (a set of financial schemes that includes PWS) utilise a material valuation of the resources or services that a particular ecosystem provides. "A PES scheme, simply stated, is a voluntary, conditional agreement between at least one "seller" and one "buyer" over a well-defined environmental service—or a land use presumed to produce that service" (Kooijman et al., 2021). As previously discussed, water has been undervalued as a public good, and many private firms have taken advantage of the freshwater supply provided by healthy watersheds. PES helps to address this "tragedy of the commons" by directly valuing the functionality of watersheds while charging freshwater users for their withdrawal of finite water resources (Debaere & Kapral, 2021).

PES employs several funding mechanisms which include government-financed PES, collective action PES and water quality trading and offsets (Salzman et al., 2018). At the watershed level, PES are funded by water users to finance watershed restoration projects, such as land management improvements (WWF-UK, 2017). According to Salzman et al. (2018), "The watershed PES sector is the most mature in terms of transaction value and geographical distribution", implying that there are already established structural drivers in position to expand this particular type of PES.

Nature-based Solutions Theory

Due to the fact that true water risk management relies on a comprehensive watershed-level approach and that such an approach requires the restoration of natural infrastructure, NBS should be a core element of water risk mitigation strategies. Kang et al. (2023) define NBS as "the protection, improved management, or restoration of natural or modified ecosystems that address societal challenges". The theoretical concept of NBS is thus central to an analysis of the capability of watershed-level restoration as a risk management strategy. Three thematic categories have emerged from the literature review regarding NBS theory. These are (1) the ability of NBS to provide co-benefits to society and the environment (2) the cost-effectiveness and resiliency of NBS compared to grey infrastructure solutions and (3) the novelty of NBS theory, which increases perceived risks and uncertainties about the effectiveness of such solutions.

Co-Benefits

Perhaps the most important justification for the use of NBS is the ability of these interventions to provide economic, social and environmental co-benefits. For example, a specific NBS project designed to mitigate flooding, such as a constructed wetland, may also provide carbon sequestration, recreational opportunities and biodiversity benefits (Kang et al., 2023). Watkins et al. (2019) draw the connection between NBS and the ecosystem services these solutions provide; among these are freshwater provisioning services, flood regulation, cultural services and habitat restoration. Another example that demonstrates the ability of NBS to mitigate certain risks is the capacity of forest fuel treatment techniques to prevent the occurrence of catastrophic wildfire events (Buckley et al., 2014).

Conversely, grey infrastructure solutions can conflict with environmental well-being, such as a hydroelectric dam preventing the migration of spawning trout (Kang et al., 2023). Meanwhile, NBS can enhance resiliency and deliver other financially measurable economic benefits while promoting the health of ecosystems (Watkins et al., 2019). "This ability of NBS to realise multiple (co-)benefits towards different sectors, addressing multiple sustainability challenges at once, can potentially lead to cost-efficient solutions to complex societal problems" (Mayor et al., 2021). In the watershed context with a diverse range of converging stakeholder interests and environmental concerns, the ability of NBS to provide co-benefits is an essential asset.

Cost-effectiveness and Resiliency

The capacity of NBS to provide co-benefits, alone, may not be enough to justify their use. According to Egusquiza et al. (2021), NBS must provide these co-benefits in a cost-effective manner in order for decision-makers to approve their implementation. A core tenet of NBS theory is the ability to address environmental, economic and societal challenges in a cost-effective manner (Egusquiza et al., 2021). The economic viability of NBS stems from two key characteristics. First, a single NBS project can address a wide range of challenges, where traditional grey infrastructure is typically constructed for a specific purpose (Mayor et al., 2021). However, this adds a layer of complexity, as the value attributed to an NBS project is determined by "the preferences of the different stakeholders, and the specific socio-political context where they are implemented (Egusquiza et al., 2021).

Second, NBS employ naturally occurring processes, such as the cooling potential of trees planted in an urban forestry initiative, meaning that maintenance and investment costs for certain NBS are much lower than built alternatives (Varshini, et al., 2022). Watkins et al. (2019) cite "reductions in upfront capital investment" and "reduced operations and maintenance costs over the project lifecycle" as evidence of the cost-effectiveness of NBS. While grey infrastructure may break down over time, incurring substantial renovation or replacement expenses, NBS rely on natural processes that are self-sufficient and sustainable over longer periods of time (Varshini, et al., 2022). However, Egusquiza et al. (2021) point out that the resilience and resulting cost-effectiveness of NBS projects relies on proper "long-term management". Though NBS projects do require periodic maintenance and sustained financial commitments, "unlike grey infrastructure solutions which depreciate over time, NBS appreciate over time" in their ability to mitigate social problems and provide co-benefits (Mayor et al., 2021).

Uncertainties and Perceived Risks

Perhaps the greatest barrier to mainstreaming NBS has been the novelty of the concept and the resulting uncertainties and perceived risks associated with investing in these solutions. The term NBS was first introduced by the European Commission in 2017, and many organisational decision-makers are still unfamiliar with this concept or the potential value of investing in NBS projects (Mayor et al., 2021). Gaps in knowledge regarding NBS have begun to be filled as a multitude of successfully implemented projects demonstrate the practical application of NBS theory (Kang et al., 2023). Additionally, frameworks and metrics for conducting cost-benefit analyses prior to the initiation of NBS projects have advanced in recent years (Kang et al., 2023). Still, because each NBS addresses a specific set of challenges in a particular context with unique actor compositions, it can be difficult to transfer the lessons learned from existing NBS projects to comparable potential projects (Kang et al., 2023).

One of the most significant perceived risks associated with NBS is the high administrative or transactional costs which arise from the complexity of the technical and organisational makeup of projects (Kang et al., 2023). Furthermore, it can be difficult to prove the ROI of NBS projects, which is specifically necessary to justify private sector investment, as previously discussed (Kang et al., 2023). To overcome these obstacles, multi-stakeholder partnerships could be utilised to pool resources and share costs or perceived risks. According to Dhyani, et al. (2021), "Mainstreaming NbS will need larger partnerships amongst diverse policy areas, sectors, and stakeholders. It will require broader collaboration and support that includes financial support from the private sector" (Dhyani, et al., 2021).

Private Engagement with Nature-based Solutions

The final section of the literature review will present the current state of knowledge surrounding private sector engagement with NBS. It is important to point out that the justification for the initial research topic, incentives for private sector engagement with nature-based solutions for water security, was derived from the observed deficit in academic literature pertaining to private engagement with NBS. This research gap, as outlined in Chapter 1, implies that the articles discovered through the literature review likely represent a majority of the publications pertaining to private engagement with NBS.

Historically, a plurality of funding for NBS projects has come from government or public sector, sources (Mayor et al., 2021). For example, "An overview of NBS cases in Europe revealed that local authority's budgets represent the lion's share of investment in NBS, although a relatively high incidence of hybrid financing of NBS is also documented" (Mayor et al., 2021). Budget cuts resulting from the COVID-19 pandemic, have resulted in government investments being insufficient to scale up NBS to their full potential (Mayor et al., 2021). Several of the reviewed literature underlines the importance of increased private engagement with NBS to mainstream the mechanism and "close the funding gap" (Kang et al., 2023).

There are several major barriers to private engagement with NBS. First, because many NBS projects are considered small-scale investments, private investors are unwilling to engage with these solutions, as they may yield relatively insignificant returns (Mayor et al., 2021). A possible remedy for this issue could be the adoption of a "portfolio approach" where a single investor can fund a set of NBS projects with a more significant combined return (Mayor et al., 2021). Though a large share of NBS projects have been implemented in urban settings, Mayor et al. (2021) argue that the "rural context" could allow for "larger-scale investments" a concept that relates to the watershed-level approach described earlier.

Another major barrier is a low level of awareness about NBS in the private sector, where uncertainties regarding the benefits of NBS investment create a higher perceived risk for investors (Mayor et al., 2021). Several factors contribute to these uncertainties including a lack of understanding of natural processes, general knowledge gaps and a deficiency in frameworks or guidance (Watkins et al., 2019). Though a collection of NBS projects have been implemented across the globe, "the financial viability of NbS has not been sufficiently proven at scale to fully engage private sector investment and/or utilization of NbS… Because of this uncertainty, NbS will often be perceived as riskier than traditional engineering solutions, regardless of their actual risk profile" (Watkins et al., 2019). Decreasing uncertainty requires establishing a business case for investment, as well as establishing the "costs, benefits, and risk profiles" for each project (Watkins et al., 2019).

A core aspect of private sector uncertainty regarding NBS is the lack of perceived or demonstrated value attributed to the ecosystem services these solutions provide. In recent years, reputational and regulatory pressure has persuaded private firms to "contribute to the creation of shared value" where firms invest in projects with broader social or environmental benefits (Mayor et al., 2021). Perhaps this explains why a majority of private NBS activities take place through a respective firm's CSR initiatives (Watkins et al., 2019). To address undervaluing, Davies & Lafortezza (2019) argue that private firms "should incorporate non-monetary values related to nature" (Davies & Lafortezza, 2019). However, to attract large-scale private engagement with NBS, these solutions must be incorporated into the business strategy of firms, indicating a need to create a "business-driven rationale" (Watkins et al., 2019).

Finally, for the value of an NBS intervention to attract private investment, the investing firm must be able to "appropriate" the value (Watkins et al., 2019). This means that material value, such as the utility of reliable water supplies, is a far more convincing incentive for private NBS investment than non-material value, such as social benefits arising from increased recreational opportunities (Watkins et al., 2019). The ability of NBS to address a wide range of challenges and stakeholder needs also means that it is hard to fairly attribute the range of co-benefits to organisations that invest in NBS projects (Toxopeus & Polzin, 2017). It is for this reason that a water risk-management approach may be the most appropriate for incentivising private engagement with NBS, by demonstrating the material value of ensuring reliable water supplies through the restoration of watershed ecosystems.

Summary of Literature Review

The following section presents a framework to organise major themes from the literature review into a decision-making process for private firms looking to engage with water stewardship. The reviewed literature has revealed a three general steps for private engagement with water stewardship: motivations, approaches and solutions. The four categories of literature, presented above, fit into this framework; category 1 falls under the motivations step, category 2 details the approaches step and categories 3 and 4 both relate to the solutions step.

Figure 2.1 below illustrates this three-step framework, including motivations (in orange), approaches (red) and solutions (green). At each step, a decision between two alternative approaches can be made by a firm looking to implement water stewardship activities. The options on the left-hand side of the chart (Risk Management Motivation, Watershed-level Approach and NBS) represent novel approaches to private water stewardship, while those on the right (CSR & Philanthropic Motivation, Internal Conservation Approach and Grey Infrastructure Solutions) have traditionally defined corporate water initiatives. It is important to note that the options at each step of the framework are not mutually exclusive, and private firms can employ both, in varying degrees, to achieve their water stewardship goals. However, based on the reviewed literature and the overall aim of this thesis, the novel approaches have been highlighted within this framework, and will contribute to the guiding assumptions for this research.

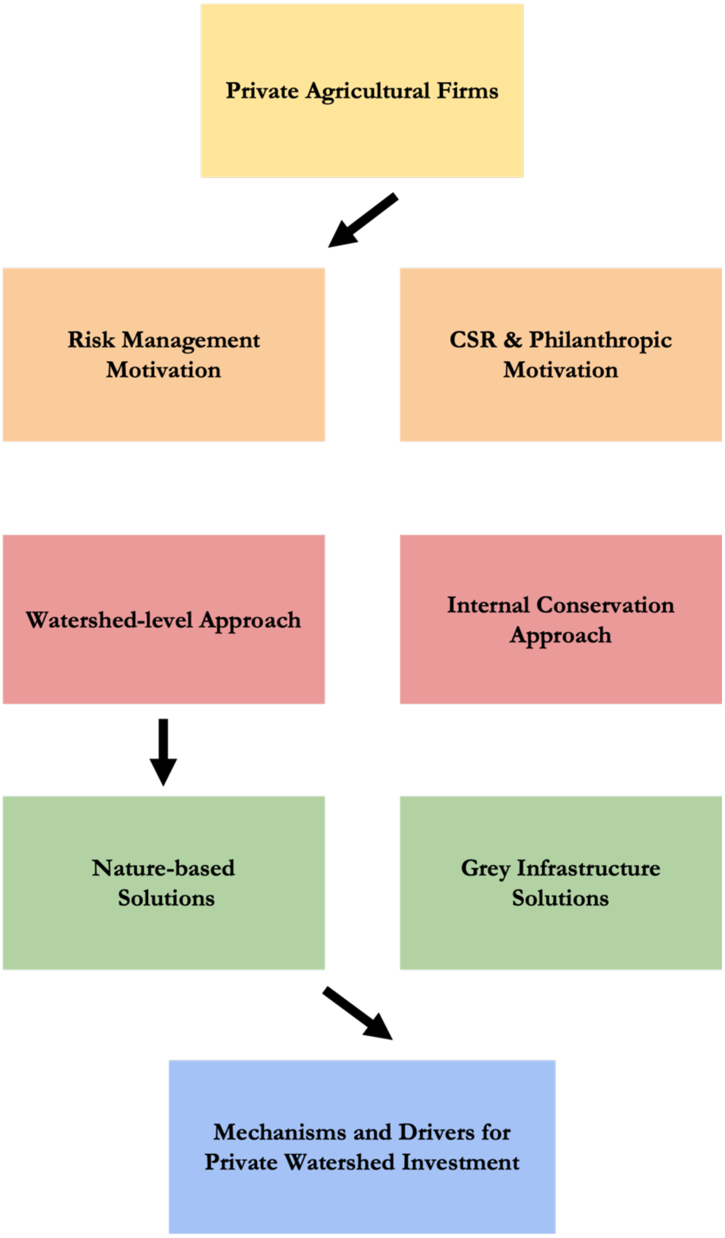

Figure 2.1. The Three Steps for Private Engagement with Water Stewardship

Source: created by the author using relevant themes from the literature review (Section 2.1)

Theoretical Framework

The results of the literature review have indicated that the most appropriate approach for studying private engagement with NBS is to view the subject through a risk management lens. The logical first step here would be to analyse the relevant risks within a given context. Due to the urgency of the water scarcity crisis within the San Joaquin Valley, and the direct reliance of the region's massive agricultural sector on freshwater resources, this specific context was selected for analysis.

Risk Analysis

Though a complete risk analysis containing quantitative probability calculations was not completed, due to time constraints and a lack of accessible data, Chapter 4 seeks to identify and describe the physical, regulatory and reputational water risks facing private firms with agricultural assets in the San Joaquin Valley. To structure this analysis, a theoretical framework for risk assessment factors was derived from Ronco et al. (2017), which establishes a larger risk assessment framework for irrigated agriculture. The three primary factors that comprise this theoretical framework are (1) hazard, (2) exposure and (3) vulnerability.

Hazard conveys the probability of future water scarcity or a disruption of supply (Ronco et al., 2017). Exposure indicates the impacted context, including natural features and populations (Ronco et al., 2017). In this case study, private firms with agricultural assets in the San Joaquin Valley, and communities and ecosystems in the valley, will represent the impacted context. Vulnerability conveys the susceptibility of certain populations to water risks. For example, the agricultural sector has a higher vulnerability to water risks compared to a less water-dependent industry. Each of the risk categories identified in Chapter 4 will be analysed based on risk hazard, exposure and vulnerability. Figure 2.1 below illustrates the theoretical risk assessment factor framework that will be used for the data analysis, including definitions of each of the three factors, derived from (Ronco et al., 2017).

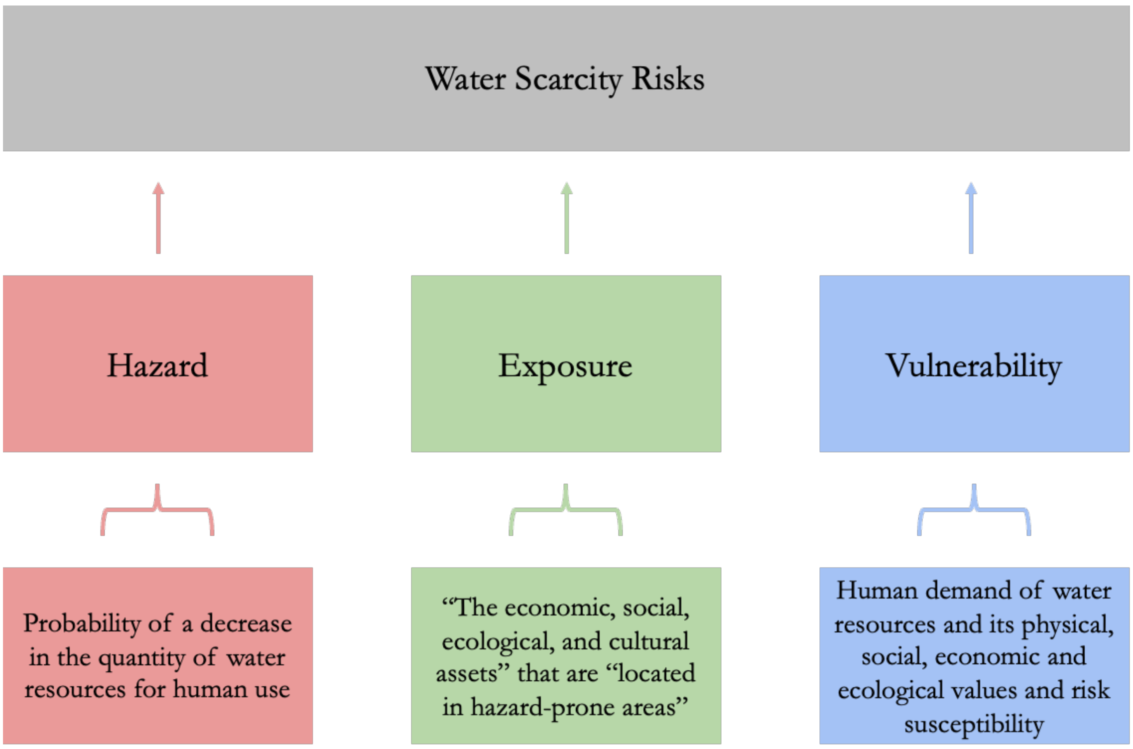

Figure 2.2. Risk Assessment Factor Framework

Source: Created by the author, based on risk assessment factors presented in Ronco et al. (2017)

Risk Management Capacity

While there are several risk management measures that private firms can employ to mitigate the impacts of water scarcity on their operations, the literature review has indicated that taking an external watershed-level approach may be the most comprehensive method for addressing the natural and anthropogenic causes of water scarcity (Reig et al., 2019). Additionally, watershed restoration investment represents a direct mechanism for private engagement with NBS. As such, the risk management measure that was selected for analysis is watershed restoration to promote sustainable freshwater flows in the San Joaquin Valley. Specific techniques and categories of restoration activities will be presented in Chapter 4.

To determine the worth of a risk management measure, its capacity to manage risks must be analysed. A theoretical framework to investigate the risk management capacity of various watershed restoration techniques was drawn from Jaffe et al. (2010), which develops a general conceptual framework for agricultural supply chain risk assessment. This framework includes three factors that contribute to risk management capacity. They are (1) availability, (2) access and (3) timing. Availability is determined by the existence of risk management techniques, in this case, watershed restoration initiatives (Jaffe et al., 2010). Access refers to the ability of impacted groups to implement risk management techniques (Jaffe et al., 2010). Specifically, are private firms with agricultural assets in the San Joaquin Valley able to participate in regional watershed restoration projects? Timing indicates the speed with which impacted actors can access the risk management techniques (Jaffe et al., 2010). In the context of this case study, does the current political and economic landscape allow for the timely participation of private firms in restoration activities to address urgent water scarcity risks? Figure 2.2 illustrates the three capacity factors, and includes definitions taken directly from (Jaffe et al., 2010).

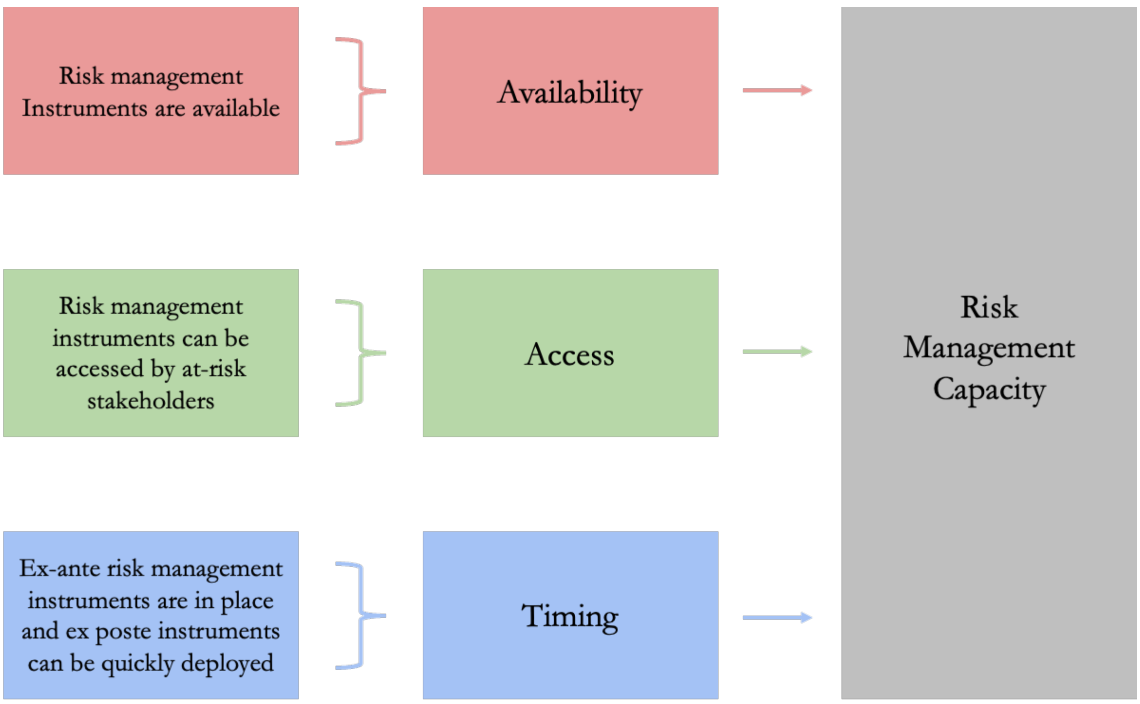

Figure 2.3. Risk Management Capacity Factor Framework

Source: Created by the author, based on risk management capacity factors presented in Jaffe et al. (2010)

Guiding Assumptions

The following is a list of guiding assumptions that have directed the research in subsequent chapters of this thesis. These assumptions were gleaned from the results of the literature review and background research on the specific context of this case study and will be used to compare the results of this study with existing knowledge on the topic in Section 5.1 below.

The following guiding assumptions have been identified from the literature review, and form a guide for subsequent research and data collection:

1. A core driver of private water stewardship is the demonstration of material value, achieved through the adoption of a risk management motivation

2. Private agricultural companies in California face acute physical, regulatory and reputational water risks

3. Water users in a particular watershed should focus on a watershed-level and collaborative approach for effective water risk management

4. Nature-based solutions for watershed restoration can provide a competitive set of benefits to improve water quantity downstream

5. Investment in upstream watershed restoration projects is a cost-effective and resilient method for downstream firms to manage water risks

3 Research Design, Materials and Methods

Chapter three will describe the research design and data collection methods.

Research design

Because the research questions require a focus on a specific problem context, a qualitative, descriptive, single case-study design has been chosen to answer these questions. A qualitative design is best suited for exploring and understanding an understudied concept or phenomenon (Creswell & Creswell, 2018, pg. 57). As demonstrated in the previous chapter, research into private engagement with NBS is limited, and the concept of private firms investing in watershed restoration as a risk management strategy is an emerging and uncharted subject. A qualitative design is ideal for uncovering the unknown variables that drive or inhibit private sector engagement with watershed solutions (Creswell & Creswell, 2018, pg. 57). Furthermore, the research questions require a holistic account of the studied problem and context and can be best answered through the emergent nature of a qualitative research design, where themes and key factors are uncovered through the study of multiple perspectives (Creswell & Creswell, 2018, pg. 258). Finally, the research assumes an inductive approach, as the collected data will be coded into broad themes which will then be presented as guidance to promote future work on this topic (Creswell & Creswell, 2018, pg. 109).

According to Yin (2014), a case study design is best suited for describing a contemporary problem in a real-world setting. The research design takes the form of an individual case study focused on a single context with defined spatial boundaries and a selected study population and intervention (Creswell & Creswell, 2018). Specifically, the research will focus solely on the specific water scarcity risks impacting private firms with agricultural assets in California's San Joaquin Valley and select watershed restoration methods. As discussed in Chapter 2, nature-based investments need "to be tailor-made for specific local conditions" and therefore a multiple case study design was ruled out to avoid issues with transferability that could arise by studying and comparing two or more case contexts (The Nature Conservancy, 2019b). While the decision to focus on a single case will allow for an in-depth analysis of the chosen context, the context-dependent nature of water scarcity issues means that it may be difficult to generalise the findings of this thesis to other settings. However, it is hoped that the results of this research will provide not only a detailed illustration of the specific San Joaquin Valley context but also a general overview of growing water risks and common trends or themes related to private investment in watershed restoration and NBS. Where data from external contexts are presented in this paper, it is to demonstrate these wider trends and themes.

Yin (2014) describes three common case study types; descriptive, explanatory and exploratory (Yin 2014, pg. 238). A descriptive case study was selected to chronicle the real-life phenomena that are central to the two research questions (Yin 2014, pg. 238). For RQ 1, "What are the water quantity risks impacting the agricultural sector in California's San Joaquin Valley region?", the studied phenomena are the various context-specific factors that contribute to or create the water risks. For RQ 2, "What is the water risk management capacity of watershed restoration when employed by private firms with agricultural assets in California's San Joaquin Valley?", the studied phenomena are specific NBS techniques or watershed restoration activities with the potential to mitigate water risks for the regional agricultural sector. Another important characteristic of descriptive case studies is a focus on the "real-world context" in which the studied phenomena occur (Yin 2014, pg. 238). Understanding the contextually specific risk factors and context-dependent viability of the identified interventions is vital for answering RQ 1 and RQ 2, further justifying the application of a descriptive case study design.

Literature Review Methods

For the initial literature review, the keywords listed in Table 3.1 were searched within Google Scholar, the Library Catalogue at Lund University, and the SCOPUS literature database.

Table 3.1. Search String for Literature Review

Private sector	water	Water shortage	Corporate
Water scarcity	Private engagement	Nature-based solutions	Private firm
Water stewardship	Investment	Agricultural sector	Public-private partnerships

These keywords were combined in various sets while searching these databases. Upon identification of all relevant articles, two general categories of literature were identified: 1). literature regarding private sector engagement with water stewardship 2). literature pertaining to mechanisms for private sector investment in water security. Literature was selected based on its relevance and transferability to the initial research topic identified in the introduction; How can private firms be incentivised to invest in NBS for water security? In all, 20 academic articles were selected for the literature review. Though a surplus of articles pertaining to NBS, and freshwater shortages were discovered, specifically relevant articles were selected based on their direct relation to the initial thesis topic. Specific literature pertaining to private engagement with NBS was far less common, and the articles reviewed here represent most of the available research on this specific topic. The next step in the literature review was to create a synthesis matrix. Here, common themes in the literature were identified by utilising an inductive Thematic Content Analysis (TCA) through the software Nvivo 14. Using an inductive approach, emergent coded themes were identified from the literature review which would guide the subsequent TCAs performed for data analysis (described in Section 3.4).

Methods Used to Collect Data and Materials Collected

A properly designed case study "relies on multiple sources of evidence, with data needing to converge in a triangulation fashion" (Yin 2014, pg. 17). One of the crucial steps in the design of this case study was the selection of data sources. This process involved two considerations: (1) which data sources would best serve to answer the two research questions, and (2) what sources would be realistically accessible to the author within the timeframe of the thesis project. Yin (2014) describes six sources of data which can support a case study. The following outlines three of these source types which have been selected for this thesis based on considerations of utility and feasibility. Note that Sources 1 and 2 will yield secondary data while Source 3 provides primary data.

Secondary data sources

1. Documentation - defined as administrative documents, formal studies or evaluations and news articles (Yin 2014, pg. 106)

2. Archival records - these include statistical data, organisational records, survey data and maps/charts (Yin 2014, pg. 109)

Primary data source

3. Interviews - both shorter case study interviews and survey interviews have been conducted with the goal of understanding "interviewee's perceptions and own sense of meaning" (Yin 2014, pg. 110 -111)

The three data source types were selected for their ability to yield information that would serve to answer RQ 1 and RQ 2. Documentation and archival records are useful for gathering specific information about a phenomenon and would therefore be functional for understanding the aforementioned phenomena (water risk factors and watershed restoration / NBS interventions) which are the subject of the research questions (Yin 2014, pg. 106). Additionally, documentation and archival records can provide broad information that describes multiple events or phenomena that occur over a long period of time (Yin 2014, pg. 106). This is specifically relevant for this research topic, as the water risks and intervention measures, the subjects of the research questions, function over longer time frames. For example, in order to understand the extent of the identified water scarcity risks, it would be important to collect data related to drought conditions within the San Joaquin Valley over a relatively longer time frame.

Data source types were also selected based on feasibility considerations. Yin (2014) argues that a quality case study design will "rely on as many sources as possible". It was determined that a collection of data from three unique source types (documentation, archival records and interviews) would be sufficient to triangulate the research findings (Yin 2014, pg. 17). The three selected source types represent those deemed feasible to access within the scope of the thesis project. Though direct observations were considered as a fourth data source, factors such as funding constraints and financial aid restrictions prevented the collection of this type of primary data (Yin 2014, pg. 113). The author receives financial aid from the U.S. Department of Education. As part of the terms for receiving this aid, the author is prohibited from completing any coursework within the United States. As mentioned in Section 1.4, this research work has not been funded by any external sources, and therefore, travel to the San Joaquin Valley was not financially feasible.

Despite this, the availability of grey and academic literature pertaining to the research topic meant that large quantities of data from sources 1 and 2 could be easily collected to compensate for an inability to employ direct observations in the research design. To further ensure triangulation, primary data collected through conducted interviews provided "an essential source of case study evidence" to confirm or reject the findings from secondary data (Yin 2014, pg. 113).

Secondary Data Collection

Secondary data to support RQ1 and RQ2 was collected through a review of grey and academic literature pertaining to the subject matter of each research question. As previously discussed, secondary data was retrieved from two of the six sources of evidence identified in Yin (2014); namely documentation and archival records. Table 3.2 outlines the various sources under each of these two categories.

Table 3.2 Collection of Secondary Data

Source Type, as described by Yin (2014)	Examples of specific data sources	Research Question answered by data	Data Collection Time Period
Documentation	Administrative or internal documents Corporate reports, Government publications Formal studies and evaluations News articles NGO reports	RQ 1 & RQ2	January - April 2023
Archival Records	Maps and Charts Organisational Records Survey data Government records or statistical data	RQ 1 & RQ2	January - April 2023

Source: Created by the author, based on the "Six Sources of Evidence" described in Yin (2014)

Secondary data sources were located using Google Search, Google Scholar, the Library Catalogue at Lund University, and the SCOPUS literature database. Tables 3.3 and 3.4 below represent the search strings used to uncover secondary data sources for RQ1 and RQ 2 respectively. The keywords listed in each table were combined in various sets while searching the databases. As this case study focuses on a contemporary event with fast-changing dynamics, only sources published after 2010 were reviewed. It was further determined that secondary sources from 2010 onward were sufficient for providing necessary information about relevant historic events, such as flooding or drought, making it unnecessary to consult older sources. As data was collected, processed and coded, further keywords were identified for future searches.

Table 3.3. Search String for RQ 1: What are the water quantity risks facing the agricultural sector in California's San Joaquin Valley Region?

Water	Water scarcity	Water shortage	California	Private sector
Water security	Water stewardship	Risk(s)	Watershed	Crops
Groundwater	Drought	San Joaquin Valley	Farms	Risk assessment
Flooding / Floods	Water quantity	Central Valley	Agriculture / Agricultural	Risk management

Table 3.4. Search String for RQ 2: What is the water risk management capacity of watershed restoration when employed by private firms with agricultural assets in California's San Joaquin Valley?

Water	Restoration	California	Private Sector	Private sector
Water security	Watershed	Sierra Nevada	Headwaters	Investment
Water stewardship	Wetlands	San Joaquin Valley	Catchment	Payments for ecosystem services
Forests	Meadows	Central Valley	Agriculture / Agricultural	Risk management
Floodplain	Rivers	Basin	Shared value	Public-private partnerships

Primary Data Collection

Primary information to support the research questions was collected through shorter case study interviews and structured questionnaires. Interviews were an essential element of the data collection methods as they demonstrated the practical perspective of real-world stakeholders, their understanding of water risks impacting agricultural firms in the San Joaquin Valley (RQ1) and the perceived role or ability of the private sector to invest in NBS and watershed restoration as a risk management strategy (RQ2). In total, 107 practitioners were contacted through email, phone and LinkedIn direct message. In all, 8 practitioners responded to requests for an interview. Two declined to participate based on a lack of understanding of NBS, while another was unable to participate due to scheduling constraints. The five remaining respondents agreed to be interviewed, though one asked to complete a structured questionnaire. Table 5.1 lists the two types of interviews, when and how many of each interview type were conducted, and the research question each interview type addressed.

Table 3.5. Types of Interviews Conducted

Type of Interview as described in Yin (2014)	Number	Research Question Addressed by Data	Data Collection Time Period
Shorter Case Study Interviews	4	RQ 1 & RQ 2	March - April 2023
Structured Questionnaire	1	RQ 1 & RQ 2	March 2023

All shorter case study interviews occurred via Zoom and lasted between 30 and 60 minutes. Audio and video from these interviews were recorded using Zoom, and participants were presented with the Informed Consent Form, described under Section 1.4, prior to the commencement of the interview.

The structured questionnaire form was introduced to the research methodology to compensate for participants with time constraints that prevented them from scheduling a direct interview. Additionally, this questionnaire provides an overview of the types of questions asked during the direct interviews. The following is a list of the eight questions found within the Structured Questionnaire Form (Appendix II)

1. What is your familiarity with the water security crisis in California? In your academic or professional experience, have you worked with technical methods for water conservation or watershed management in the U.S.? What were the major challenges of implementing these methods, and how were they overcome, if at all?

2. Please briefly describe, if any, the nature-based solutions (NBS) for water security (i.e., pollution control, water retention or flood management) you have professional or academic experience working with. Please list the benefits and drawbacks of implementing the solutions you choose to describe and what role (if any) the private sector could play in this implementation.

3. Do you have any experience working with the following watershed management mechanisms for private engagement; 1) public-private partnerships 2) water trading markets 3) corporate internal water stewardship best practices 4) payments for ecosystem services 4) corporate philanthropy 5) green investments (ESG) or 6) private water service or infrastructure providers? If so, please describe that experience, including the benefits and challenges of engagement with these mechanisms.

4. Do you perceive any physical water risks (i.e., risks from flooding, low water quality or lack of sufficient water supply) for the agricultural sector in California? In your opinion, what is the severity and likelihood of occurrence for the risks you have identified?

5. Can you identify any specific regulatory or reputational risks related to water use in California's agricultural industry? If so, what is the severity and likelihood of occurrence for the risks you have identified?

6. Has your current or previous work required you to engage with public-private partnerships? If so, please briefly describe the benefits or challenges you encountered while working in this collaborative setting.

7. In your opinion, does the responsibility for sustainable water use extend beyond the internal boundaries of a private firm? Do you believe it would be economically, environmentally or socially beneficial for private firms to take a more collective approach (i.e., collaboration with other actors for watershed restoration) or address external water risks (i.e., water risks in a supply chain)? What drawbacks do you foresee for these engagement strategies?

8. What role can the private sector play in watershed management in general or, if you are familiar, with the specific context of the water security crisis in California? What drawbacks to private engagement with watershed management do you see? Do you believe the current state of private engagement with watershed management is sufficient to address water-related risks in California?

The five participants represent different organisations directly related to the research topic. Table 5.2 categorises the five participants into various sectors and provides a brief justification for their selection. Note that the specific organisation, agency or firm that each participant represents will not be stated in this paper. Furthermore, participants will henceforth be identified by the participant number assigned to them in Table 5.2 below.

Table 3.6. Interview Participants

Participant Number	Sector / Profession	Justification for Selection	Cited As
Participant 1	NGO Representative	NGOs were identified as facilitators and important sources of information regarding water risk and private engagement with water stewardship	Interview 1 (2023)
Participant 2	Private Industry Representative	The input of private sector representatives was pertinent to demonstrate perceptions of water risks and private interest in NBS	Interview 2 (2023)
Participant 3	Private Industry Representative	Same as above	Interview 3 (2023)
Participant 4	Private Industry Representative	Same as above	Interview 4 (2023)
Participant 5	Regenerative Agriculture	This perspective was specifically relevant to demonstrate motives and perceptions	Interview 5 (2023)

	Specialist	within the agricultural sector	

Methods Used to Process Information

When reviewing the aforementioned sources of secondary data, a synthesis matrix was created to concisely manage information. Data was attributed directly to each source, while sources were grouped into types (i.e., NGO report vs. news article). All data has been stored on the author's personal computer and within the author's Lund University student Google Drive and Microsoft Office cloud databases.

Primary data from the shorter case study interviews was originally collected in the form of typed interviewer notes and digital audio/video files created through Zoom's recording function. This data has been stored using the databases listed above. The digital files were transcribed using the Zoom Transcription Feature, as well as through FreeSubtitles.AI for redundancy. Once this transcription was complete, the author reviewed the transcription documents to manually check for potential errors. Data from the structured questionnaires was collected in the form of typed responses to each question on the document, and so did not require any transcription.

Once the secondary and primary data materials were collected, a TCA was conducted using NVivo 14. This analysis type was selected as it offers "a method for identifying, analysing, and reporting patterns (themes) within data" (Braun & Clark, 2006). To answer the two research questions, it was imperative to study the perceptions and artificial or natural factors that contribute to both the perceived risk (RQ 1) and the potential for various NBS or watershed restoration measures to serve as risk management strategies for private agricultural firms (RQ 2). Therefore, a TCA was selected to sort these perspectives and factors into themes that serve to describe the "contemporary phenomenon" researched in this single case study (Yin 2014, pg. 16).

According to Braun & Clark (2006), there are two methods for identifying themes and patterns within data: inductive and deductive. The TCA used for this thesis utilised an inductive-deductive approach through two separate TCA rounds. An initial TCA was performed, using Nvivo, in mid-March which utilised an inductive approach to organise data into a set of coded themes. All subsequent data, including primary data from the remaining interviews, was analysed using the coding structure created in this initial TCA and the theoretical frameworks that underlie the study (as described in Chapter 2). Thus, the second TCA took the form of a deductive or theoretical thematic analysis "driven by the researcher's theoretical or analytical interest in the area" (Braun & Clark, 2006). The coded themes make up the structure of the presentation of findings in Chapter 4.

Reliability and Validity

According to Baškarada (2014), there are four factors to consider when determining the quality of an empirical study: construct validity, internal validity, external validity and reliability.

Construct validity is "the accuracy with which a case study's measures reflect the concepts being studied" (Yin 2014, pg. 238). Here, construct validity is confirmed using multiple data sources, and a clear "chain of evidence" established by the described methodology and data collection/analysis measures (Baškarada, 2014). Internal validity is not relevant for descriptive case studies, and so will not be addressed here (Baškarada, 2014). External validity concerns the ability of the findings of one study to be generalised to other studies or contexts (Yin 2014, pg. 238). Because the goal of this paper is to analyse the collected data through the lens of the two theoretical frameworks listed in Chapter 2, the external validity of this case study is sufficiently achieved (Baškarada, 2014).

Finally, a well-designed case study must demonstrate reliability, or that the "same results can be obtained by repeating the data collection procedure" (Baškarada, 2014). The guiding interview questions (se e Appendix II) and structured research design all contribute to the reliability of the thesis conclusions (Baškarada, 2014). By providing a detailed account of the methods and research design, as well as the presentation of traceable data sources, it would be possible to undertake similar research yielding near identical results.

4 Findings and Data Presentation

In this Chapter, the outcomes of the data collection and processing are presented. As discussed in Chapter 3, all primary and secondary data was processed using a TCA through NVivo 14. Findings from the data are presented here under subheadings which correspond to the thematic categories identified in the TCA. Table 4.1 below presents the thematic categories stemming from the data analysis, including five broad themes: (1) context themes, (2) water risk themes, (3) private engagement with water stewardship, (4) mechanisms and drivers for private watershed investment and (5) watershed restoration techniques. It should be noted that many of the themes identified in Chapter 4 have first been presented in the literature review (Section 2.1).

Table 4.1. Thematic Categories Identified through the TCA

Context Themes	Water Risk	Private Engagement with Water Stewardship	Mechanisms and Drivers for Private Watershed Investment	Watershed Restoration Techniques
Watersheds and Landscapes	General Risk Theory	Motivations for Private Sector Engagement with Water Stewardship	Financial Mechanisms	Source Watershed Restoration
San Joaquin Valley Agriculture	Physical Risks	Approaches for Private Sector Investment in Water Stewardship	Multi-stakeholder Partnerships & Government Collaboration	Watershed Restoration within the San Joaquin Valley
	Regulatory Risks	Solutions for Comprehensive Water Stewardship		
	Reputational Risks			

Source: Created by the author.

Context Themes

Within this broader category, two thematic categories emerged. The first pertains to the landscape and watershed features which make up the San Joaquin Valley. The second relates to the agricultural industry operating within the valley.

Watersheds and Landscapes

The San Joaquin Valley contains two major hydrological regions; the San Joaquin River Watershed and the Tulare Lake Watershed (Hanak et al., 2019). Figure 4.1 below illustrates these regions, separated by the horizontal red line. Through these two watersheds, the valley receives water from headwaters in the Sierra Nevada Mountain Range. For example, the San Joaquin River, the primary body of water within the San Joaquin Watershed, originates in the Sierra Nevada range and flows through the valley, into the Sacramento-San Joaquin Delta, and out into the San Francisco Bay (The Nature Conservancy, 2023). The Tulare Lake Watershed was originally part of the same hydrologic system as the San Joaquin River Watershed, but the construction of grey infrastructure over the past century, such as dams and canals, has diverted much of the water out through exports to the San Francisco Bay Area (Hanak et al., 2019).

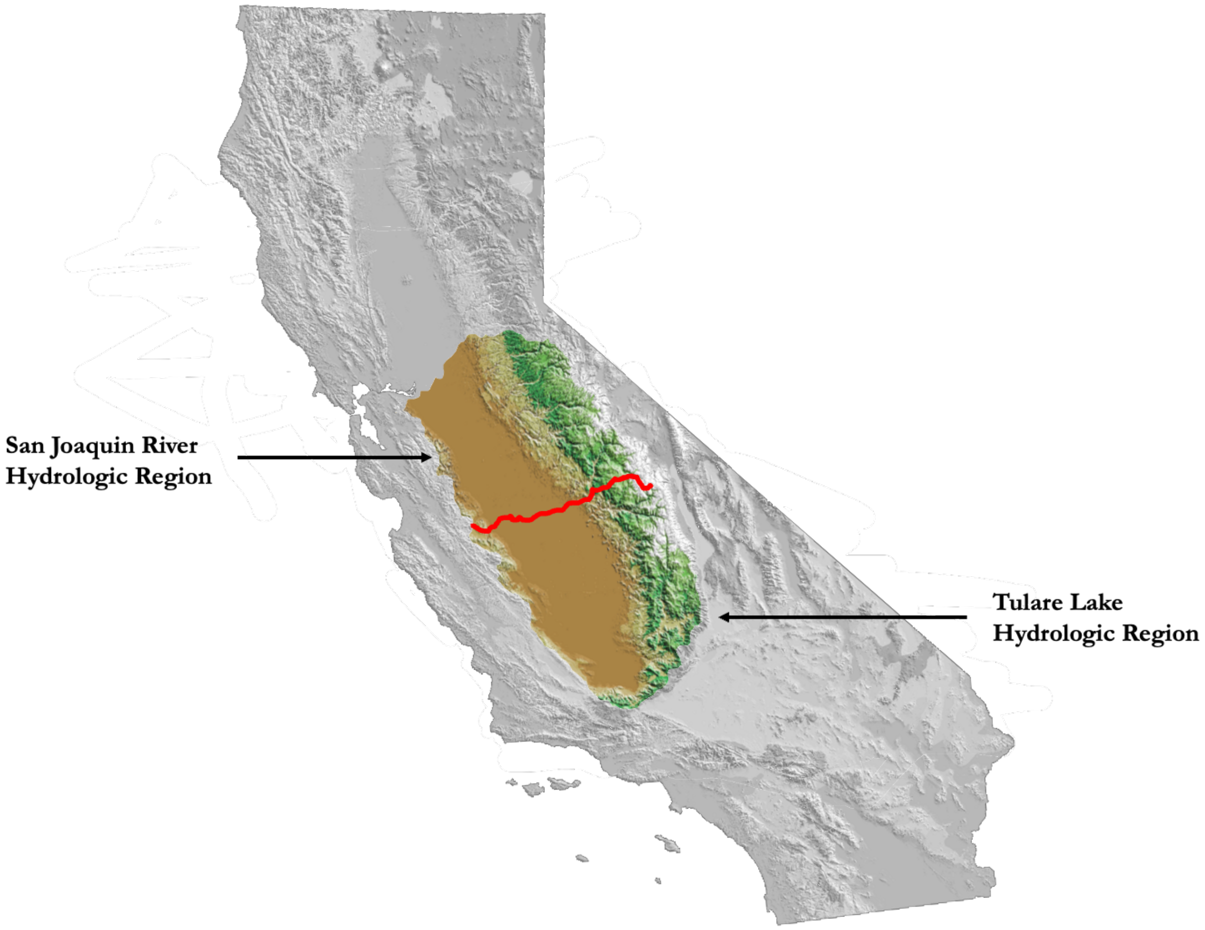

Figure 4.1 The San Joaquin River and Tulare Lake Hydrologic Regions

Source: Created by the author using data from Hanak et al. (2019). Map base layer sourced from USGS (2005)

The San Joaquin Valley uses an annual net water quantity of 16.7 million acre-feet, where agriculture is responsible for 87% of water use in the region (Hanak et al., 2019). The valley's water is drawn from three primary sources. The first is local supplies, which account for 70% of water use within the region. Local supplies include water from rivers and streams flowing from headwaters within the Sierra Nevada Mountain Range, as well as water from precipitation within the San Joaquin Valley (Hanak et al., 2019). According to Participant 1, "CA water supply systems tend to depend on long-distance water transport from mountainous uphill areas". The second source is imports from the Sacramento-San Joaquin Delta, where California's Central Valley Project (CVP) provides an additional 19% in pumped imports (Hanak et al., 2019). Finally, water is sourced through groundwater pumping which supplies 11% of the valley's net water consumption. This method relies on water drawn from aquifers within the valley, though the rate at which groundwater is consumed has yielded overdraft conditions where groundwater is pumped at a higher rate than it can be replenished (Hanak et al., 2019).

The landscape of the San Joaquin Valley consists of a variety of habitat and land use types. Figure 4.2 is derived from California Natural Resources Agency (2022) and details the natural and working land types within the region, as well as the total percentage of Valley land they represent:

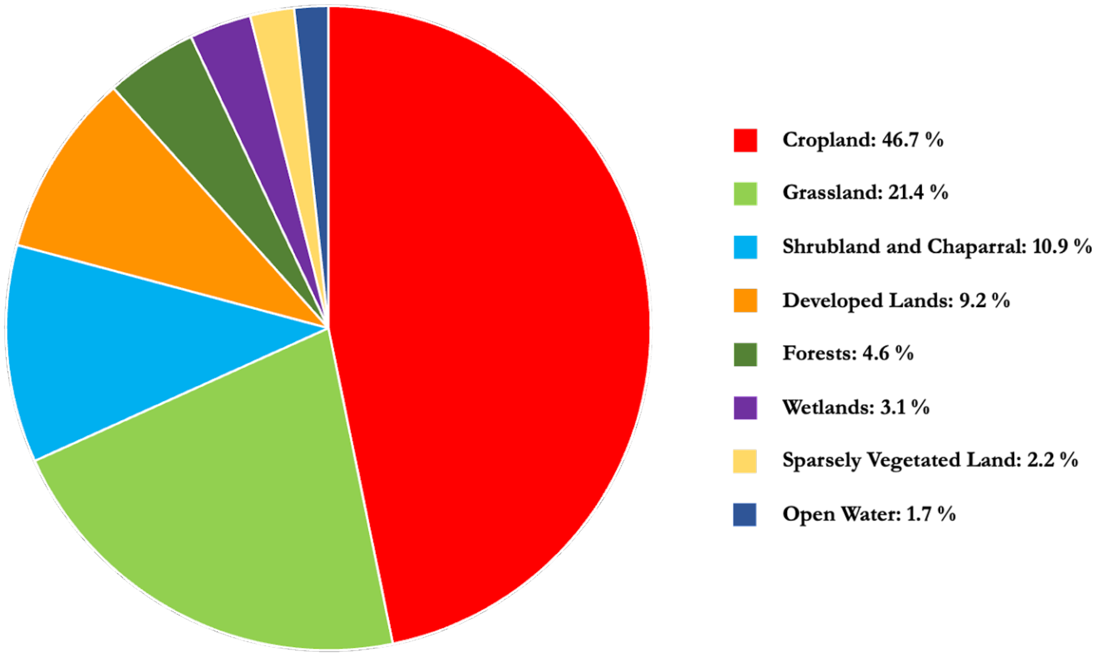

Figure 4.2. Land Types within the San Joaquin Valley.

Source: Created by the author with data from California Natural Resources Agency (2022)

Additionally, California Natural Resources Agency (2022) provides information about land ownership within the San Joaquin Valley. Figure 4.3 below, demonstrates landowner types and the percentage of Valley land they possess.

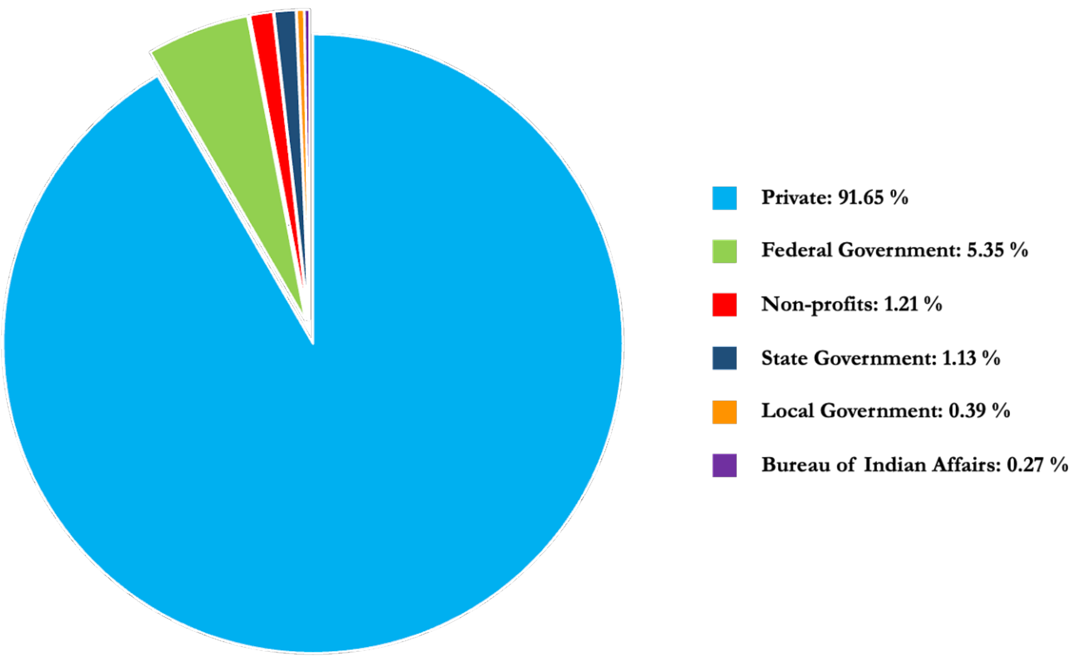

Figure 4.3. Land Ownership within the San Joaquin Valley.

Source: Created by the author with data from California Natural Resources Agency (2022)

The history of the San Joaquin Valley is one of rapid and seemingly unrestricted development. (California Natural Resources Agency, 2022) reports that "The San Joaquin Valley was historically a humid region with ephemeral rivers and lakes surrounded by San Joaquin Valley Desert and perennial grasslands. However, 95% of these wetlands have been lost". Depleted wetlands were once responsible for providing reliable freshwater flows to densely populated indigenous communities (Austin, 2022).

Following the Gold Rush of the mid-1800s, much of the floodplain within the San Joaquin Valley began to be converted to cropland (Austin, 2022). This process accelerated in the 20th century, as a system of grey infrastructure, including aqueducts, canals and dams, diverted river flows and fundamentally altered the landscape of the valley (Austin, 2022). Because of this, many of the natural features of the two watersheds within the valley have been permanently altered, and many experts emphasise an urgent need for watershed restoration within the region (The Nature Conservancy, 2023). "The San Joaquin Valley is the most altered non-urban environment in California—with one of the highest concentrations of endangered species in the country…The valley's remaining riverine, wetland, and upland ecosystems exist in small strips and patches dispersed across the region" (Hanak et al., 2019).

Due to the unsustainable development of the San Joaquin Valley and the intensity with which the region consumes freshwater, water authorities within California have begun to cut back water allocations, specifically in light of recent drought conditions. According to a 2022 survey, one out of five state water agencies predict that water supplies will not be enough to meet demand in 2024 (Bland, 2022). Additionally, it is estimated that severely low water levels in 2021 contributed to a decline in crop revenue of 2% for the San Joaquin River region and 1% for the Tulare Lake region (Escriva-Bou et al., 2022). Drought conditions are expected to continue in increasingly severe cycles, as several of the most severe drought years on record have occurred within the past decade (Greene & Suh Lauder, 2023).

San Joaquin Valley Agriculture

As previously described, the San Joaquin Valley is responsible for more than 50% of California's agriculture output and is essential for maintaining a reliable food supply in the United States (Escriva-Bou et al., 2023). "In 2018, about 4.5 million acres of cropland were irrigated in the region, using 16.1 million acre-feet (MAF) of water" (Escriva-Bou et al., 2023). These vast expanses of cropland generate crop revenue of around $24 billion annually, while $34 billion in food and beverage industry revenue depends on crops from the valley (Escriva-Bou et al., 2023). Communities within the San Joaquin Valley rely heavily on this booming agricultural sector. Approximately one-fifth of jobs within the San Joaquin Valley are within this sector (Hanak et al., 2019).

A variety of crops and animal products are produced within the San Joaquin Valley. These include (1) dairy and beef, (2) other livestock products, (3) feed crops, (4) almonds and pistachios, (5) tree and vine crops, (6) vegetables and non-tree fruits and (7) cotton and grains (Hanak et al., 2019). Of these, almonds and pistachios (4) and tree and vine crops (5) occupy the greatest percentage of cropland acreage (Hanak et al., 2019). Dairy and beef (1) as well as other livestock products (2) represent the products with the highest revenue for the agricultural sector (Hanak et al., 2019).

Figure 4.4. Irrigated farmland stands out against the arid landscape of the San Joaquin Valley

Source: Photo taken by author in March 2019

Water Risks

Another broad thematic category is data pertaining to water risks within the San Joaquin Valley. Here, four specific thematic categories were uncovered through the performed TCA. These are (1) General Risk Theory, (2) Physical Risks, (3) Regulatory Risks and (4) Reputational Risks. In Chapter 5, data from the last three categories (physical, regulatory and reputational risks) will be analysed by applying the Risk Assessment Factor Framework presented in Chapter 2.

General Risk Theory

Risk management involves predicting the probability of various negative consequences that could impact an organisation, and determining tools and methods for avoiding, transferring, accounting for, reducing or mitigating the identified risks (Jaffe et al., 2010). Classically, risk management techniques have been primarily retrospective, while risk associated with climate change requires a forward-thinking perspective to predict events in the near to distant future (The World Bank, 2020). In light of these posed challenges, many private firms have begun to develop risk management initiatives that directly address climate-related risks, including the availability of natural resources (The Nature Conservancy, 2019b). Both Participants 3 and 4 have revealed their firm's acknowledgement of material water risks (Interview 3, 2023, & Interview 4, 2023).

In order to assess organisational risk, two main considerations must be taken. First, definitions for risk assessment are necessary. Several identified articles include three primary definitions for risk assessment; (1) hazard, or the probability of future water scarcity or a disruption of freshwater supply, (2) exposure or the impacted context, including natural features and populations and (3) vulnerability, which conveys the susceptibility of certain populations to water risks (Ronco et al., 2017). These three risk assessment factors make up the Risk Assessment Factor Framework presented in Chapter 2.

A second consideration for a company undertaking a risk management initiative is the measurement of risk management capacity for selected techniques. Again, several reviewed articles have presented three factors for determining risk management capacity. These are (1) availability or the existence of risk management techniques, (2) access or the ability of impacted actors to implement the available risk management techniques and (3) timing, or the speed with which impacted actors can access risk management techniques (Jaffe et al., 2010). As described in Chapter 2, these three factors comprise the Risk Management Capacity Factors Framework, which will be used to analyse the uncovered risk management techniques described in later sections of Chapter 4.

A review of relevant data sources revealed that most corporate water risks can be broken down into three categories: physical, regulatory and reputational (4 & 8). These three categories were identified in the TCA and form the thematic categories which follow below. It is important to note that other risk categories were also identified from various sources, including transition risks and financial risks (The World Bank, 2020). However, through the TCA and analysis of all data, the three primary risk categories were selected for study, as they encapsulate all of the major risks facing the San Joaquin Valley and are most commonly presented in relevant risk literature (4 & 8).

Physical Risks

This thematic category encompasses the identified risks to the health of the agricultural sector in the San Joaquin Valley which originate from water quantity shortages. Though water quality is an equally important consideration for agricultural risk management, such risks fall outside of the scope of this case study. The decision to exclude water quality risks from consideration stems from the multitude of policy and market-based interventions that seek to address water-quality concerns; most notably water-quality or nutrient trading schemes (EPA, 2021). In order to investigate a less-explored topic, the issue of water quantity was selected as the focus of this thesis.

There are several factors that have contributed to water stress, or insufficient water resources to meet demands, in the San Joaquin Valley. These include natural phenomena such as drought conditions, rising temperatures, faster snowmelt, wildfires, and increased flooding events (California Natural Resources Agency, 2022). It is important to point out that many of these hostile conditions are the direct result of climate change. "Although average precipitation is not expected to change, rising temperatures, shrinking snowpack, shorter and more intense wet seasons, and more volatile precipitation will all bring water management challenges" (Hanak et al., 2019). Additionally, Escriva-Bou et al. (2022) conclude that "Climate change is making California's variable climate even more volatile, with increasingly dramatic swings between wet and dry conditions—or "precipitation whiplash".

A fundamental challenge contributing to the San Joaquin Valley's physical water risks is intensifying drought periods. California experienced an unprecedented five-year drought between 2012 and 2016 causing "[water] allocations to drop, issues for water-intensive crops such as almonds, sparse groundwater basins, wildfires, and increased cost of obtaining that groundwater" (Aquaoso, 2021b). Additionally, in 2020 and 2021, California experienced its second driest period since recording commenced in 1895 (Escriva-Bou et al., 2022). As a result, the CVP began the 2023 water year with the lowest level of water storage in recent history (U.S. Bureau of Reclamation, 2023). The California State Water Project reported water allocations for 2023 that account for only 5% of demand (U.S. Bureau of Reclamation, 2023). California's wet season has shrunk, consequently, and "seasonal precipitation now arrives nearly a month later than it did 60 years ago". (Aquaoso, 2021d)

It should be noted that drought conditions create compounding water shortage issues, such as increased wildfire severity and damaged ecosystems, which further contribute to water shortage risks (Bustic et al., 2017).

Another major risk factor contributing to water scarcity challenges in the San Joaquin Valley is the increasing occurrence and intensity of wildfires. According to Aquaoso (2021d), "Wildfire probability presents additional risk to agricultural lending portfolios and should be factored into due diligence. Though wildfires pose a direct risk to cropland through damage caused by burning or smoke contamination, (as was demonstrated when $3.7 billion in vineyard assets were destroyed by wildfires in the Sacramento Valley in 2020), wildfires in headwater regions can have a profound impact on reliable freshwater flows (Gartner et al., 2022). When wildfires ravage source watersheds in the Sierra Nevada mountains, sediment runoff into streams and rivers increases substantially (Pacific Forest Trust, 2021). Over time, this sediment damages built infrastructure and clogs watershed features, impacting the reliability of freshwater flows (National Fish and Wildlife Foundation, 2010).

Climate change has contributed to dramatically increasing temperatures throughout the western United States. In 2021, average temperatures in California were nearly 3.5 degrees (Fahrenheit) higher than averages throughout the 20th Century (Escriva-Bou et al., 2022). Rising temperatures contribute to several water scarcity risks. First, higher temperatures increase evaporation rates; in 2021 an additional 3-4 inches of evaporation were observed in California's waterways (Escriva-Bou et al., 2022). Secondly, higher temperatures create higher crop water demand, which increased by 8% for California agriculture in 2021 (Escriva-Bou et al., 2022).

Higher temperatures also impact the reliability of freshwater flows from the Sierra Nevada headwaters. Source watersheds in this region provide greater than 60% of California's freshwater supply (U.S. Forest Service, 2019). "Roughly a third of the state's annual supply is stored as snowpack that melts during the spring and early summer when water demands are high" (Public Policy Institute of California, 2016). Because of this, the snowpack in the Sierra Nevada is considered California's "largest reservoir" (California Natural Resources Agency, 2022). Snowpack is an essential component of California's infrastructure planning and is crucial to water supplies within the San Joaquin Valley (Fresno State California Water Institute, 2020).

The impact of increasing temperatures on these natural assets can be observed in both shrinking snowpacks and decreasing snowfall (Hanak et al., 2019). Snowpack within the Sierra Nevada mountains feeds the streams and rivers that flow into the San Joaquin River and Tulare Lake Watersheds (Pacific Forest Trust, 2022). As temperatures increase, the speed of snowmelt increases and precipitation which would typically fall as snow becomes rain. Both of these factors mean that water from the Sierra Nevada flows into the San Joaquin Valley during shorter periods of time, increasing flooding and disrupting "well-metered water yields later into the year" (Pacific Forest Trust, 2022). Figure 4.5 below illustrates snowpack within the Sierra Nevada range. This photo, taken by the author in May 2016, shows snowmelt flowing via a waterfall into the Merced River, a major tributary of the San Joaquin River.

Figure 4.5. The Merced River; fed by snowpack from Half Dome, a large granite batholith within Yosemite Valley, California

Source: Photo taken by the author in May 2016

Though the aforementioned natural phenomena play a significant role in the physical water risks facing the San Joaquin Valley, human overconsumption is another major contributing factor. Urban water use, especially in the San Francisco Bay Area, has meant a redistributing of freshwater which would normally supply the San Joaquin Valley (Austin, 2022). In a response to a structured questionnaire, Participant 1 states that; "it is fairly clear that increased water demand, coupled with uncertain supply due to climate change, will lead to increasing competition for water between the agricultural and urban sectors" (Interview 1, 2023). Increasing urban populations within the valley, which are predicted in the coming decade, will only exacerbate this problem (Hanak et al., 2019.

Groundwater pumping (drawing water from underground aquifers) has been a widely used technique for irrigation within the San Joaquin Valley. However, as a result of increasing drought conditions, aquifers are being drained faster than they can be replenished; this is known as groundwater overdraft (Hanak et al., 2019). As a result of these depleted groundwater supplies, large segments of cropland will need to be fallowed (or come out of production) (Fresno State California Water Institute, 2020). According to (Escriva-Bou et al., 2023) approximately 900,000 acres of cropland in the San Joaquin Valley will need to be fallowed as a direct result of groundwater overdraft. This in turn would lead to a decline in regional economic activity of around 2.3% and cost approximately 50,000 jobs (Escriva-Bou et al., 2023). Participant 3 confirmed the reliance of drought-ridden farmlands in the San Joaquin Valley on rapidly depleting groundwater reserves.

Regulatory Risks

A myriad of federal, state and local water regulations constitute the regulatory risks facing the agricultural industry in the San Joaquin Valley. Through analysis of the collected data, three major regulations have emerged that contribute the most to these regulatory risks. These are (1) conservation regulation, (2) the Sustainable Groundwater Management Act (SGMA) and (3) water fee increases.

While not directly applied to agricultural water consumption, federal and state conservation regulations, including the U.S. Endangered Species Act (ESA) and San Joaquin River Restoration Program, require volumes of freshwater diversion to achieve their wildlife conservation objectives. For example, the San Joaquin River Restoration Program, formed by a 2006 court order, is an initiative to restore stream flows for migrating salmon and other native fish species (Hanak et al., 2019). This program requires unobstructed river and stream flows in the San Joaquin River watershed, meaning that these flows cannot be easily redirected to supply cropland in the San Joaquin Valley. Additionally, various endangered species regulations, such as the ESA, require water resources to be redirected to protected freshwater habitats (Hanak et al., 2019).

Perhaps the regulation that contributes most to regulatory risks for California's agricultural sector is the SGMA. This law, enacted in 2014, "requires local water users to form groundwater sustainability agencies and develop and implement groundwater sustainability plans to bring use to sustainable levels by the 2040s" (Escriva-Bou et al., 2023). As a consequence, groundwater pumping in the San Joaquin Valley will need to decrease, necessitating a decline in cropland productivity or the identification of supplemental water supplies (Kelsey et al., 2020). "The Public Policy Institute of California (PPIC) estimates that at least 535,000 acres of irrigated agricultural land will need to be idled" (Kelsey et al., 2020). The SGMA is expected to contribute to a decline in the San Joaquin Valley's GDP of approximately $4.5 billion (Escriva-Bou et al., 2023).

A third major regulatory risk involves increased water fees as California's water agencies cope with decreasing freshwater supplies. One contributing factor is the SGMA, which allows authorities to charge additional fees to cover groundwater management efforts (Hanak et al., 2019). Another potential fee increase could come in the form of a parcel tax, where a per acre fee is charged to irrigated cropland (Fresno State California Water Institute, 2020). Furthermore, groundwater pumping fees have increased significantly, with energy bills from pumping activities increasing by $184 billion in California when compared to costs between 2002-2016 (Escriva-Bou et al., 2022).

Reputational Risks

As discussed within the literature review in Chapter 2, reputational considerations often drive corporate sustainability initiatives. Consequently, reputational risks associated with private water overconsumption present a direct threat to the profitability of corporations. Reputational water risks can be broken down into two major categories. The first is risks associated with investor perception. Second, consumer opinions are a major consideration for corporations looking to avoid tarnished brand images stemming from unsustainable behaviour.

The risks associated with depleted natural resources, such as freshwater, "are becoming increasingly well understood by the investment community" (The Nature Conservancy, 2019b). Investors are beginning to realise that private firms with unsustainable freshwater use, or those operating in high-risk watersheds, pose clear material risks to a reliable ROI. A 2019 survey, conducted by The Nature Conservancy (TNC), found that more than 20% of investors considered a "reduction in availability and/or quality of freshwater" as a justification for divestment in a company (The Nature Conservancy, 2019b). As the business risks associated with declining freshwater supplies become increasingly recognized, investors are requiring companies to disclose water-related risks in their annual reports (Barton et al., 2017). In light of a progressively competitive investment banking industry, private firms could attract investment capital by engaging in natural resource management to differentiate themselves from competitors (The Nature Conservancy, 2019b). Finally, many investors are driving investments in watershed restoration by encouraging firms "to take [a] collective action and catchment-based approach" (PRI, 2018).

Reputational risks related to consumer perception are well understood by the private sector. It is this dynamic that has driven many corporate sustainability initiatives (Debaere & Kapral, 2021). According to a survey conducted by the Public Policy Institute of California, around 63% of Californians believe that "water supply is a big problem in their region" (Baldassare et al., 2021). Private firms who are perceived to withdraw an unfair amount of freshwater from water-stressed regions will inevitably draw consumer ire. More specifically, certain brands or products with either a green brand image or an environmentally conscious consumer base must meet higher sustainable water use standards to avoid reputational risks (Interview 4, 2023). Additionally, Participant 3 highlights the importance of reputational considerations for products with particularly evident environmental impacts (i.e., food products containing water-intensive crops) (Interview 3, 2023).

Private Engagement with Water Stewardship

Motivations for Private Sector Engagement with Water Stewardship

As previously demonstrated, freshwater use and water risk impacts are an increasing concern for the private sector. Section 4.3 describes some of the coded themes that have emerged regarding motivations and types of actions private firms can employ to address freshwater scarcity risks.

CSR and Philanthropy

In the past, the primary business motivation for addressing freshwater scarcity fell under the CSR or philanthropic functions of firms. As discussed in the literature review (Section 2.1), reputational considerations stemming from "evolving societal views" have driven many of the CSR and philanthropic actions undertaken by private firms to mitigate their impact on freshwater resources (Debaere & Kapral, 2021). Participant 3 verified that "philanthropy may be the only real justification to invest outside of farms at watershed level" (Interview 3, 2023). Such actions can be broadly categorised as corporate water stewardship measures and may include interventions deployed within the internal boundary of a firm (such as drip irrigation or no-till farming methods used by farmers) or CSR activities at a broader scale (such as supply chain monitoring or philanthropic watershed initiatives) (Escriva-Bou et al., 2022).

In an interview with a representative of the clothing and garment industry, several motivations for private investment in water stewardship were discussed. First, a private firm may be motivated to invest in greater water conservation measures if it perceives higher CSR action amongst competitors (Interview 2, 2023). Secondly, Participant 3 explained that reputational motivations, such as those discussed in Section 2.1 above, are only effective if the consumer base is aware of the sustainability issues related to a firm's operations (Interview 3, 2023). For example, the interviewee highlighted "an ongoing challenge in terms of convincing business leaders that there is a connection between the consumer's understanding of the product that they have and who is bearing the externalities of that [product]" (Interview 2, 2023).

In another interview with a representative from the food and beverage industry, the importance of philanthropic motivations in CSR activities was further stressed. The interviewee explained that while private firms may have a clear business incentive to conserve water within their organisational boundaries, external investment in sustainable solutions is almost entirely driven by philanthropic motivations (Interview 3, 2022). However, as the inherent business risks associated with water scarcity become more widely understood by private firms, "projects and initiatives that for years were considered mostly as philanthropic, now are starting to be considered strategic" (Mulongoy & Fry, 2016). Beyond the reputational benefits of CSR and philanthropic project investment, many firms now understand the benefits of water stewardship activities for mitigating tangible water risks (The World Wildlife Fund, 2011).

Risk Management

The World Wildlife Fund (2011) reports that "At its core, water stewardship is a response to risk". The concept of water as a material risk has been introduced in Section 2.1 of the literature review, where companies perceive a greater value for water stewardship interventions if they can be directly attributed to a reduction in material risks (Debaere & Kapral, 2021). For this reason, many large, agricultural-dependent enterprises have begun to address water risks through investment in water stewardship initiatives (Abell et al., 2017). Investment in natural capital, such as rivers, wetlands and other watershed features, is a new but developing concept for the private sector. As demonstrated above, the primary motivating factor for private investment in external water stewardship has traditionally been philanthropy. However, according to a 2019 survey of investors conducted by TNC, greater than 25% of respondents reported risk-sharing / risk reduction measures as a motivating factor for investment in natural capital (The Nature Conservancy, 2019b).

To better understand water risk as a motivation for private investment in water stewardship, three interviews were conducted with representatives from the private sector. Participant 3, representing a major food and beverage firm, revealed that "water is a major risk area for us that has been identified by both our growers and at the global [company] level. We saw flooding this year and extreme droughts last year. In many of the sourcing strategies we include water-related risks in [California] as a near-term threat impacting supply" (Interview 3, 2023). In contrast, Participant 4 (a representative of a major garment firm) acknowledged that water is probably the firm's "number one environmental factor", but they concluded that this is a broader recognition of the garment industry's intensive freshwater consumption, and not an indicator of specific water risks impacting the firm (Interview 2, 2023). However, this interviewee also described a "growing interest in reducing risk from disruption due to [flooding] or drought" (Interview 2, 2023). An additional interview, conducted with a representative of the utilities sector, indicated that private firms lack the monitoring capabilities to determine the materiality of water risks, and many firms would require such information to justify investment in external watershed stewardship interventions (Interview 2, 2023).

Approaches for Private Sector Investment in Water Stewardship

This section explores a growing recognition of the importance of a watershed-level approach to water risk management. As presented in Section 2.1, private water stewardship measures can be categorised as internal or external. While internal measures represent the vast majority of private water stewardship activities, there has been a growing emphasis on a watershed-level approach to address water risks (The World Wildlife Fund, 2011). This section will briefly describe internal water conservation techniques that are frequently employed by the agricultural sector. Finally, the concept of a watershed-level approach will be discussed, and the current state of private engagement with this approach will be elaborated on.

Internal Measures

Several internal mechanisms for water conservation are employed by agricultural firms, including selective breeding, precision or drip irrigation, and no-till farming (Escriva-Bou et al., 2022). Through an interview with a regenerative agriculture specialist, the widespread use of these types of water conservation measures was emphasised (Interview 5, 2023). However, this interviewee also pointed out the importance of considering external factors, specifically deforestation; "You can't remove a significant portion of the water cycle and expect water [flows] to remain constant" (Interview 5, 2023). According to The World Wildlife Fund (2011), "many companies perform well within their factory gates, with often high efficiency, reuse and recycling [measures]. Yet efficient companies on water bodies that are poorly managed remain at high risk, as the social and environmental dimensions of water are difficult to separate within such a shared resource". This may explain why, despite innovative water efficiency techniques, California farms continue to face severe water shortages due to a reliance on imported freshwater for irrigation (Escriva-Bou et al., 2022).

External Measures

Many firms have employed innovative water efficiency measures within their organisational boundaries. Still, freshwater scarcity is caused by a dynamic network of natural and anthropogenic factors at the wider watershed level, and internal measures may not be adequate to address external threats to freshwater supplies. "The most efficient and low-polluting operation can still be at risk when other users, including factories, farms, or households, overuse or pollute the resource. Corporate responses must take these risks into account in formulating strategies, often in the form of watershed-based collaborations that effectively engage other stakeholders to improve the shared management of water" (Barton et al., 2017). Participant 2 substantiates this claim, arguing for a "network view" to address the overconsumption of water resources (Interview 2, 2023). There are two major benefits to adopting a watershed-level approach to water risk management. First, this proactive approach addresses water issues at their source, rather than reacting to the effects of water scarcity when they become apparent in a firm's internal operations. Second, a watershed-level approach allows multiple actors who rely on the same freshwater resources to collaborate, share resources and participate in decision-making.

Addressing water risk at the watershed level may be an effective method for water conservation within the San Joaquin Valley, as a majority of water scarcity factors can be directly attributed to stresses at the watershed level (Pacific Forest Trust, 2021). Unlike other environmental concerns, such as greenhouse gas emissions, the management of freshwater resources requires a focus on local watershed conditions (The World Wildlife Fund, 2011). According to WWF-UK (2017), "Taking a basin-scale approach to river management, including cross-sectoral integration, equitable water allocation and a focus on a wide range of uses, is central to maximising the benefits rivers can provide to society". Participant 5 substantiated this claim, arguing that "stewardship should be aligned with the overall health of the ecosystem (Interview 5, 2023). The benefits of addressing water risks at the watershed level have been affirmed by the myriad of watershed conservation measures implemented across the globe, including nutrient trading schemes and other PES mechanisms (EPA, 2021). The importance of this approach is highlighted by the fact that "the largest market for ecosystem services is for watershed conservation" (The World Bank, 2020). Specific techniques and examples of interventions to address water scarcity at the watershed- level will be further discussed in subsequent sections.

Another major benefit of a watershed-level approach is that it allows for the participation of impacted actors in watershed management decisions. For a private agricultural firm within the San Joaquin Valley, crop irrigation relies on the importation of water from various sources within different "hydrological and political boundaries" (Hanak et al., 2019). Because of this, firms can better exercise influence over the freshwater resources they rely on by focusing actions at the watershed level (Christian-Smith & Merenlender, 2010). Rather than anticipating water risks from depleted watershed resources, a private firm could adopt a watershed-level approach to proactively manage water risks that would normally be outside of their organisational control (Barton et al., 2017).

Furthermore, collaboration and knowledge sharing are promoted through this approach by creating a sense of shared value and responsibility (WWF-UK, 2017). Major barriers to healthy watershed management, such as jurisdictional silos, lack of knowledge transfer and deficiency in replicable funding mechanisms could be overcome through the collaborative nature of watershed-level approaches (Abell et al., 2017). "Within a given region or watershed, collaborative action between industry and other water users can be critical to addressing problems related to the health of the shared water resource" (Barton et al., 2017).

Solutions for Comprehensive Water Stewardship

Grey Infrastructure

As demonstrated in the previous subsections, a holistic approach to water risk management requires a focus on the broader watershed level. Additionally, agricultural producers within the San Joaquin Valley are facing numerous risks related to freshwater scarcity, and new supplies are needed to address the expected surface and groundwater shortages. Two categories of supply augmentation were uncovered through the TCA. Here, grey or built infrastructure solutions to increase water imports to the valley will be described.

Grey infrastructure, such as dams, canals or groundwater pumps, have been the most frequently employed solutions for California's water needs, representing a majority of water supply enhancement projects in the state (Tenorio, 2017). More specifically, "Interbasin water transfers (IBTs), which move water from one watershed to another, have been the grey infrastructure solution of choice for addressing water stress" (Abell et al., 2017). For example, the CVP, California's largest freshwater network, brings water from various sources (such as the Sierra Nevada mountains or Sacramento River Watershed) into the San Joaquin Valley utilising 400 miles of grey infrastructure (U.S. Bureau of Reclamation, 2023). While this network has aided in the creation of some of the most fertile land in the United States, concerns about the conditions of infrastructure assets within the CVP, as well as the high costs of repairs for dilapidated facilities, indicate a need for innovative solutions for freshwater importation.

The CVP has provided a reliable source of freshwater for almost a century (Fresno State California Water Institute, 2020). However, as facilities within the CVP age, deterioration has become increasingly evident, especially in the dams, canals and reservoirs that supply freshwater to the San Joaquin Valley (Fresno State California Water Institute, 2020). Pacific Forest Trust (2022) reports that repairing, replacing or expanding these grey infrastructure facilities "is expensive, contentious, and undependable". Investment in this type of infrastructure may not be suitable for long-term freshwater security, as these types of solutions tend to depreciate in value as they age (Mayor et al., 2021).

According to Pacific Forest Trust (2022), "Built infrastructure alone cannot solve our supply problems, and neglecting our watersheds is both dangerous and costly". However, because grey infrastructure solutions have been the standard for addressing freshwater supply needs in the region, it is likely that decision-makers will settle into a "path dependency", through which they are inclined to revert to grey infrastructure rather than exploring other options, such as NBS (Ofosu-Amaah & Trémolet, 2023, & Wilson & Browning, 2012). Everard et al. (2020) argue that the concept of grey infrastructure vs. NBS is a "false dichotomy" where both solutions can be implemented in a "hybridised" approach to maximise their respective benefits (Everard et al., 2020). Participant 5 confirmed the "path dependency" of agricultural investment in grey infrastructure solutions and argued that "living systems operate on a longer time scale than man made systems" and "investing in natural solutions can be a perceived financial risk, as there is less perceived human control over natural systems and a longer ROI timeframe for NBS" (Interview 5, 2023).

Nature-based Solutions

Whether substituting or enhancing grey infrastructure features, NBS implementation has grown rapidly in recent years. According to The Nature Conservancy (2019b), "Over the next five years, nature-based projects to improve the quality and supply of water are expected to see the greatest increase in investment". In California, Governor Gavin Newsom recently directed agencies to consider NBS for the achievement of the State's climate goals through Executive Order N-82-20 (California Natural Resources Agency, 2022). The advantages of utilising NBS for freshwater security stem from three economic rationales. These are "cost-effectiveness, co-benefits and the precautionary principle" (Kroeger et al., 2017).

As revealed within the literature review (Section 2.1), the cost-effectiveness of NBS is a key motivator for private sector investment. The World Bank (2020) reports that "Economic analysis has demonstrated that in some cases, natural infrastructure can supply the same quantity and quality of water at lower costs". Similarly, The Nature Conservancy (2019b) proposes that "nature-based solutions can be cheaper, longer lasting and yield more co-benefits than technology-based solutions". Though many scholars argue that NBS are more cost-effective when compared to grey infrastructure alternatives, in order to attract investment, the "competitiveness" of NBS with grey infrastructure must be proven in practice (Kroeger et al., 2017).

To substantiate claims of competitiveness, successful examples of NBS projects must be demonstrated. Knowledge gaps have begun to be filled with an increasing number of NBS project examples, especially those that employ transferable cost-benefit analyses (Abell et al., 2017). However, California Natural Resources Agency (2022) notes that the true benefits of NBS are often only realised at larger scales. This has created major barriers to the perceived competitiveness of NBS projects, which are typically fragmented and implemented at smaller scales (Mayor et al., 2021). Participant 4 confirmed that their firm also invests primarily in small-scale, fragmented NBS projects, and highlighted a "lack of large-scale projects that demonstrate the success or value of [NBS] investment (Interview 4, 2023). To establish the competitiveness of NBS against conventional grey infrastructure, it is imperative to showcase examples of large-scale, rural NBS projects that effectively illustrate the comprehensive spectrum of benefits these alternatives offer (Mayor et al., 2021). Participant 3 emphasises a challenge to the scaling up of NBS; "Nature-based solutions require a significant technical background compared to other forms of sustainability jobs" (Interview 3, 2023).

When fully realised, the multiple co-benefits NBS provide serve as a second rationale for investment. Regarding the water scarcity crisis facing the San Joaquin Valley, the primary benefit NBS could provide is enhanced water quantity and regulated flows. "Natural ecosystems such as forests, grasslands and wetlands provide a natural regulating function for the hydrologic cycle" (Abell et al., 2017). Specific benefits could include groundwater recharge and flood risk reduction (Chamberlin et al., 2020, & California Natural Resources Agency, 2021). On top of this, the co-benefits of NBS projects for water security include increased habitat land, improved air quality, enhanced recreational opportunities and other ecosystem services (Kroeger et al., 2017). While many grey infrastructure solutions disrupt natural ecosystem functions, NBS utilise these functions to contribute to economic and social value (Wilson & Browning, 2012).

A third economic rationale for investment in NBS utilises the precautionary principle, where investment in natural capital preserves the potential future value of intact natural assets (Kroeger et al., 2017). Future value may be supplied by intact natural infrastructure through a "higher resiliency to climate change and higher hydrologic service flows" (Kroeger et al., 2017). Additionally, as NBS assets tend to appreciate in value over time, the precautionary principle requires a consideration of the value these assets may provide when faced with the uncertainty of future water needs and risks (Kroeger et al., 2017). "The precautionary principle can also justify conservation or restoration of natural systems based on the recognition that such systems have worked well so far" (Kroeger et al., 2017).

Finally, it is important to recognize that NBS can be employed within the internal boundaries of an organisation, as well as at the external watershed level. NBS techniques that are implemented within the internal boundary of agricultural firms include riparian zone restoration, cover cropping and the use of compost materials as fertilisers (Chamberlin et al., 2020). Although these solutions have proven their worth and have been implemented on farms across the globe, this paper will continue to concentrate on NBS at the watershed level.

External NBS include forest, grassland, wetland and waterway restoration (Chamberlin et al., 2020). Specific NBS interventions at the watershed level will be discussed in Section 4.5 below. Gartner et al. (2022) argue that such external solutions are far more effective in addressing water risks when compared to internal corporate water stewardship measures. "Rather than focusing on water solutions at the site level - such as fixing leaky pipes - nature-based solutions focus on the systems that underpin water security" (Gartner et al., 2022).

Mechanisms and Drivers for Private Watershed Investment

Financial Mechanisms

The following subsections summarise various resources and financial mechanisms that enable private firms to invest in watershed management beyond their organisational boundaries. One mechanism for investment in watershed management involves direct land acquisition and maintenance, where a private firm may purchase property containing key watershed features (such as an area of forest land or a segment of riverbed) in order to restore the feature directly (The Nature Conservancy, 2019b). This method of engagement will not be elaborated on in this paper, as it extends beyond the scope of the research into external investment in watershed management (once the land is acquired by a private firm, restoration activities would then become part of the firm's internal operations).

Payments for Ecosystem Services

PES is an umbrella term that describes "a variety of arrangements through which the beneficiaries of environmental services, from watershed protection and forest conservation to carbon sequestration and landscape beauty, reward those whose lands provide these services with subsidies or market payments" (The World Wildlife Fund, 2020). The services provided to beneficiaries under such a scheme have been dubbed "natural capital", and include water flow regulation, natural water purification and carbon sequestration (Aquaoso, 2021c). According to Aquaoso (2021c), "The link between the wellbeing of natural capital and the wellbeing of financial capital is strong and must not be overlooked. Still, the connection can be hard to measure and track" (Aquaoso, 2021c). PWS (a type of PES) represent the majority of PES programs, and, as of

2015, were present in 62 countries with a global market value of $24.7 billion (Salzman et al., 2018). The success of PWS can be attributed to the direct connection between land management and beneficiaries in a locally defined context (The World Bank, 2020). Essentially, beneficiaries can easily trace improvements in downstream water quality and quantity to upstream watershed restoration efforts, creating a more robust case for investment. According to Participant 3, challenges for implementing watershed management techniques stem from a misunderstanding of the local landscape (Interview 3, 2023). PWS schemes connect actors within a local context, allowing for the sharing of specific knowledge about local ecological, social and political factors.

For the restoration of watershed resources, PWS programs can use a "beneficiary-pays" model, whereby conservation costs are included within water use fees (4 & Kroeger et al., 2017). This model allows for equitable distribution of the costs needed to restore watersheds, where those who use more freshwater pay more for restoration (Fresno State California Water Institute, 2020). Another mechanism to promote the success of PWS programs is the use of bundling, where multiple benefits (such as carbon sequestration and water quality improvement) are bundled together within single restoration projects (Townsend et al., 2012). Currently, around 94% of PWS payments come from public sources (Abell et al., 2017). The use of "beneficiary-pays" models could alter this dynamic. Additionally, other funding mechanisms, such as the water funds or resilience bonds discussed below, could provide alternative mechanisms for private investment in watershed restoration (Bustic et al., 2017).

Water Funds

Water funds are multi-stakeholder investments in upstream watershed restoration which lead to water quality and quantity improvements downstream (Ofosu-Amaah & Trémolet, 2023). In the context of the San Joaquin Valley, private agriculture firms could collaborate with government agencies, other freshwater users and NGOs to combine funding resources for the restoration of upstream watershed features. According to Ofosu-Amaah & Trémolet (2023), water funds "enable stakeholders to overcome common challenges such as governance fragmentation and lack of coordination and help them invest at scale in nature-based solutions like reforestation, habitat restoration and sustainable agricultural practices" (Ofosu-Amaah & Trémolet, 2023). According to Participant 1, "Water funds unite public, private and civil society stakeholders around the common goal of contributing to water security through NBS and sustainable watershed management" (Interview 1, 2023). Furthermore, water funds address issues surrounding the multi-jurisdictional nature of watersheds, where actors across jurisdictional boundaries can collaborate to achieve shared water goals (Abell et al., 2017).

The inclusion of private sector actors in water funds is crucial for several reasons. Abell et al. (2017) report that private actors can provide capital investment to fill funding gaps and launch watershed restoration projects. Private sector engagement can also help to legitimise restoration efforts, as firms who initially invest may encourage investment from other firms within their network (Abell et al., 2017, & Ofosu-Amaah & Trémolet, 2023). Participant 4 confirmed the importance of "peer pressure" as a driver for private sustainability efforts. "A main motivating factor [for water stewardship] is just looking at competitors and seeing what they are doing" (Interview 4, 2023). The private sector has been increasingly driven to engage with watershed conservation in the wake of increasing water security risks (Abell et al., 2017). Water funds connect the beneficiaries of freshwater resources to the watershed features that provide them, helping to overcome a historic undervaluing of these resources (Abell et al., 2017).

According to Abell et al. (2017), several factors must exist in order to secure funding for water fund models. First, the investment opportunity must be large enough to attract private financing (roughly $15-$30 million) (Abell et al., 2017). Second, investment risks must be adequately diversified through risk sharing among participating actors (Abell et al., 2017). Third, water funds must be able to keep pace with changing project dynamics and timelines (Abell et al., 2017). Fourth, water funds must have a sufficient credit rating (Abell et al., 2017). Finally, independent auditing for a transparent reporting of project results is crucial (Abell et al., 2017).

There are several drivers for the success of water funds. These include the value proposition for securing freshwater resources, and the range of sectors and actors who rely on these resources (Abell et al., 2017). However, there are also several factors which can inhibit the success of water funds. These include knowledge gaps regarding the benefits of watershed restoration, high transaction costs, and the lengthy turnaround time for ROI for restoration projects (Abell et al., 2017). Despite these barriers, several successful examples of water funds do exist. For example, TNC has coordinated a water fund within the San Joaquin Valley at Capinero Creek where segments of fallowed agricultural land are purchased and transformed into groundwater recharge facilities (The Nature Conservancy, 2020).

Resilience Bonds

Another mechanism for collective watershed investment is the forest resilience bond. Rather than attracting only beneficiaries to watershed restoration investment, resilience bonds rely on third-party investors who are then paid by the beneficiaries of the restoration activities (The Nature Conservancy, 2019b). One specific type of Resilience Bond is the Forest Resilience Bond (FRB). "The FRB is taking the critical steps of bridging the gap between investors and environmental interventions by developing the measurement technology, innovative contracting scheme, and financial structures that will allow private capital to fund land management" (Blue Forest Conservation, 2023). There are four primary goals which underpin an FRB. These are (1) to introduce novel financial or technical resources to drive restoration, (2) to establish innovative financing mechanisms to be replicated in other contexts, (3) to restore forests and watersheds and (4) to mitigate risks to ecosystems and dependent communities (Blue Forest Conservation, 2023).

The implementation of FRB requires the use of Implementation Partners or third-party actors who facilitate the actual restoration activities once funding has been secured from investors (Blue Forest Conservation, 2023). Participant 4 argues that it is "critical to form partnerships with third parties to support company efforts. Companies do not have the proper expertise to address watershed restoration and need partners to share their experience and expertise" (Interview 4, 2023). One example of an Implementation Partner is Blue Forest Conservation, an NGO that has partnered with the U.S. Forest Service for the restoration of headwaters within the Sierra Nevada region, providing $4 million from private investors for the restoration of 15,000 acres of forests in California (Blue Forest Conservation, 2023).

Multi-stakeholder Partnerships and Government Collaboration

Multi-stakeholder Partnerships

According to WWF-UK (2017), multi-stakeholder partnerships (MSPs) "are particularly vital for water resources management, given the grave challenges facing freshwater ecosystems, the multiplicity of actors who have an impact on them – and are impacted by them – and the shared nature of water risks". The use of MSPs is crucial for the conservation of freshwater resources for several reasons. First, such collaborative groups help to empower less influential actors by including them within decision-making structures (WWF-UK, 2017). Second, knowledge, as well as technical and financial resources, can be shared to contribute to more sustainable and effective watershed restoration projects (WWF-UK, 2017). Participant 1 confirms the importance of these resources, arguing the importance of utilising science-based targets for project legitimisation (Interview 1, 2023). Third, the legitimacy of restoration projects increases through MSPs, as impacted actors and community members can participate in restorative actions that directly mitigate their water risks (WWF-UK, 2017). Participant 5 argues that "collaborative efforts of knowledge and technical know-how sharing are essential, but collaborations need trust, and rely on a convincing platform with assurances and guarantees" (Interview 5, 2023). Finally, multi-stakeholder partnerships can be particularly useful in addressing the social drivers of watershed degradation, such as landowners and high-intensity water users, by including them in restoration efforts (Christian-Smith & Merenlender, 2010).

The San Joaquin Valley, with a myriad of jurisdictional authorities, private sector operations and landowners, would benefit greatly from the use of MSPs for watershed restoration. According to Kelsey et al. (2020), "Partnerships are needed to shape land use change in the San Joaquin Valley in a way that increases the long-term viability of agriculture while improving social and environmental outcomes". In light of the connectivity between the regional economy of the valley, and the water resources provided by the San Joaquin River and Tulare Lake Watersheds, the full range of stakeholders operating within the regional economy should be included in watershed restoration activities (Fresno State California Water Institute, 2020).

The fragmentation of jurisdictions within the San Joaquin Valley creates a significant barrier to the conservation of cross-boundary watersheds (Salzman et al., 2018). Figure 4.6 below demonstrates this fragmentation by illustrating the 15 counties which comprise the San Joaquin Valley. Of particular relevance here is the SGMA, which requires the formation of regional agencies known as Groundwater Sustainability Agencies (GSAs) (Fresno State California Water Institute, 2020). 108 GSAs have been formed within the San Joaquin Valley and are each responsible for specific water supplies (Fresno State California Water Institute, 2020). Fresno State California Water Institute (2020) argues that more "comprehensive GSAs" could have been formed by focusing on economic and social factors, rather than "water supply availability". Holistic watershed management within the San Joaquin Valley requires a collaborative, cross-jurisdictional approach (Chamberlin et al., 2020). MSPs, which encourage the participation of impacted communities, private firms, government agencies and other supporting groups, may be critical to address common watershed challenges and bridge jurisdictional boundaries. However, Participant 1 argues that MSPs may further complicate restoration projects; "In general, the more stakeholders involved in planning and project implementation, the longer and more cost-intensive meetings and consultations are. These challenges can be overcome with time and sufficient resources" (Interview 1, 2023).

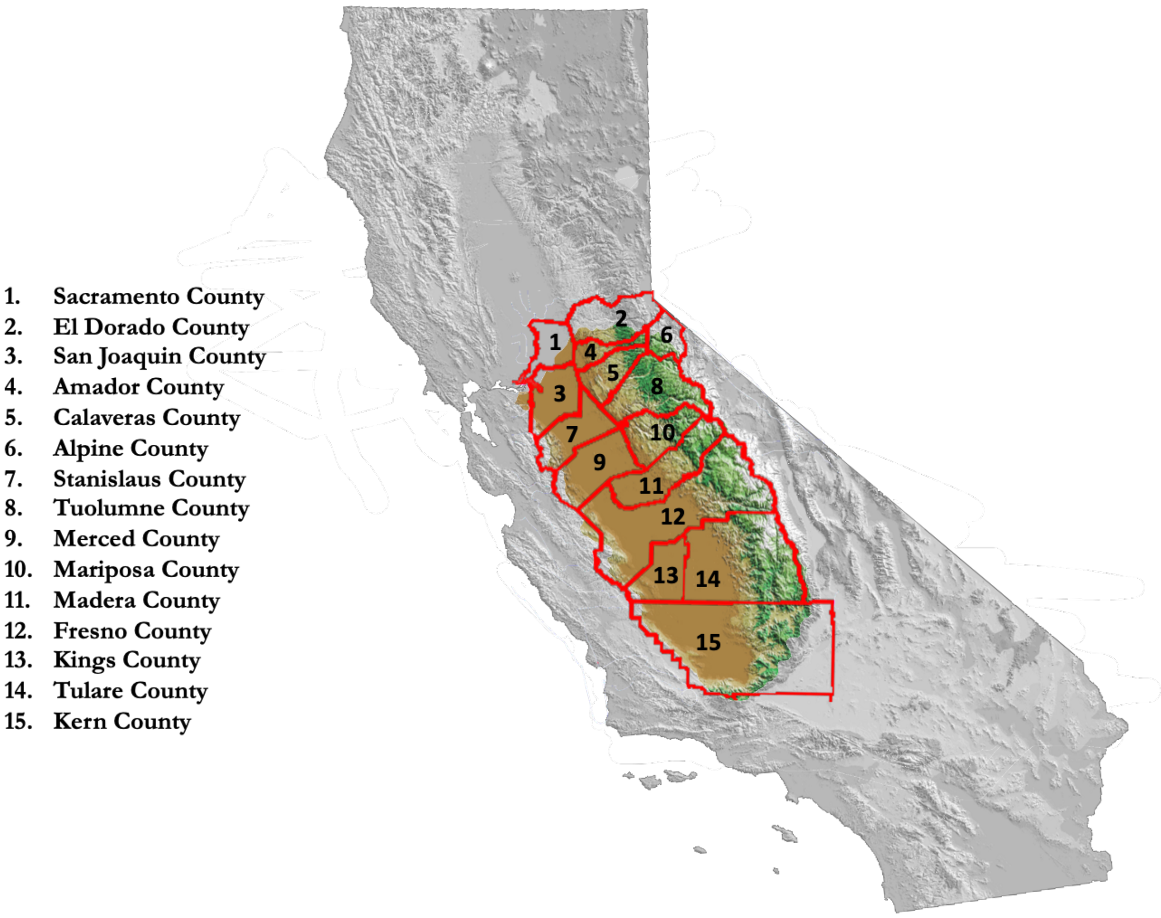

Figure 4.6 Counties within the San Joaquin Valley

Source: Created by the author using data from Hanak et al. (2019). Map base layer sourced from USGS (2005)

Government Collaboration

Considering that public funding has traditionally represented the majority of investment in NBS, government agencies will also play a critical role in incentivising private engagement with NBS (Mayor et al., 2021). Governments can drive private investment through command-and-control measures, incentive programs and knowledge/resource sharing (Escriva-Bou et al., 2022). Recent policies, including California's Executive Order N-82-20 and the Federal Infrastructure Investment and Jobs Act, have allocated public funding for use in "nature-based infrastructure solutions" (California Natural Resources Agency, 2022, & Wolters Kluwer, 2023). As government officials and agencies begin to embrace NBS, they should seek to incentivise private engagement with these solutions through the creation of incentive programs and the sharing of knowledge gained from successful NBS project implementation (The Nature Conservancy, 2019b).

Due to uncertainties regarding costs and benefits, the private sector typically perceives NBS projects as higher-risk investments (The Nature Conservancy, 2019b). Participant 4 confirms this; "Risk of water scarcity may be less than the perceived risk of investing in novel approaches - especially when a company is not doing well financially (Interview 4, 2023). The public sector may help to mitigate these perceived risks by offering technical and experience-based expertise, and financial support mechanisms (i.e., first-loss guarantees) (The Nature Conservancy, 2019b). According to Participant 1, a clear legal framework is necessary to achieve private-sector participation (Interview 1, 2023). To fully address the high-risk perception and uncertainty surrounding NBS projects, PPPs should be employed within the San Joaquin Valley to promote the participation of the private sector in well-established public restoration projects (Debaere & Kapral, 2021). Conversely, Participant 3 points out that "the cultural differences between the public and private sector, especially on timing and level of administrative detail can make the process incredibly painful" (Interview 3, 2023).

4.5 Watershed Restoration Techniques

In the San Joaquin Valley context, one option for addressing the risks brought about by water scarcity is investment in new freshwater supplies. "Sources for new supplies might include local recharge, changes in operations to capture more flood flows under new climate conditions, and imports from other regions" (Escriva-Bou et al., 2023). For example, to mitigate water risks associated with the SGMA, Escriva-Bou et al. (2023) estimate that an investment equal to $500 per acre-foot (AF) of agricultural land within the San Joaquin Valley could reduce expected GDP losses by 58 - 61% and unemployment by 57-69%.

The following section will describe various techniques for watershed restoration that could be employed to increase freshwater supplies for the San Joaquin Valley. Through the mechanisms described in Section 4.4, private firms could invest in these techniques as part of their water risk management strategies. The TCA has revealed two categories of watershed restoration; efforts that take place within source watersheds (i.e., land within the Sierra Nevada Mountain Range) and restoration activities within the San Joaquin Valley floodplain. Figure 4.7 illustrates these two restoration regions (separated by the vertical red line) and the specific restoration activities that could be implemented in each region.

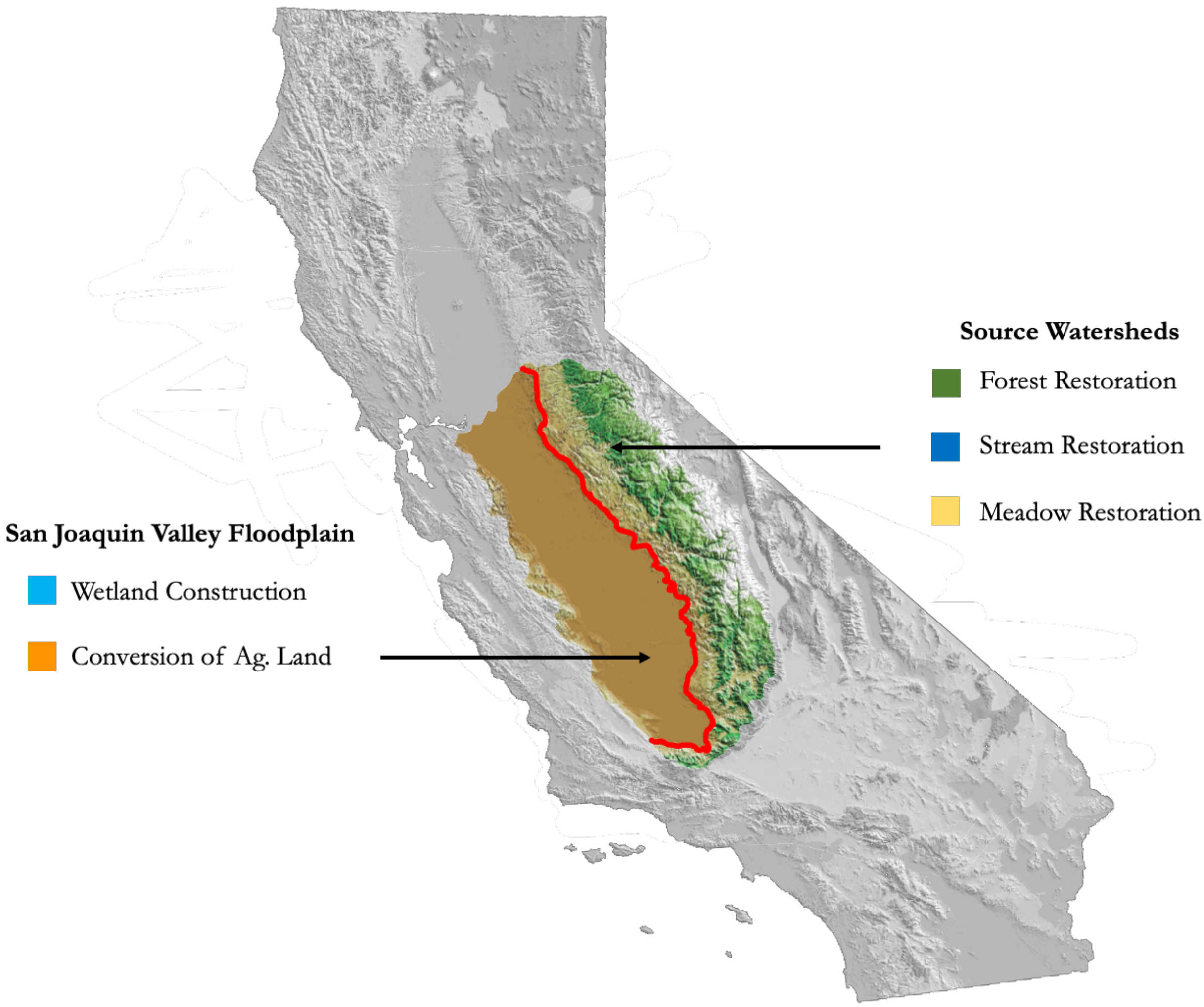

Figure 4.7 Restoration Activities within the San Joaquin Valley and Source Watersheds

Source: Created by the author using data from Hanak et al. (2019). Map base layer sourced from USGS (2005)

4.5.1 Source Watershed Restoration

The health of California's headwater forests is in decline, and restoration is imperative to protect the water storage and flow capacity of these source watersheds (Bustic et al., 2017). "Decades of fire suppression, an emphasis on short-term management priorities, weather extremes, and a warming climate have set the stage for the decline in forest resilience" (Bustic et al., 2017). As previously stated, two-thirds of California's freshwater flows from the Sierra Nevada headwaters, and investment in this region is imperative to tackle ongoing water scarcity issues in the state (Bustic et al., 2017).

"Water risk is not only linked to how a producer could affect others downstream (impacts) but how reliant they are on others upstream (dependencies)" (Aquaoso, 2021). This principle establishes that agricultural water users in the downstream San Joaquin Valley would benefit from healthy upstream resources. Pacific Forest Trust (2022) confirms the importance of source watersheds; "Without these watersheds, no amount of infrastructure can guarantee California's water security". Despite the importance of source watersheds for California's water supplies, "the potential to cost-effectively deliver key hydrologic services through watershed investments far exceeds the current extent of watershed conservation programs (Kroeger et al., 2017). Reiterating this point, California AB 2480 refers to source watersheds as "integral components of California's water infrastructure" (Tenorio, 2017).

The following subsections will focus on three main types of source watershed restoration: (1) meadow restoration, (2) forest restoration and (3) stream restoration.

Meadow Restoration

Historically, cattle grazing, wildfire management techniques and the formation of homogeneous conifer groves have impacted the natural hydrologic functions of source watershed (Pacific Forest Trust, 2021). According to Pacific Forest Trust (2021), "100% of studied dry meadows and 85% of wet meadows [in the Sierra Nevada range] needed restoration". These meadowlands provide multiple watershed services, including (1) flood reduction and flow reliability, (2) increased dry season flows, (3) erosion reduction, (4) water temperature regulation and (5) groundwater recharge (National Fish and Wildlife Foundation, 2010). It is estimated that freshwater flowing from the headwater region of the Sierra Nevada mountains could increase by 50,000 to 500,000 acre-feet per year, as a result of restored meadows (National Fish and Wildlife Foundation, 2010).

Irrespective of the potential for water flow improvement from meadow restoration, some lingering doubts about the effectiveness of such activities persist. "Scientific consensus is lacking on the amount of water that can be retained in restored meadows across meadow types, the downstream water quantity and quality impacts of restoration, benefits to downstream flow reliability, and the overall cost-benefit of restoration" (National Fish and Wildlife Foundation, 2010). Furthermore, such projects require long pre-implementation planning periods (around 2 years) and even longer monitoring periods (3 years) to confirm their success (National Fish and Wildlife Foundation, 2010). This uncertainty can be mitigated by three steps, according to National Fish and Wildlife Foundation (2010):

1. Before/after comparison of water and habitat benefits of restoration with coordinated monitoring and analysis

2. Quantification of groundwater storage and streamflow regulation

3. Economic analysis of ecosystem service values provided by restoration

Forest Restoration

Forests provide several key hydrologic functions, including water filtration and flow regulation (Gartner et al., 2022). Deforestation in the Sierra Nevada region has led to unnaturally dense forests, contributing to an increased risk of wildfires which decrease downstream water flows and freshwater quality (Pacific Forest Trust, 2021). Participant 5 highlighted the impact of deforestation on reliable freshwater flows; "When you remove trees, you disrupt the water cycle. You need plants to ensure healthy water supply. You can't remove a significant portion of the water cycle and expect water to remain constant" (Interview 5, 2023). According to The Nature Conservancy (2019a), around 64% of forests in this region are degraded. Several management strategies exist to combat these threats, including mechanical thinning, controlled burns and tree parasite control (Bustic et al., 2017).

Like meadowland restoration, there are several barriers to the successful implementation of forest restoration projects for freshwater security. First, the thinning of dense forests may allow larger trees to absorb more water or small shrubs to grow back quickly; in both cases, freshwater flows from forests would decrease (Bustic et al., 2017). This fact emphasises a need for long-term maintenance of restored forest areas, driving up the cost of restoration efforts (Bustic et al., 2017). Second, there is a significant deficiency of projects to prove the value of forest restoration for water conservation, and the projects that do exist are on a relatively small scale (Bustic et al., 2017). In conclusion, the varied assembly of landowners within the Sierra Nevada headwater region, each adhering to unique land management approaches, amplifies the complexity of comprehensive restoration endeavours. (Townsend et al., 2012).

Stream Restoration

A final category of restoration activities is the restoration of stream and riparian zone health within the headwater region. Though such improvements can provide multiple benefits, including water quality enhancement and habitat revival, restoration activities can also help to improve flow yields from headwater streams (Bardeen, 2022). According to Bardeen (2022), "Rivers [in the San Joaquin Valley region] once provided twice as much groundwater as they do today. That's not surprising because of the dams built in the last 100 years, but it suggests that rivers could at least double what they put into the ground today". Increased flows to the San Joaquin Valley can be expected from purposeful stream restoration in the Sierra Nevada region, and when increased yields reach the San Joaquin Valley floodplain, the mountain runoff will help to recharge the valley's groundwater tables (Bardeen, 2022).

Streams within the San Joaquin Valley are also in need of restoration. Erosion from unpaved roads and agricultural conversion present serious threats to the health of these watershed features (Pacific Forest Trust, 2021). Additionally, the fragmentation of streams, from varied land ownership and constructed dams, disrupts the natural flow of freshwater into the San Joaquin Valley (Pacific Forest Trust, 2021). It is estimated that 10,513 miles (~16919 km) of streams are in need of restoration within the Sierra Nevada source watershed region (Pacific Forest Trust, 2021).

4.5.2 Restoration Within San Joaquin Valley Floodplain

While improvements in source watershed regions could help to promote steady and consistent flows of freshwater into the San Joaquin Valley, improvements within the floodplain watersheds of the valley could also contribute to the water security of the region. Two categories of restoration activity in the valley have been identified; these are (1) the conversion of agricultural lands and (2) the construction or enhancement of wetland areas.

Converting Agricultural Lands

In the wake of significant demands for fallowed agricultural lands within the San Joaquin Valley as the result of groundwater scarcity and regulatory restrictions (SGMA), many thousands of acres of farmland have the potential to be converted into natural assets which could promote watershed health and water security (Escriva-Bou et al., 2023). Rather than retiring these agricultural lands in an arbitrary manner, Kelsey et al. (2020) argue that "Consolidating restoration will create significantly better outcomes for nature than a fragmented pattern of land idling across the valley". Furthermore, it will be essential to attract "public and private funding" in order to achieve strategic farmland idling (Kelsey et al., 2020). Participant 3, a representative of a food and beverage company that sources from the San Joaquin Valley, indicated that their firm has already begun to implement the sustainable conversion of agricultural land within the region (Interview 3, 2023).

One of the primary reuses for fallowed agricultural land could be the establishment of groundwater recharge features (Blue Earth County, 2022). Other co-benefits, such as habitat restoration, further justify a sustainable restorative approach to farmland idling in the valley (Kelsey et al., 2020). Hanak et al. (2019) list several potential uses for fallowed agricultural lands, including restoration of riparian areas and desert habitat, solar energy generation and the construction of wetlands to promote watershed health (Hanak et al., 2019). According to Hanak et al. (2019), "Some retired land—perhaps 20,000 acres—may be suitable for multiple-benefit projects that reduce flood risk, increase groundwater recharge, and expand riparian corridors and floodplains". A major concern for fallowed farmland is desertification, and Participant 5 argues that such conditions "prevent water from being absorbed into the soil" preventing groundwater recharge (Interview 5, 2023). Another potential use for idled farmland could be the construction of built wetland habitats (Hanak et al., 2019). The following section will outline the benefits to water security that can be achieved by introducing constructed wetlands.

Wetland Construction

"Constructed wetlands from their beginning emerged as a nature-based solution (NbS) in various water resources management practices" (Saquib et al., 2022). There are two primary functions of constructed wetlands that could help to mitigate water risks in the San Joaquin Valley; groundwater recharge and flood risk mitigation (Gartner et al., 2022). Additionally, wetlands can promote wastewater recycling to increase freshwater availability (Saquib et al., 2022). Saquib et al. (2022) describe several advantages of constructed wetlands, which include:

1. Nature-based solution (NbS) for wastewater treatment
2. Cost-effective systems
3. Treated water can be used in irrigation and other essential services
4. Devoid of any chemical treatment like conventional methods
5. Enhance aesthetics of an area

Unlike other watershed restoration activities, constructed wetlands are considered a decentralised solution, which can be established on fragmented land segments while still achieving desired sustainability benefits (Saquib et al., 2022). The decentralised nature of these features makes them an ideal solution for the reuse of idled farmland (Blue Earth County, 2022). Still, strategic restoration of the San Joaquin Valley floodplain requires a collaborative and coordinated approach and constructed wetlands should be created within a system of restorative initiatives (Kelsey et al., 2020).

5 Chapter 5 Discussion

Chapter 5 will serve as an analysis and discussion of the findings presented in Chapter 4. First, collected data will be analysed through the two frameworks presented in Section 2.2 to answer RQ 1 and RQ 2 respectively. Next, the results of this analysis will be compared to the existing body of knowledge identified in the literature review (Section 2.1). This chapter will then conclude with a reflection on methodological choices, legitimacy and generalisability.

Analysis of Findings

RQ 1: What are the water quantity risks impacting the agricultural sector in California's San Joaquin Valley region?

The collected secondary and primary data reveal an array of water-related risks that will likely impact the agricultural sector within the San Joaquin Valley. To structure the answer to this research question, water risks will first be broken down into the 3 main categories of risk (physical, regulatory and reputational) identified in the TCA of Chapter 4 (Section 4.1). Each category of risk will then be analysed using the Risk Assessment Factor Framework presented in Section 2.2 above. Figure 5.1 (a replication of Figure 2.2) illustrates this framework for reference. Data from Chapter 4 will be used to demonstrate the hazard, exposure and vulnerability of each of the three risk categories.

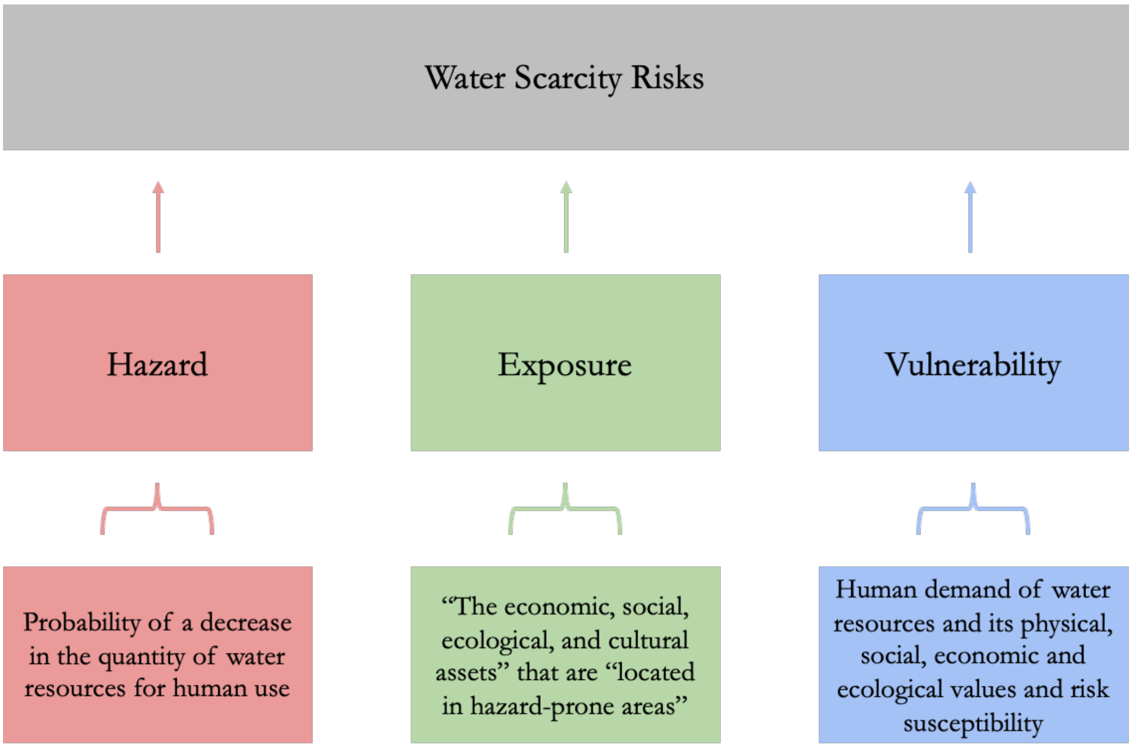

Figure 5.1. Risk Assessment Factor Framework

Source: Created by the author, based on risk assessment factors presented in Ronco et al. (2017)

Physical Water Risks

Hazard

The likely increase in water demand from growing populations and intensifying natural phenomena brought about by climate change indicate a high probability of significant decreases in freshwater supply for the San Joaquin Valley region. Major risks stemming from severe drought conditions, rising temperatures, catastrophic wildfires, urban competition and groundwater overdraft are all significant threats to the freshwater flows that are necessary for the survival of the agricultural sector in the valley.

Drought conditions in the state have intensified in the past decade, with some of the driest years on record recorded in the past 5 years (Escriva-Bou et al., 2022). These conditions have already created notable shortages in water storage and allocations, as reported by major water providers in the region (U.S. Bureau of Reclamation, 2023). Uncontrollable wildfires have ravaged the state, introducing sediment to waterways that inhibit healthy water flows (National Fish and Wildlife Foundation, 2010). Rising temperatures, contributing to shrinking mountain snowpacks and increasing evaporation rates in rivers and irrigated land, also threaten the valley's freshwater resources (Escriva-Bou et al., 2022 & 22). As urban populations within the state grow exponentially, increasing competition for freshwater resources will further limit the availability of water for agricultural use (Interview 1, 2023 & Austin, 2022). Finally, groundwater overdraft within the San Joaquin Valley has led to reduced aquifer health, further limiting supplies of freshwater for agricultural consumption (Escriva-Bou et al., 2023).

Exposure

Several groups are directly exposed to water shortage risks within the San Joaquin Valley. The agricultural sector within the valley is particularly exposed to such risks. The sector's size and economic output have been emphasised in Chapter 4 above (Escriva-Bou et al., 2023). Communities in the valley are directly exposed to water shortage risks, and around one-fifth of all jobs in this region rely on thriving agricultural production (Hanak et al., 2019). Investors and firms that source crops from the valley are also exposed to the identified water risks. Crops from the San Joaquin Valley supply around $34 billion in revenue for the food and beverage industry, while investors have emphasised the risks associated with investing in water-stressed firms (Escriva-Bou, 2023, & The Nature Conservancy, 2019b). Finally, ecological functions and the region's biodiversity depend on stable hydrologic conditions in a region "with one of the highest concentrations of endangered species in the country" (Hanak et al., 2019).

Vulnerability

Many economic, social and ecological assets are particularly vulnerable to physical water risks. The agricultural sector in the region is specifically vulnerable, as it relies on a staggering 16.1 MAF of water per year to support over 4.5 million acres of irrigated land (Escriva-Bou et al., 2023). It is this dependency on freshwater resources that justified a focus on the region's agricultural sector for the scoping of this thesis (Section 1.3) For example, around 900,000 acres of cropland will likely be abandoned as the result of depleted groundwater resources (Escriva-Bou et al., 2023). Meanwhile, communities in the valley are directly vulnerable to the economic decline of around 2.3 %, that is predicted as a result of groundwater overdraft. The agricultural sector, and reliant communities, have a deeply dependent relationship with freshwater and are therefore considerably vulnerable to water scarcity risks.

Regulatory Water Risks

Hazard

Regulation will only continue to increase as water supplies are further depleted. The probability of new regulations is quite high and current water regulations, such as the SGMA, have fast-approaching deadlines for compliance (Escriva-Bou et al., 2023). The likelihood of water shortages as a result of the SGMA is also high; groundwater pumping restrictions under this law will require the idling of over 535,000 acres of farmland (Hanak et al., 2019). Furthermore, various conservation regulations, such as the ESA, demand large amounts of freshwater which will in turn become unavailable for agricultural use (Hanak et al., 2019). Finally, fee increases, as a result of reduced water supplies and regulatory measures, will also increase the likelihood of freshwater shortage risks impacting the agricultural sector (Fresno State California Water Institute, 2020, & Escriva-Bou et al., 2023).

Exposure

Fast-changing regulations, in light of increasingly scarce freshwater resources, expose private firms with agricultural resources in the San Joaquin Valley to regulatory risks. Small farms are particularly exposed to the regulatory risks posed by increasingly stringent laws, whereas larger farms may be better equipped to adapt (Interview 5, 2023). All cropland within the San Joaquin Valley is subject to certain regulations, such as the SGMA, which will create significant water risk impacts (Escriva-Bou et al., 2023). Finally, higher water fees will harm the bottom line of all private firms and investors with stakes in the agricultural assets of the valley (Hanak et al., 2019).

Vulnerability

Because farms are commodity-focused, the driving force for agricultural firms is their ability to turn a profit (Interview 3, 2023). Thus, higher fees and stricter regulations are a direct threat to this financial motivation. For example, it is estimated that the SGMA will contribute to a $4.5 billion decline in the valley's GDP (Hanak et al., 2019). Furthermore, the novelty of these regulations and the rapid implementation of new laws could threaten the capacity of private firms to adapt, as many uncertainties surround the identified mitigation measures for regulatory risks (Hanak et al., 2019).

Reputational Risks

Hazard

A growing acknowledgement of global freshwater scarcity will increase the probability of reputational risks associated with investor and consumer perceptions. The collected data has indicated that investors are increasingly considering water risk as a major justification for divestment in a company or project (The Nature Conservancy, 2019b). Additionally, a majority of consumers within California have expressed concern about water scarcity in their region and could be inclined to avoid firms or brands that are perceived to be unsustainable in their consumption of water resources (Baldassare et al., 2021). However, Participant 4 emphasises that such reputational risks will only be relevant if consumers are specifically aware of the connection between a firm's operations and regional water scarcity (Interview 4, 2023).

Exposure

The firms most exposed to reputational risks will be high-profile agricultural or agriculture-reliant companies with assets in the San Joaquin Valley. Firms with a green brand image, or those with an environmentally conscious consumer base, are particularly exposed to consumer-based reputational risks (Interview 3, 2023). Industries with a reputation for freshwater overconsumption, particularly the food and beverage and garment sectors, will also be exposed to reputational risks when sourcing from high-water stress regions like the San Joaquin Valley (Interview 3, 2023 & Interview 4, 2023). Finally, as investors began to consider reductions in available water as a major justification for divestment, firms sourcing from the water-stressed San Joaquin Valley will be further exposed to investor-based reputational risks (The Nature Conservancy, 2019b).

Vulnerability

Firms with agricultural assets in the San Joaquin Valley are notably vulnerable to reputational risks due to their dependence on freshwater resources, heightened consumer and investor awareness of water scarcity in the region and agriculture's global contribution to freshwater overconsumption. As revealed in section 2.1, reputational considerations have traditionally been the primary drivers of private engagement with water stewardship techniques (Debaere & Kapral, 2021). The results of the conducted interviews with three private sector representatives indicate that certain firms continue to regard reputational risks as the primary driving force behind their investments in water stewardship (Interview 3, 2023 & Interview 4, 2023). Based on this information, it is clear that private firms, specifically those with agricultural assets in the San Joaquin Valley, perceive themselves as particularly vulnerable to water-related reputational risks.

RQ 2: What is the water risk management capacity of watershed restoration when employed by private firms with agricultural assets in California's San Joaquin Valley?

In the following sections, data from Chapter 4 regarding the two categories of restoration measures (source watershed restoration and restoration within the San Joaquin Valley Floodplain) will be analysed using the Risk Management Capacity Factors Framework, presented in Section 2.2. Figure 5.2 (a replication of Figure 2.3) illustrates this framework below.

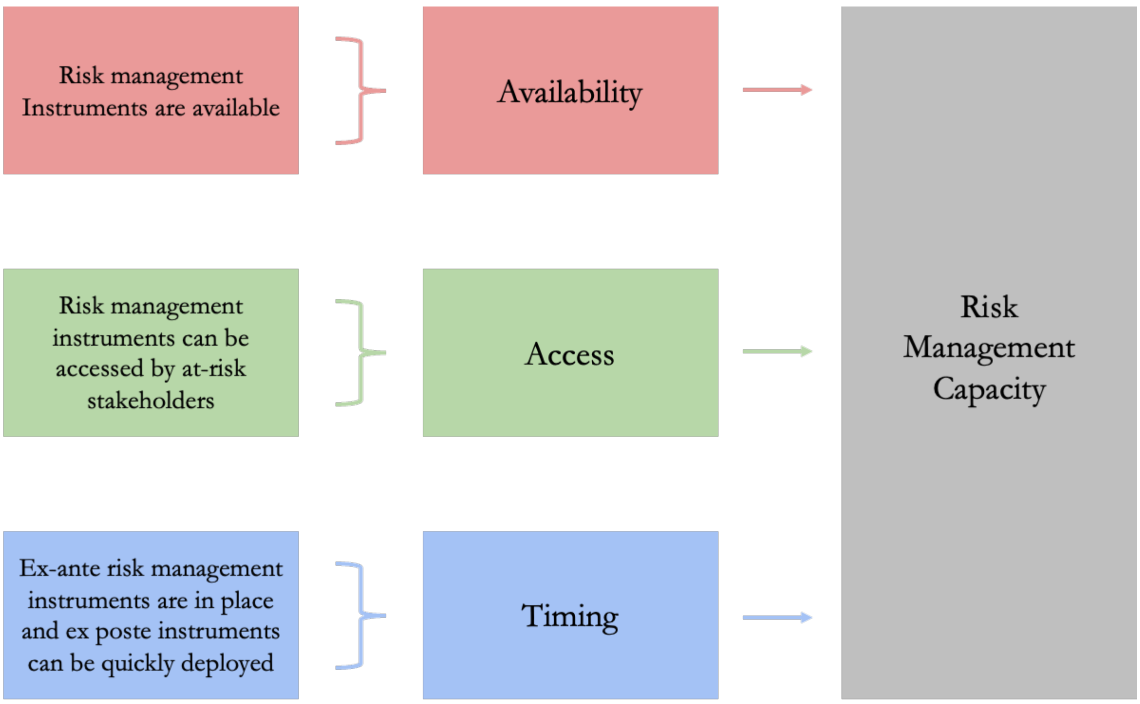

Figure 5.2. Risk Management Capacity Factors Framework

Source: Created by the author, based on risk management capacity factors presented in Jaffe et al. (2010)

Source Watershed Restoration

Availability

The number of mechanisms and demonstrable programs for engaging the private sector in source watershed restoration is growing (Salzman, 2018). Consequently, the availability of knowledge about NBS for source watershed management will increase as more examples of successful projects emerge (Kang et al., 2023). Many watershed features in the Sierra Nevada mountains are in critical need of restoration, indicating the availability of sites for risk mitigation investment if barriers related to land fragmentation and technical uncertainties are overcome (National Fish and Wildlife Foundation, 2010). As government agencies and private investors increasingly employ watershed management and NBS approaches for mitigating water risks, the availability of specific restoration programs, avenues for investment and mechanisms for private engagement will likely also increase (The Nature Conservancy, 2019b, & Salzman, 2018).

Access

The ability of private firms to access the available source watershed restoration programs depends a lot on several major barriers and drivers. First, private firms must adequately understand the value and potential ROI of watershed resources in order to justify restoration investments. Mechanisms, such as PWS, Water Funds and Resilience Bonds, may help to address the undervaluing of watershed resources by utilising a "beneficiary pays" model for restoration activities (WWF-UK, 2017). Second, in order to overcome barriers posed by uncertainties and perceived risks of investment in source watershed restoration, examples of water supply benefits achieved through completed restoration projects must be proven at scale (Kang et al., 2023). While a collection of restoration projects have emerged in the Sierra Nevada source watersheds, these projects are fragmented and of relatively small scale, providing low investment value and falling short of demonstrating the comprehensive array of benefits attainable at larger scales (Mayor et al., 2021). Third, the fragmentation of projects can be attributed to the diversity of landowners within the source watershed region, creating a clear barrier to the accessibility of restoration for risk management (Townsend et al., 2012). To achieve restoration projects at scale, MSPs, along with government assistance and incentives, could drive collaboration between beneficiaries, landowners, conservation groups and other relevant stakeholders (WWF-UK, 2017).

Timing

Though many of the source watershed restoration programs are in their infancy, the existence of even a few potential programs indicates a time-sensitive window of opportunity, where private firms can invest early for a competitive advantage and proactive risk management approach. However, a major timing issue concerns the long ROI timeframe for NBS and restoration projects (Kang et al., 2023, Abell et al., 2017, and Interview 5, 2023). Private agricultural firms may have access to available restoration projects to address future (ex-ante) water risks, but because such projects employ natural functions, increased water supplies may not be achieved for several years after project completion (Abell et al., 2017 & Interview 5, 2023). While it is essential for private firms to address ex-ante water risks, investment in source watershed restoration will not serve as an ex-post risk mitigation instrument for addressing current freshwater shortages in the San Joaquin Valley.

Watershed Restoration within the San Joaquin Valley Floodplain

Availability

Techniques to improve hydrologic conditions in the floodplains of the San Joaquin Valley are perhaps more available than techniques to address source watersheds. This is due to an array of successful examples of farmer investment in NBS within their property lines (Chamberlin et al., 2020). The same regenerative techniques implemented in these cases can be easily applied to the conversion of agricultural land within the valley. Additionally, the increasing availability of idled farmland within the valley, as the result of SGMA restrictions, could provide over 20,000 acres for restoration projects (Hanak et al., 2019). The climate and geography of the San Joaquin Valley may also aid in the availability of wetland construction sites, as only 5% of historic wetlands remain in the valley, indicating the potential for the restoration of some lost wetlands (California Natural Resources Agency, 2022).

Access

The accessibility of watershed restoration projects in the San Joaquin Valley for firms looking to manage their water risks, is dependent on many of the same factors as those pertaining to source watershed restoration. However, the fragmentation of land ownership and jurisdictional boundaries impose the most significant barriers to large-scale restoration in the valley floodplain. For example, the SGMA, which will likely serve as a significant driver of restoration in the valley, employs a fractured network of GSA authorities to achieve groundwater recharge goals. Again, MSPs and government collaboration are vitally important to link GSAs, other government agencies, landowners, investors and conservation organisations to achieve comprehensive restoration within the valley's flood plain (Kelsey et al., 2020). Large-scale, watershed-level projects can then provide a holistic demonstration of the value and bundled benefits provided by watershed restoration in the San Joaquin Valley.

Timing

As with source watershed restoration, firms must seize a window of opportunity for investing in local watershed management. As farmland is idled within the valley, investors and firms looking to address water stress should seize opportunities to consolidate restoration efforts and take advantage of available land before it is acquired for other purposes (Kelsey et al., 2020). Again, the lengthy time frame associated with watershed restoration and NBS projects could prove to be a major drawback to the timing capacity of these types of risk management factors (Kang et al., 2023, Abell et al., 2017, and Interview 5, 2023). The water security benefits from restoration investments may serve as ex-ante risk mitigation measures for future water stress but will do little to address urgent valley water risks in an ex-post manner.

Synthesis of Thesis Findings and Existing Knowledge

Section 5.3 will provide a brief synthesis of existing knowledge (from the reviewed literature in Section 2.1) and the thesis findings presented in Chapter 4. Figure 5.3 (a replication of Figure 2.1) outlines the three steps for private engagement with water stewardship (motivations, approaches and solutions) first presented in the literature review.

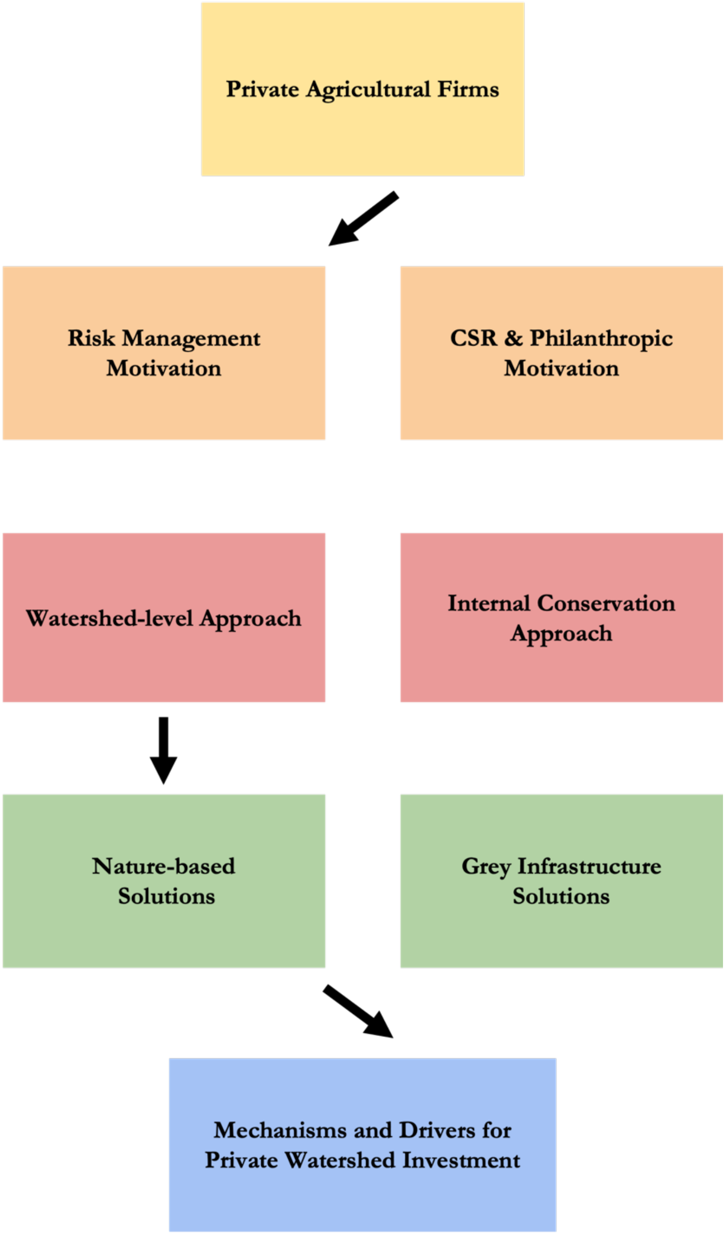

Figure 5.3. The Three Steps for Private Engagement with Water Stewardship

Source: created by the author using relevant themes from the literature review (Section 2.1)

Step 1: Motivations. Utilising a risk management or CSR and philanthropic motivation to drive water stewardship (orange boxes). At this level, a private firm must decide whether their primary motivations for engagement with water stewardship stem from reputational goals within their CSR and philanthropic functions, or whether freshwater scarcity presents material risks to their business operations, requiring a strategic risk management approach. The reviewed literature indicates that while CSR and philanthropic motivations have traditionally been the primary driver of corporate water stewardship, firms should recognize the material value of avoiding water risks in their operations and supply chains (Debaere & Kapral, 2021 & 113). The reviewed literature argues for a risk management motivation at this step (illustrated by the black arrow above the "Risk Management Motivation" option).

Step 2: Approaches. Adopting internal conservation or watershed-level approach to combat perceived water risks (red boxes). At this point, a private firm may implement certain internal measures, such as production line efficiency improvements, to achieve water stewardship goals (The World Wildlife Fund, 2011). However, several of the reviewed articles argue for a more comprehensive, watershed-level approach to strategically address water scarcity risks (Gartner et al., 2022). While internal measures have seen the most widespread implementation, there is a clear shift towards holistic approaches as highlighted by the reviewed literature (Reig et al., 2019). Therefore, the decision to implement a watershed-level approach is made at this step (Illustrated by the black arrow above the "Watershed-level Approach" option).

Step 3: Solutions. Once a decision is made to invest at the watershed level, a private firm can then decide to engage with NBS or grey infrastructure solutions to promote restoration. Again, while grey infrastructure has been (and remains) the norm for restorative action, there is a growing interest in NBS alternatives to achieve similar social and economic benefits (Kang et al., 2023). At this step, the growing interest is demonstrated by the selection of NBS over grey infrastructure solutions (Illustrated by the black arrow above the "Nature-based Solutions" option).

Findings from the literature review (Section 2.1), structured into the above framework, helped to guide the data collection, presentation and analysis within Chapter 4. Specifically, Section 4.3 applies collected data to the three-step framework. The following section proposes an expanded framework that includes the three-step framework from the literature review and thematic categories from Chapter 4, demonstrating a synthesis of known information and findings from this thesis. Figure 5.4 below illustrates this framework and builds upon the three-step framework presented in Figure 5.3.

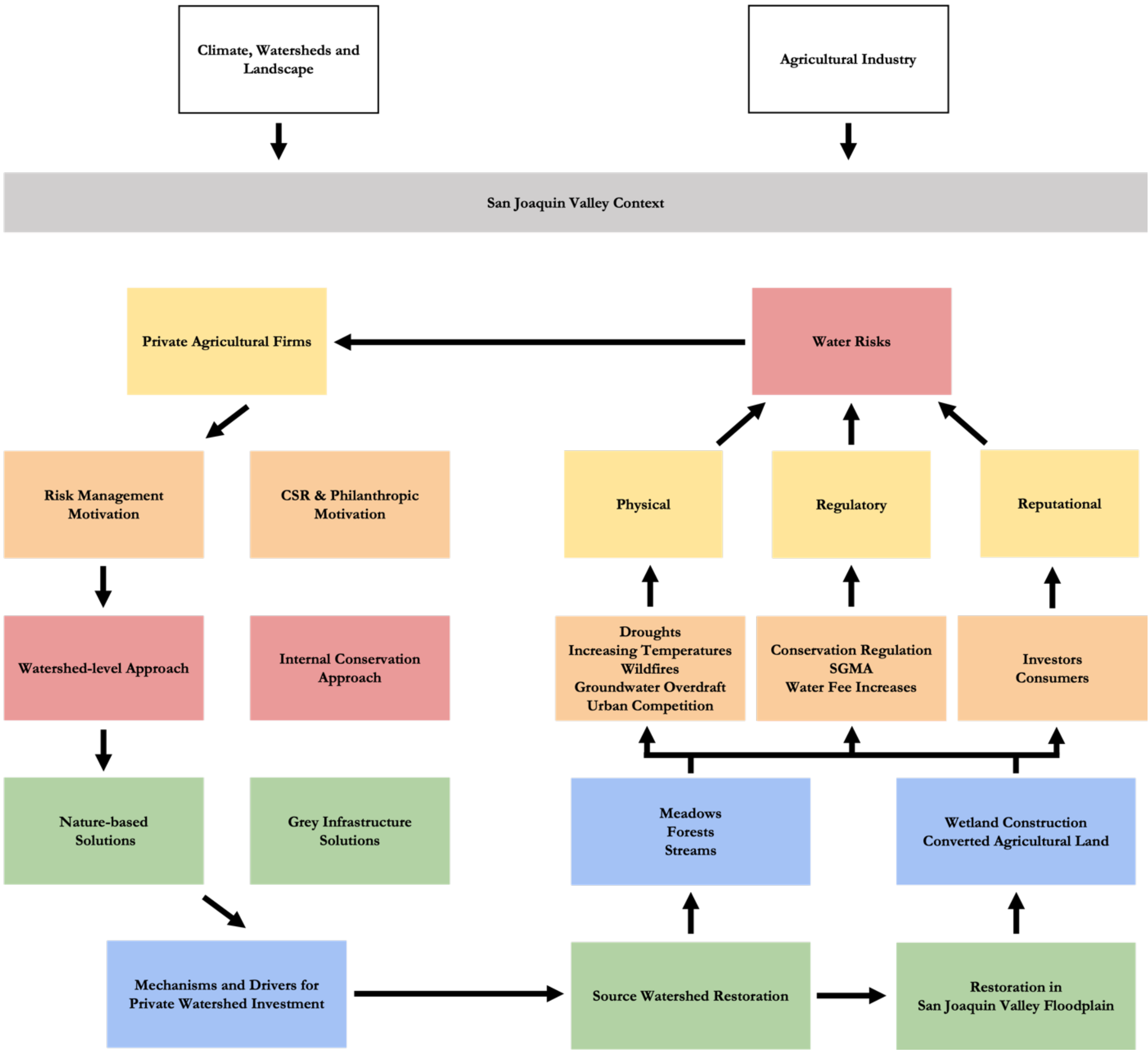

Figure 5.4. Comprehensive Framework to Synthesis Existing Knowledge and Thesis Findings

Source: Created by the author using relevant themes from Chapters 2 and 4

To the left-hand side of Figure 5.4, the three-step framework (from Figure 5.3) is presented. Following the black arrow, the mechanisms and drivers for private watershed investment (blue), presented in Section 4.4, are included. Once a private firm has decided to work with NBS at the watershed level, to address their water risks, these mechanisms and drivers can support investment in restoration projects. Resources and capital then flow towards either of the two categories of restoration projects identified in section 4.5. These are source watershed restoration and restoration within the San Joaquin Valley floodplain (green). Within these categories are several different restoration techniques (also presented in Section 4.5) which are highlighted in blue on the right-hand side of Figure 5.4. These restoration techniques could be employed to manage the specific water quantity risks (right-hand side orange) which were detailed in Section 4.2. These specific risks can be classified into the three categories (physical, regulatory and reputational) exhibited in Section 4.2 (right-hand side yellow). These three risk categories contribute to overall water risks (right-hand side red) which impact private agricultural firms (left-hand side yellow). Finally, the climate, watersheds and landscape of the San Joaquin Valley, and the dynamics of the region's agricultural industry (white) contribute to the overall context of the studied region (grey). These contextual themes have been presented in Section 4.1 above. This comprehensive framework provides a synthesis of findings from the thesis with existing knowledge while providing an outline to apply theoretical knowledge with practical application to guide stakeholders within the San Joaquin Valley

Reflections on methodological choices

Collection of primary data through interviews

In order to accurately research the studied context, it was essential to collect primary data to reveal the perspectives of relevant practitioners. Such information was particularly relevant for understanding perspectives on perceived water risks (to support RQ 1) and potential risk mitigation measures (RQ 2). Though the author contacted over 100 practitioners to request interviews, only five practitioners participated. Furthermore, one of these participants asked to complete a structured questionnaire due to time constraints. This could indicate that practitioners would be more likely to participate in research if surveys or questionnaires, rather than interview requests, were presented to them. For further research into this topic, surveys may allow for a larger pool of practitioners to be studied. Indeed, several of the studied documents utilised surveys to collect practitioner perspectives (Bland, 2022, Reig et al., 2013, The Nature Conservancy, 2019b, & Baldassare et al., 2021).

Inability to travel to the studied region

Another potential source of primary data is direct observation (Yin, 2014). To substantiate the findings of this thesis, direct observations of the water risk impacts within the San Joaquin Valley (to support RQ 1) and implemented watershed restoration projects (RQ 2) could have been collected. However, as stated in Section 3.3, the author was unable to travel to the studied region due to funding and financial aid constraints. Future research, which includes direct observations in the San Joaquin Valley, could augment the findings of this thesis.

Lack of access to data from specific agricultural firms

A final limitation in the methodological choices of this thesis comes from an inability to access data from specific firms with agricultural assets in the San Joaquin Valley. Such data could include information about risk perceptions, freshwater consumption and investments in water stewardship. By obtaining this data, it would be possible to produce a quantitative water risk analysis (to support RQ 1) and a cost-benefit analysis to examine the risk management potential of specific watershed restoration projects (RQ 2). Further research into this topic could benefit from collaboration with specific agricultural firms in the valley to obtain such primary data.

Legitimacy and Generalisability

The legitimacy of the research questions has been supported by the literature review and collected data. There are clearly significant water risks impacting the agricultural sector in California's San Joaquin Valley Region (RQ 1) and certain watershed restoration techniques have demonstrated a capacity to manage some of these risks (RQ 2). Both research questions have been answered by the performed research. However, further research, utilising the other data collection techniques described above, would help to verify the answers to the research questions.

An acknowledgement of a need for further research helps to validate the generalisability of the thesis results. By providing an overview of the studied context through a descriptive case study, this thesis can guide further research by highlighting key factors that could be studied in a more detailed manner. For example, future research could utilise the results of the thesis to pinpoint a specific agricultural firm or restoration intervention to serve as a subject for study. The results of this case study provide an organised overview of existing knowledge, relevant actors, water risks, interventions for water security and drivers or barriers to private engagement with watershed-level NBS in the San Joaquin Valley. These findings could therefore be used to guide other relevant studies and practical work pertaining to this topic and context.

6 Conclusions

6.1 Results of Analysis to Answer the Proposed Research Questions

The aim of this thesis project was to explore private engagement with NBS to promote water security. Though many private firms have implemented small-scale NBS projects, there is a critical need to scale up NBS with the support of private investment. Though many firms have participated in small scale NBS projects as part of their philanthropic or CSR endeavours, encouraging large scale private engagement requires a demonstration of the material value of NBS investment. Through a review of relevant literature, it became apparent that adopting a risk management motivation and watershed-level approach may be the most effective avenues for a private firm to realise the full range of benefits and true financial value of NBS engagement.

The San Joaquin Valley, with an acute water scarcity crisis and freshwater dependent agricultural sector, provides an ideal context to better understand the impacts of water risks on the private sector. Furthermore, the region's watersheds, which are comprised of an array of different land types, support a range of potential NBS solutions to combat water scarcity at the watershed-level. To achieve the refined aim of this thesis, the specific water quantity risks impacting the valley's agricultural sector (RQ 1) and the capacity of NBS (specifically watershed restoration measures) to mitigate water risks, where analysed through identified theoretical frameworks (Section 2.2). The following provides a brief summary of the results of this analysis.

RQ 1: What are the water quantity risks impacting the agricultural sector in California's San Joaquin Valley region?

Hazard

The probability of a decrease in the quantity of water resources for agricultural use in the San Joaquin Valley is increased by clear physical, regulatory and reputational risks.

Exposure

Firms with agricultural assets in the San Joaquin Valley, the communities they support and the ecosystems they compete with, represent the exposed assets located within the hazard prone San Joaquin Valley.

Vulnerability

Because of the agricultural sector's reliance on freshwater resources, firms within the San Joaquin Valley are especially vulnerable to water risks. Consequently, the communities supported by the agricultural industry and the ecosystems within the valley, are also vulnerable to risks associated with decreasing freshwater supplies.

RQ 2: What is the water risk management capacity of watershed restoration when employed by private firms with agricultural assets in California's San Joaquin Valley?

Availability

Source watersheds and fallowed agricultural land within the San Joaquin Valley are in critical need of restoration. Furthermore, there are a range of available avenues, partnerships and mechanisms which contribute to the availability of watershed restoration projects that can serve as risk management instruments.

Access

Several barriers, including value realisation, lengthy ROI timeframes, perceived risks in NBS investment and the fragmented nature of restoration projects, may inhibit private access to watershed restoration for water risk management. Conversely, drivers, such as novel financial mechanisms, MSPs, government incentives and demonstrated examples of successful restoration projects, could help to promote private sector access to watershed restoration projects.

Timing

To adopt a proactive approach to risk management, private agricultural firms with assets in the San Joaquin Valley should look to invest in local watershed restoration before key landscape features are further degraded or developed in a nonstrategic manner. Issues, related to the long-time frame of natural processes, may reduce the capacity of restoration projects to mitigate agricultural water risks in an ex-post manner.

6.2 Summary of Barriers and Drivers

The following list summarises the major barriers and drivers associated with private investment in the identified watershed restoration techniques, to address agricultural water risks.

Barriers

1. A high risk perception associated with NBS and watershed restoration investment

2. A lack of technical or scientific know-how to support investment in restoration projects

3. The long-time frame for the full realisation of restoration projects which rely on natural processes

4. Most NBS and watershed restoration projects are implemented in a fragmented manner at smaller scales, while the true benefits of such solutions are realised at larger, comprehensive scales

5. Private firms often view water as a public good, and have largely failed to attribute adequate value to this natural resource

6. The private sector has traditionally adopted philanthropic and CSR motivations for water stewardship investment, and an understanding of the material risks associated with freshwater scarcity is lacking

Drivers

1. Government collaboration and MSPs can allow for investment risk sharing and reduction

2. Third party experts, including NGOs, landowners and government agencies, can fill knowledge-gaps and provide technical support for private firms looking to invest in watershed restoration

3. The large areas of watershed land in need of restoration within the San Joaquin Valley, and the collection of existing restorative projects and actors in the region, provide an opportunity for private firms to invest now to mitigate future water risks in an ex-ante manner

4. Adopting a watershed-level approach for private water stewardship will allow for a realisation of the full range of benefits associated with restorative NBS

5. With growing corporate, consumer and investor concern regarding global freshwater scarcity, the need for a private firm to adopt a risk management motivation for water stewardship investment will be promoted by the introduction of novel frameworks, monitoring schemes, financial incentives and competitor "peer pressure".

6.3 Recommendations

Recommendations for Researchers

To advance research in this field, several key areas warrant exploration. First, researching specific firms with agricultural assets in the San Joaquin Valley would be invaluable. Such studies could facilitate the assessment of both perceived water risks, and current external restoration investments. Second, dedicating attention to a specific restoration project is essential. Conducting a comprehensive cost-benefit analysis of such initiatives can offer crucial insights into their value and risk management capacity.

Recommendations for Practitioners

Private firms with agricultural assets in the San Joaquin Valley should adopt a risk management motivation and watershed-level approach for their water stewardship initiatives. Exploring the risk management capacity of watershed restoration projects should be a top priority for such firms. NGOs, conservation groups and government agencies should engage with these firms to establish valley-wide partnerships to achieve comprehensive freshwater security. Furthermore, these enabling groups should continue to investigate the water flow augmentation potential of various restoration techniques, specifically source watershed restoration and floodplain land repurposing, to demonstrate the benefits and financial value of investment in restorative projects. California's state government should promote a comprehensive approach by requiring the myriad of landowners, local governments, GSAs, conservation groups and private firms to adopt a watershed-level approach to farmland fallowing and water stewardship.

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8 Appendix

Appendix I: Informed Consent Form

Informed Consent Form

1. Please state your full name and todays date (interview participant)

   ____

2. I, the above stated interview participant, agree to partake in a brief interview or questionnaire to support a master's thesis authored by Ethan Dunnenberger (researcher), an MSc student at Lund University's International Institute for Industrial Environmental Economics (IIIEE). The focus of this research shall be to determine the barriers, drivers, risks and opportunities for private sector engagement with watershed management in California.

   Mark only one oval.

   ◯ Yes
   ◯ No

3. I feel I have been sufficiently informed about the focus of the thesis and the purpose of my participation in the questionnaire or interview.

   Mark only one oval.

   ◯ Yes
   ◯ No

4. I understand that my participation in this research is strictly voluntary. I reserve the right to withdraw my consent at any time, and request that any data collected through my participation be deleted and omitted from the final research output.

   Mark only one oval.

   ◯ Yes
   ◯ No

5. I am assured that my identity shall be kept confidential, and my name will not appear in any research output unless I specifically request otherwise.

   Mark only one oval.

   ◯ Yes
   ◯ No

6. I understand that this particular thesis project has been reviewed and approved by the IIIEE at Lund University, and all subsequent thesis work undertaken shall be in compliance with Lund University's Privacy and Academic Integrity Policies.

   Mark only one oval.

   ◯ Yes
   ◯ No

7. I attest to my understanding of the terms of this informed consent form, and subsequently restate my agreement to participate in the aforementioned research.

   Mark only one oval.

   ◯ Yes
   ◯ No

Appendix II: Structured Questionnaire Form

LUND UNIVERSITY

iiiee

THE INTERNATIONAL INSTITUTE FOR INDUSTRIAL ENVIRONMENTAL ECONOMICS

Interview Questionnaire Form
Master's Thesis - Ethan Dunnenberger

The following form constitutes a voluntary research questionnaire for a master's thesis on the risks and opportunities for private sector engagement with watershed management in California. The results of this questionnaire will be used solely for the purpose of the aforementioned research, and the identity of the respondent will be kept confidential. The questions here can be satisfied with short answers, and the respondent is free to skip any question or omit information at their discretion.

1. **What is your familiarity with the water security crisis in California? In your academic or professional experience, have you worked with technical methods for water conservation or watershed management in the U.S.? What were the major challenges of implementing these methods, and how were they overcome, if at all?**

2. **Please briefly describe, if any, the nature-based solutions (NBS) for water security (i.e. pollution control, water retention or flood management) you have professional or academic experience working with. Please list the benefits and drawbacks of implementing the solutions you choose to describe and what role (if any) the private sector could play in this implementation.**

Interview Questionnaire Form
Master's Thesis - Ethan Dunnenberger

3. **Do you have any experience working with the following watershed management mechanisms for private engagement; 1) public-private partnerships 2) water trading markets 3) corporate internal water stewardship best practices 4) payments for ecosystem services 4) corporate philanthropy 5) green investments (ESG) or 6) private water service or infrastructure providers? If so, please describe that experience, including the benefits and challenges of engagement with these mechanisms.**

4. **Do you perceive any physical water risks (i.e. risks from flooding, low water quality or lack of sufficient water supply) for the agricultural sector in California? In your opinion, what is the severity and likelihood of occurrence for the risks you have identified?**

Interview Questionnaire Form
Master's Thesis - Ethan Dunnenberger

5. **Can you identify any particular regulatory or reputational risks related to water use in California's agricultural industry? If so, what is the severity and likelihood of occurrence for the risks you have identified?**

6. **Has your current or previous work required you to engage with public-private partnerships? If so, please briefly describe the benefits or challenges you encountered while working in this collaborative setting.**

Interview Questionnaire Form
Master's Thesis - Ethan Dunnenberger

7. **In your opinion, does the responsibility for sustainable water use extend beyond the internal boundaries of a private firm? Do you believe it would be economically, environmentally or socially beneficial for private firms to take a more collective approach (i.e. collaboration with other actors for watershed restoration) or address external water risks (i.e., water risks in a supply chain)? What drawbacks do you foresee for these engagement strategies?**

8. **What role can the private sector play in watershed management in general or, if you are familiar, in the specific context of the water security crisis in California? What drawbacks to private engagement with watershed management do you see? Do you believe the current state of private engagement with watershed management is sufficient to address water-related risks in California?**