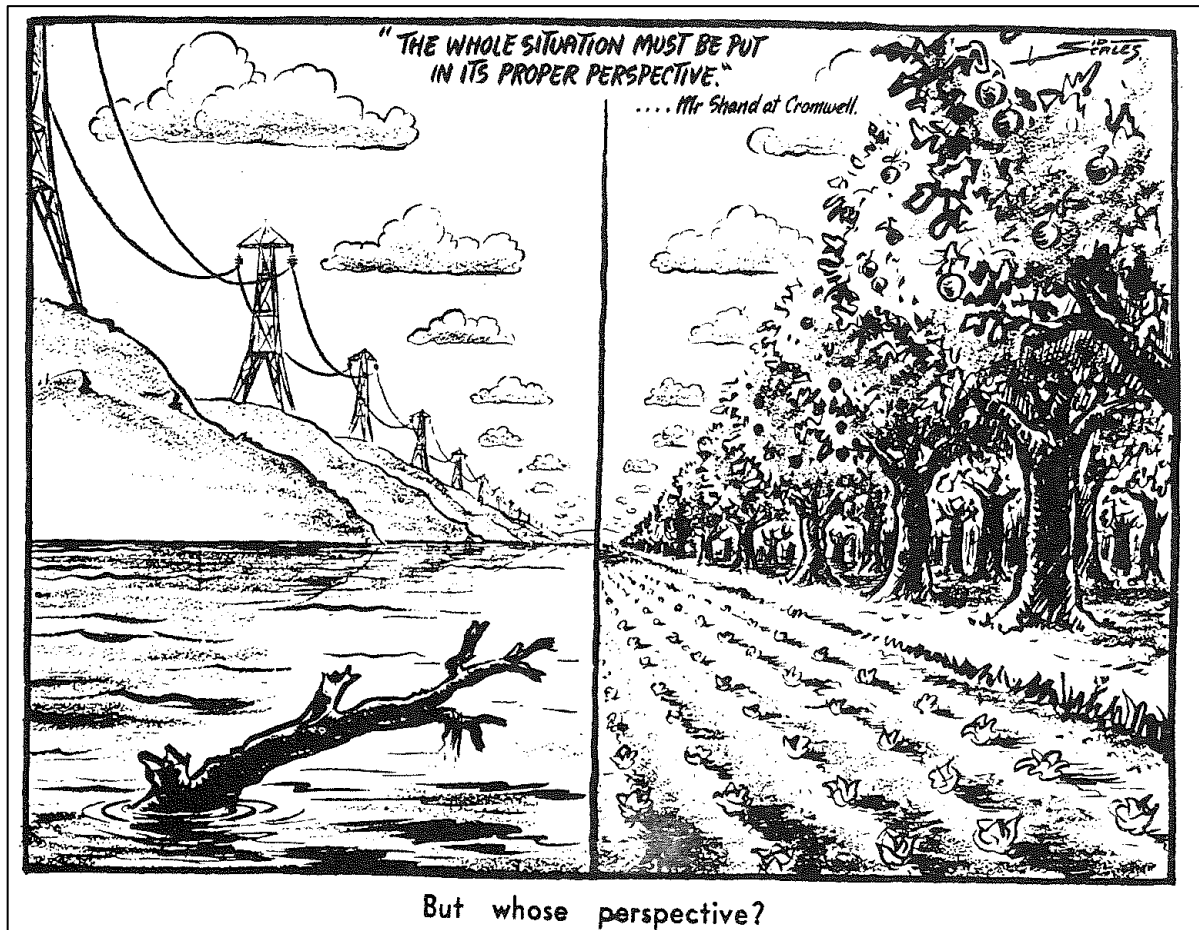


## Navigating multiple ways to value water.

A case study of the trade-offs of the Clyde Dam in Central Otago, New Zealand.



Cartoon showing the potential benefits and costs of the Clyde Dam. Quote by Mr Shand, former Minister of Mines and cartoon by Sid Scales. Source: 'Who Killed the Clutha?' Paul Powell, 1979.

*Submitted in partial fulfilment of the requirements for the degree of  
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## **Abstract**

Valuing water is complex because of its many uses. This case study shows the importance of considering different ways to value water through social, political, environmental and economic factors and the challenges this brings to collective action. Using the trade-offs of the Clyde Dam, Central Otago New Zealand as a collective action challenge, this research has both a qualitative and quantitative analysis. Historical information and interview data from nine interviewees form two distributional payoff maps that identify the distribution of costs and benefits produced from the trade-offs during phases of construction and operation. It then quantifies the different values to accentuate the challenge of making collective decisions when there are many ways to value water. The results indicate that to break away from path dependency, institutional change is not enough, rather a collective shift towards incorporating the multiple ways to value water is required.

*“The single most monstrous environmental sin over the last 30 years”*

Michael Cullen, former Minister of Finance stating that approving the Clyde Dam as his greatest regret  
-Radio New Zealand, May 2009

## **Acknowledgements**

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Most importantly, thank you to the nine interviewees who gave their time to this research project. I am very grateful that you shared your special memories of the past, present and hopes for the future of water management in Central Otago with me. Your passion towards the impact of the Clyde Dam has been inspiring and this project would not have come to fruition without your devoted time and enthusiasm.

The beginnings of this project were formed during the 2022 WSPM field trip to Yesa Dam, Spain. Experiencing in person the sheer scale of the spectrum of trade-offs that the dam had produced during its construction and again in its extension phase was overwhelming. Using this experience as a catalyst, I am delighted to have the opportunity to research (a little closer to home) the different ways in which we value water and how these threads of knowledge knit together to form collective decisions.

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# 1. Introduction

This chapter establishes a clear rationale for the purpose of this project by addressing the three challenges at the core of this research. Here we see the emergence of the central theme, understanding the multiple ways to value water. It then discusses the motivations behind this research and how it will effectively contribute to water resource management literature.

## **Challenges**

### Valuing water

Appointing value to water is complex because it has multiple physical, political, cultural and economic characteristics. This makes it challenging to measure and reconcile the full range of economic, sociocultural and environmental benefits when making decisions in water resource and infrastructure management (Garrick et al., 2017).

Valuing rivers and lakes are important to communities for spiritual and cultural well-being. In this perspective, environmental needs are put first which is a challenge when there are competing cultures in that one sees water as sacred and the other as a commodity (Shiva, 2002; Salmond et al., 2014). New Zealand has been at the forefront of this debate granting legal rights to the Whanganui River in 2017. The Rights of the River framework views water as an intrinsic value of its own designed to be inclusive of all values inherent in water (O'Donnell & Talbot-Jones, 2018). As a result, it has encouraged other countries to follow suit in attempting to incorporate their Indigenous values in policies and planning documents (Te Aho, 2019).

The narrative that water should be 'used' rather than 'wasted' has traditionally motivated the economic development of large scale hydraulic infrastructure (Bakker, 1999). The economic value of water is referred to as the benefits derived from its use (Grafton et al., 2020). Through this lens, traditional economic methods to value water are directly related to societies willingness to pay for the benefits provided and the contribution that it makes to human wellbeing (Barbier, 2011). For example, Brouwer & van Ek (2004) produce an economic study that estimated the values arising from wetlands through ecosystem structure and function. This cost-benefit analysis shows that while levee strengthening would be economically beneficial, it was also observed that socio-economic benefits would increase the value of the wetland by creating new wildlife habitats and recreational amenity values instead of the structural levee. This illustrates the importance of integrating environmental values with economic values to maximise socioecological benefits. In comparison, water can be highly political where power dynamics are deeply situated in struggles for water justice (Angel & Loftus, 2019)

Because of these diverse ways in which water can be valued, it is unlikely that all values can be met simultaneously without creating trade-offs that marginalise smaller communities (Howe et al., 2014). Groups who have the greatest control in allocating value to water typically do not recognise the multiple properties of water in policy and planning documents (MacPherson, 2019). The challenge to incorporate different ways to value water into decision making frameworks is categorised as a collective action problem. This is because water can be valued as a private good, public good and a common pool resource. These contrasting values and motivations mean that a series of collective action problems are inevitable (Garrick et al., 2017).

### Working collectively

Collective action problems and distributional issues are intertwined. Stemming from contrasting values and motivations, collective action dilemmas emerge when there is a conflict between individual and common values and their subsequent distribution of costs (Villamayor-Tomas et al., 2019). To show the complexities that consensus does not work where there are uneven distribution of costs and benefits, this research will focus on collective action problems under public goods and externalities.

Public goods have two key characteristics, they are non-rivalrous and non-excludable (Holt et al., 2012). This means that once the good is provided, you cannot stop anyone benefitting from the good nor does it reduce the amount available for others. Water is fundamentally different in this regard due its complex nature as a private, public good and common pool resource (Hanemann, 2006). Therefore, collective action in water management is critical for cooperation in societies but it can also bring problems of free riding and externalities where different perspectives towards water are evident (Weimann et al., 2019). In contrast, Baumann & Boland (1998) explain that water is no different from any other economic good and therefore obeys the normal laws of economics. These two contrasting views highlight the complex challenges decision makers face when working to produce an outcome that suits all individuals. Because of this challenge, the outcomes typically produce win – win situations for all involved, albeit unevenly.

Positive and negative externalities typically occur where the benefits of one group or individual accrue at the expense of the other. This is prominent in dam construction where the wins of downstream users are mirrored by costs borne by the upstream communities whose lands are flooded (Villamayor-Tomas et al., 2019).

Furthermore, Holt et al., (2012) contextualises externalities through an example of farmers who irrigate their land alongside a canal. If growing conditions mean field irrigation is more productive for downstream farmers but upstream farmers exploit their position by over appropriating the available water resource, then both users do not reap benefits of the resource. Referred to as the tragedy of the commons, this example shows that local resource users do not directly benefit from acting collectively even if the wider community does (Hardin, 1968). In these situations, payoffs between actors are distributed, somewhat unevenly. These payoffs give insight into the nature of cooperation and conflict within a community (Villamayor-Tomas et al., 2019).

### Cooperation and conflict

Cooperation and conflict can occur in the face of major externalities. For example, hydropower cooperation between Bangladesh and India in the Teesta River basin could be beneficial for both countries providing economic development and energy security (Rahaman & Abdullah - Al - Mamun, 2020). At the local scale, the construction plans have been controversial and serious concerns have been expressed by local communities, academics and environmentalists about the social and environmental effects of building dams in the Teesta River basin (Wiejaczka et al., 2018). These divergent water perspectives stem from contrasting perspectives of future water security plans and social values attributed to water (Salman & Uprety, 2018).

Critical junctions where natural conditions and social factors induce a course for the future are referred to as path dependent developments. Not to be confused by infrastructure that has stayed the same for an extended period of time, path dependent infrastructure is extremely difficult to alter and often commits institutions and communities to a point of lock-in (Sorensen, 2015). Consequently, not only do past decisions in water resource management inform the decisions made today, but past decisions can open future management avenues and foreclose others. This means that distributional issues do not occur against a blank slate. To transition towards inclusive water infrastructure that moves beyond historical narratives requires incorporating the contrasting values of water. This can be challenging because collective action and distributional impacts are deeply entrenched in the different ways that water can be valued (Turley, 2021).

These three challenges maintain a common thread throughout this research. By understanding diverse concepts of water use, water managers make difficult choices that ultimately create trade-offs between efficiency and equity. Despite the decisions aimed at providing for the common good, the

constantly competing perspectives discourage joint action resulting in distributional issues and path dependent outcomes (Garrick et al., 2020; Hanemann, 2006)

## **Motivation**

The overall purpose of this research is to understand the multiple ways in which water can be valued in the context of a) different interests and b) different ways of valuing water where there is no equal basis of comparison. This is important because the divergent ways that water can be valued creates distributional issues that foster cooperation and/or conflict in collective action.

This research uses the case study of the Clyde Dam, New Zealand as an example of a collective action problem. This is shown through sharply different ways of valuing water and externalities across hydropower dam development. With a controversial backdrop of conflict and cooperation between the New Zealand Central Government and marginalised groups during the construction and operation of the dam, this case study shows the importance of considering different ways to value water and the challenges this brings to collective action.

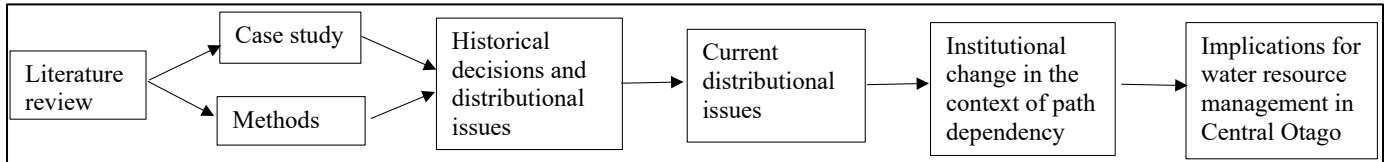
The contribution of this research is to produce a payoff map to help understand the diverse ways of how water is valued between the actors in Central Otago, as well as explore how the decisions have impacted them during the construction and operation of the dam. The nuanced results will theoretically add to understanding collective action barriers that multiple actors face when working together to make decisions in water management. These intersecting constraints are analysed through three key research aims.

**RQ. 1** What decisions shaped the distributional issues of the Clyde Dam between the investigation period and construction period (1945 to 1994) and what are the consequences of these distributional issues?

**RQ. 2** How did the distributional issues identified during the construction of the Clyde Dam shape those during the operation of the dam?

**RQ. 3** What are the implications of these distributional issues for water resource management in Central Otago?

This research uses historical notions to quantify the different ways that water can be valued through a collective action lens. To aid this narrative, the structure will follow the proposed layout in Figure 1.



**Figure 1:** roadmap of this research

## 2. Literature Review

There are four intersecting themes at the core of this inquiry drawn together by the different ways in which we value water. These themes address collective action, distributional issues during the construction and operational phases of hydropower dams and how this leads to path dependency. The following chapter will review these themes in depth.

### Trade-offs

Hydropower projects are often controversial as they are subject to competing social values and conflicting motivations that lead to a range of trade-offs for both local and external resource users (Sewell, 1987; Wiejaczka et al., 2018). This is because there will always be decisions that create trade-offs between efficiency and equity, marginalising certain actors. As a result, challenges around how to manage these distributional issues effectively have caused much debate in the 21<sup>st</sup> Century (Mosse, 2010; Obeng-Odoom, 2016).

With economic growth and power security motivating hydropower infrastructure, there is typically a narrow view of the social and environmental costs (Garrick et al., 2017; Poff et al., 2016). Recent participatory approaches have incorporated non-economic values into large infrastructure decisions. This occurs through non-market valuation where value is given to the intangible benefits generated. Despite this, when assessing the value of water it is difficult to assign a monetary value because different societies and communities place different values on species, ecosystems and biodiversity (Laurila-Pant et al., 2015). This further emphasises that water must be viewed as a cross-cutting multi-sectoral entity that goes beyond the economic value of water (Damania, 2020; Zenner, 2019). This is challenging as hierarchies of power are inevitable (Ostrom, 2009).

Because diverse ways of valuing water are expressed through conflicting objectives, they are often linked to wider contested issues about who is involved in decision making, whose voice is listened to and who receives benefits and bears the costs of environmental change (Gunawardena et al., 2020). For example, Wiejaczka et al., (2018) researched local residents perspectives towards a hydropower dam development in the Teesta Basin, India. It was found that personal attitudes towards the dam

reflected the benefits, if at all, that the dam would provide the individual. The respondents declared that the dam had provided no benefits to them or their local community. Instead, they had lost access to the river which had been their predominant source of income. This example acknowledges that trade-offs are inevitable because of the different ways in which water is perceived. It gives reason for the distributional issues that evolve as a problem of collective action, specifically during construction and operation of water infrastructure.

### Collective action

Collective action problems are ubiquitous in hydroelectric dam building (Wiejaczka et al., 2018). On the contrary, Ostrom (1990) and Olson & Zeckhauser, (1965) both argue that commons such as river basins can be managed cooperatively and benefits shared equally. For example, management of the Nile River has shown a spectrum between cooperation and conflict due to the contrasting motivations towards water use across social, cultural, economic and environmental factors (Habteyes et al., 2015; Turhan, 2021; Suhardiman et al., 2017). The Nile Water agreements of 1929 and 1959 fostered cooperation but on the other hand, conflict between Sudan, Ethiopia and Egypt is still prominent as each country prioritises their own interests around water use which creates subsequent trade-offs for neighbouring countries (Turhan, 2021). The most controversial at the moment is that of the Grand Ethiopian Renaissance Dam (GERD) which poses serious threat to the water supplies for Sudan and Egypt (De Falco & Fiorentino, 2022).

Cooperation and conflict occur at varying scales, namely when the dam is constructed and in operation. Historically, the construction of large hydropower dams has generated serious conflict between communities and governments as well as between countries. For example, on an international scale, the Atatürk Dam on the Euphrates cut water flow to downstream Syria and Iraq by 75% in 1992 and on a national scale, large-scale hydropower projects in Brazil during the 1970s saw that the promised benefits did not extend to farmers and Indigenous groups (Randell & Klein, 2021; Zaniolo et al., 2021). Both are examples of governments initiating nation-wide economic development and water security for the collective good, marginalising populations in the process. This is challenging because water is a private good, public good and common pool resource so collective action should work towards producing the best outcome for all involved, but this rarely eventuates (Ostrom, 1990).

In comparison, during the operational phase of a dam, collective action problems present themselves as uneven distributions of costs and benefits producing winners and losers (Villamayor-Tomas et al.,

2019). For example, Randell & Klein (2021) explain that the completion of the Belo Monte Dam in 2019 has led to an increase in jobs in the area but it has also led to the displacement of 20,000 people, impacting the livelihoods of fisheries, farmers and Indigenous groups. This trade-off exemplifies the problem of externalities in collective action. In the context of hydropower infrastructure, it is often the benefits of downstream users who mirror the costs of the upstream users whose lands are flooded (Villamayor-Tomas et al., 2019). Villamayor-Tomas (2019) develops this notion further by explaining that if individuals or groups do not benefit directly from the dam, there is minimal incentive for them to change their values or motivations to cooperate with the collective. Referred to as the prisoners dilemma and explained by the nature of individual self-assertive actions, this means that individuals will always select the incentive that benefits them personally rather than opting for the outcome for the collective good (Ostrom, 1990).

The exception to this is that if each person communicates and acts cooperatively to everyone's advantage, it will encourage cooperation towards managing public goods for the benefit of all individuals (Weimann et al., 2019). To do so, communities must be able to adapt to developments in technology. Failing to adapt may lead to both resource degradation and conflict between actors when making collective decisions (Grafton, 2000).

The literature indicates that consensus does not always work and that distributional issues are inevitable in collective action (Ostrom, 2009). This social dilemma is caused by divergent views towards uses of water and how these uses should be valued. As an outcome of these diverse ways of knowing, distributional issues present themselves as a range of costs and benefits based on the level of control or voice that the individual or group may have in making decisions (Salman & Uprety, 2018). As a result, marginalised groups will always bear the costs of those decisions made by more powerful actors. Despite this challenge, collective action should encourage the sharing of costs and benefits and foster co-governance arrangements. These principles can be achieved by giving a voice to communities that are historically underrepresented in decision making processes (Garrick et al., 2017).

### Distributional issues

The distributional issues of hydropower development on natural flow regimes, ecosystem services and sociocultural groups are well known (Sewell, 1987). Despite this, there is little that has been done in recent water infrastructure developments that shift value from economic use to one that values natural flow regimes, ecosystem services or the social connections to water (Chen & Olden,



2017; Howe et al., 2014). These contrasting perspectives make collective decision making extremely complex in the context of dam construction and operation. This is because both societal and ecosystem water needs must be met to provide the maximum benefit for society (Turley, 2021).

The ongoing construction of hydroelectric dams in the Mekong Delta are an excellent example of these competing values. Despite the opposition to dam development from non-governmental organisations, scientists, the local community and environmental groups, government officials continue to draw on the expertise of engineering solutions to mitigate future uncertainty in the hydrological cycle. This is dominated by the economic and political value of water. To minimise distributional issues, cross cutting multi-sectoral solutions should be used that incorporate a diverse set of values (Fox & Sneddon, 2019; Poff et al., 2016).

The severity of distributional issues can vary. In 2018, the Xe-Pian Xe-Namnoy Dam in southern Laos collapsed mid construction phase leading to 27 fatalities and over a thousand displaced, 3,000 of which were Indigenous groups forced to relocated before the construction began. In the drive to become the ‘battery of Asia’ the social, cultural and environmental characteristics were overshadowed by waters economic value. The distributional issues were still evident in 2020 where 3,224 people remained in temporary camps waiting for the restoration of homes, farmland and fair compensation (Fox & Sneddon, 2019). When examining the distribution of costs and benefits between those involved, there is no equal basis of comparison because of the different values and perspectives of the individuals.

In comparison, distributional issues are also present when a dam is operational. For example, the Gross Reservoir in Colorado was constructed in 1954 to generate hydropower and provide municipal water supply for the City of Denver (Turley, 2021). During this operational period, water allocation rights were dictated by the ‘first in time, first in right’ rule noted in the 1876 Colorado Constitution. This means that water rights established earlier in time outweighed the rights of individuals who joined later in time. With the introduction of the environmental movement in the 1970s and 1980s, perspectives towards water allocation were challenged. Water uses were no longer siloed to satisfy human needs, rather use values identified the importance of natural flow regimes, wetlands and ecosystems for fish habitats. In 1990, a proposal to expand the reservoir through the construction of the ‘Two Forks Dam’ was hoped to secure future water storage. This proposal was soon rejected because of its adverse environmental impacts and hence a recognition of the intangible benefits of water (Turley, 2021).

These two contrasting examples highlight how distributional issues can produce both positive and negative externalities to both communities and natural environments (Larson et al., 2022). Therefore, it can be argued that different ways of valuing water cannot be studied in isolation from past events because competing values and motivations can foster economic and technological lock-in factors (Fox & Sneddon, 2019; Parsons et al., 2019).

### Path dependency

The best solutions to managing water resources today may reveal critical challenges in the future (Heinmiller, 2009; McGinnis, 2011). This means that the historical context of rules and values commit institutions to trajectories that are difficult to change (Abel et al., 2016). It is argued that individuals, groups and societies have a greater influence in determining collective outcomes than is acknowledged (Tellman et al., 2018). On the contrary, while path dependence is widely a symptom of large infrastructure developments, there is a gap in the literature regarding the path dependent nature of hydropower dams (Barnett & O'Neill, 2010). This makes it challenging to encourage decision makers to take a historical approach to dam construction in effort to understand the myriad of socioecological values inherent water developments (Turley, 2021; Ahlers et al., 2014).

An example of path dependency was explored in New Zealand by Parsons et al., (2019) using historical research to demonstrate how successive generations of government actions were directed with the same goal. Underpinned by similar social values, a path dependent system of river management in the Rangitaikei River plain was identified. This was reflected in 2015 and again in 2017 when the river breached the levee and flooded the town. This was partly due to the management plan not adapting to the changing environmental and social developments. The driving reason for this lock-in nature was deeply rooted in the historic marginalisation of Indigenous values and structural engineering developments. These findings were similar to the theory discussed in Agrawal & Benson (2011) who claims that value, culture and institutionalised knowledge of a community are key factors in understanding distributional issues between actors.

Looking to a larger scale, the management of the Murray-Darling Basin in Australia is an example that path dependency is linked with common pool resource governance. Rules that capped water diversions in 1995 were implemented to maintain the health of the environment and community. These rules did not replace rather extended on to the Murray Waters Agreement of 1914. This meant that the institution took on some of its old characteristics with the new, an illustration of path dependent water governance (Heinmiller, 2009). These two examples of path dependency show that

institutional legacies are just as important as the multiple values and diverse knowledge in determining the outcomes of collective action efforts.

Kay (2005) critically explains that path dependency should be viewed as place dependent because it is nestled in the complex social and political processes that underlie infrastructure developments. On the contrary, just because infrastructure has stayed the same over time does not mean it is path dependent as it may be the most viable option (Turley, 2021). For example, South Africa is rich in coal but does not possess potential for the development of reliable hydropower (Scholvin, 2014). Finally, Sorensen (2015) argues that encouragement to break away from any path dependent trajectory is motivated by incremental changes from marginalised communities that build up overtime to create immense long-term impacts.

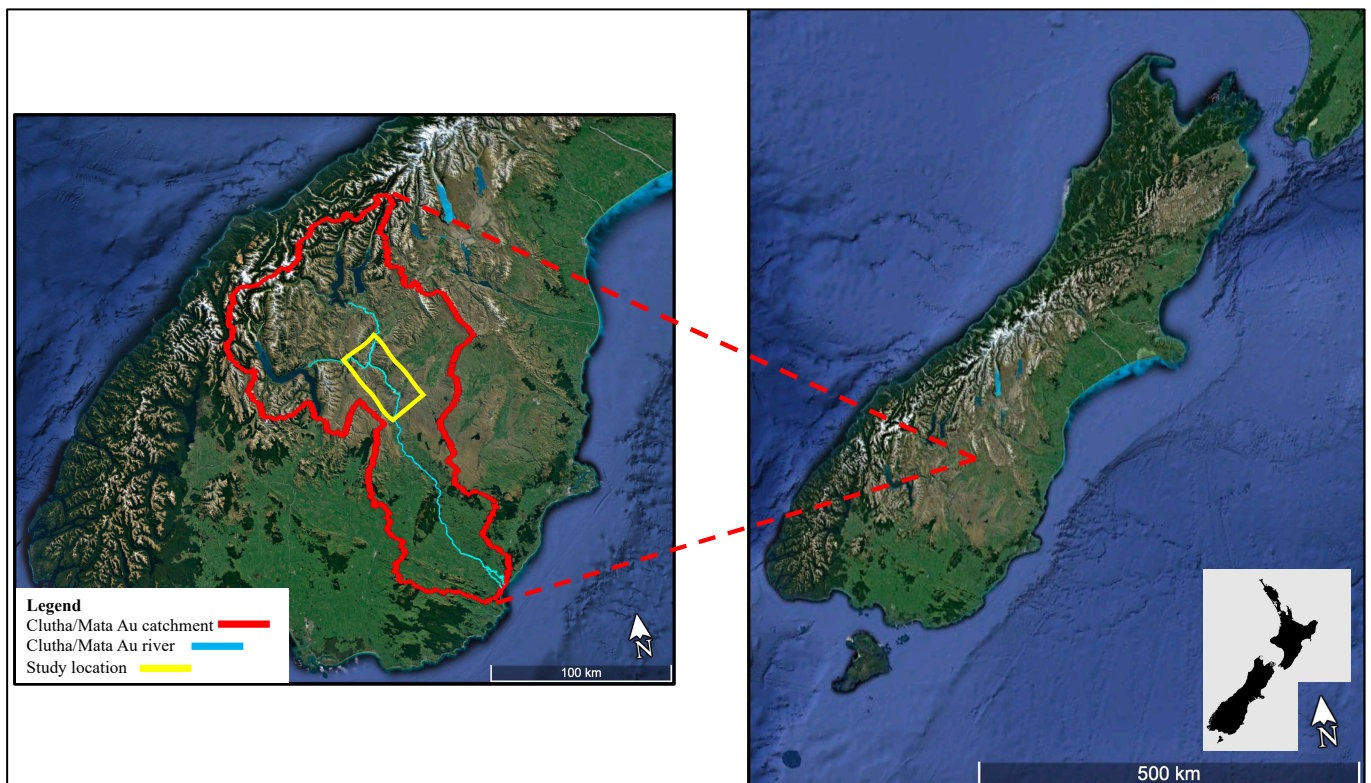
Drawing together these four threads into a coherent synthesis has proved that the different ways in which water is valued is a complex collective action problem in water infrastructure. This synthesis is now used to justify the type of data collected and analytical methods used.

### 3. Methods

The Clyde Dam regional case is introduced at both a local and catchment context. Then the type of data collected, and the qualitative and quantitative analysis methods used are explained.

#### Study location

The Clyde Dam is situated on the Clutha/Mata-Au River located in the Central Otago Region of the South Island of New Zealand (Figure 2). Built between 1975 and 1994, it is recognised as a symptom of New Zealand's 'Think Big' era, an economic strategy promoted by the Prime Minister and National Government leader, Robert Muldoon (Prime Minister between 1975-1984). At a height of 100 m and length of 490 metres it is New Zealand's largest concrete gravity dam. The main purpose of the Dam was to provide electricity for an aluminium smelter but it never eventuated. Now, the Clyde Dam provides 6% of New Zealand's power generation despite its controversial development (Stirling, 2021).



**Figure 2:** Study location.

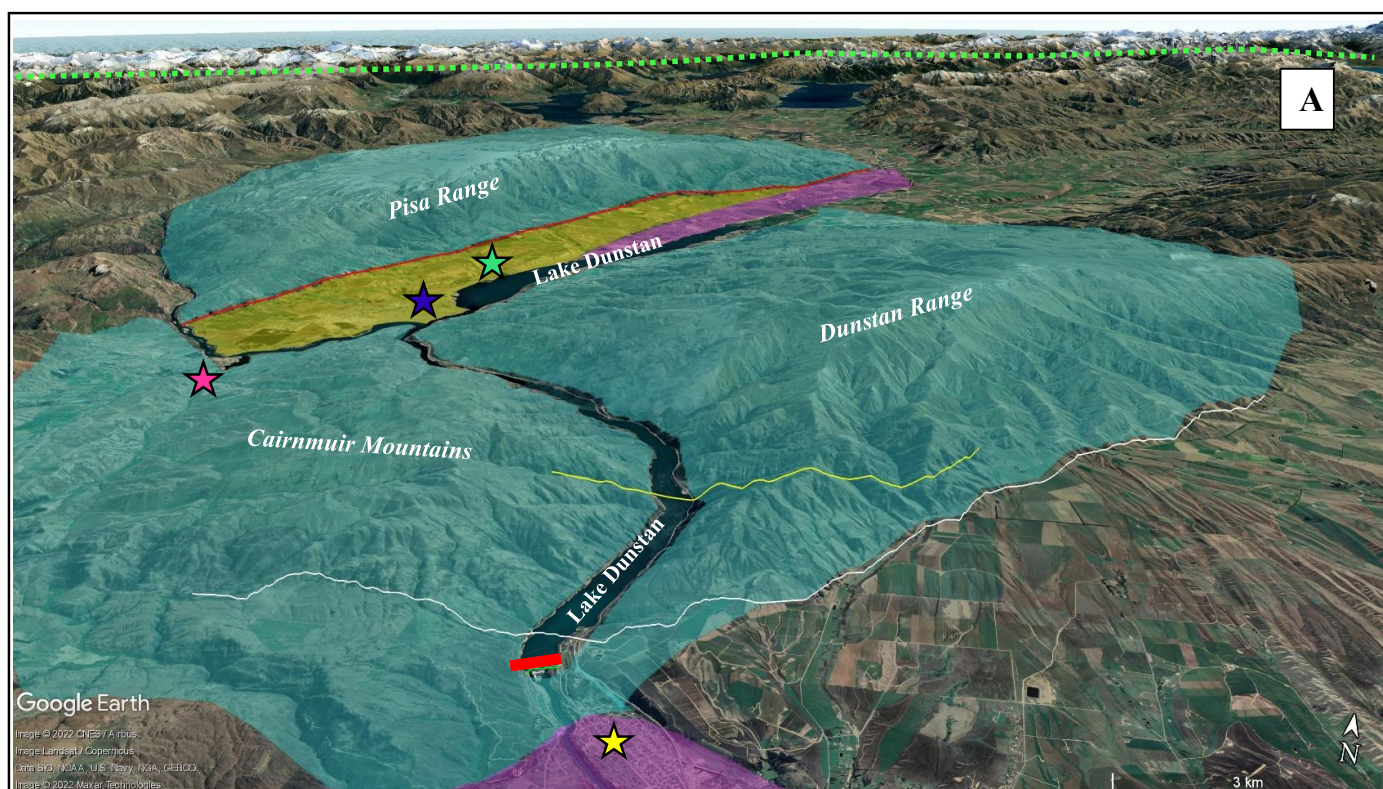
### Clutha/Mata-Au River

With an area of 21, 000 Km<sup>2</sup> and an annual discharge of 650 m<sup>3</sup> /s the Clutha/Mata-Au River drains 6% of the net total of water in the South Island (Figure 2) (Otago Regional Council, 2022). The catchment is characterised by a highly variable hydro-climate with an average rainfall of < 400 mm per year. The climate ranges from humid alpine headwaters dominated by seasonal snow to drier areas. This range in climate means water security in Central Otago is of utmost importance (Jobst et al., 2018; Watson & Perkins, 2022).

The Clutha/Mata-Au River flows for 338 km from its beginnings at Lake Wanaka, at the foothills of the Southern Alps, to the South Pacific Ocean (Jobst et al., 2018). After Lake Wanaka, it is joined by Hawea River and flows through the Dunstan, Pisa and Cairnmuir Range, past Cromwell in the form of Lake Dunstan, joining the Kawarau river before it continues through the Cromwell gorge to Clyde where it is met by the Clyde Dam (Figure 3.B) (Park, 1909).

To support the Central Otago gold rush in the 1860's, the towns of Cromwell, Bannockburn, Lowburn and Clyde were built to facilitate access to the gold deposits (Figure 3A&3B) (Williams, 1974). In terms of geological location, the placement of the dam is on a fault line comprised of schist, an easily flaked metamorphic rock (Figure 3.A). Prior to 1956 the Clutha/Mata-Au River was known to have a formidable force and was a very popular location for adventure tourism specifically kayaking in the Cromwell Gorge (Figure 3.B). Controversy around the building of the dam saw the removal of the famous rapids 'Sargoods Weir', 'Cromwell Gap' 'Lipstick' and 'Terminator' alongside fruit orchards and houses that were removed from the Cromwell Gorge to allow for the flooding of the valley.





### Key

- Cromwell ★
- Bannockburn ★
- Clyde ★
- Lowburn ★

- Clutha/Mata-Au River
- Kawarau River
- Fish Creek Faultline
- Pisa Faultline
- Waikerikeri Faultline

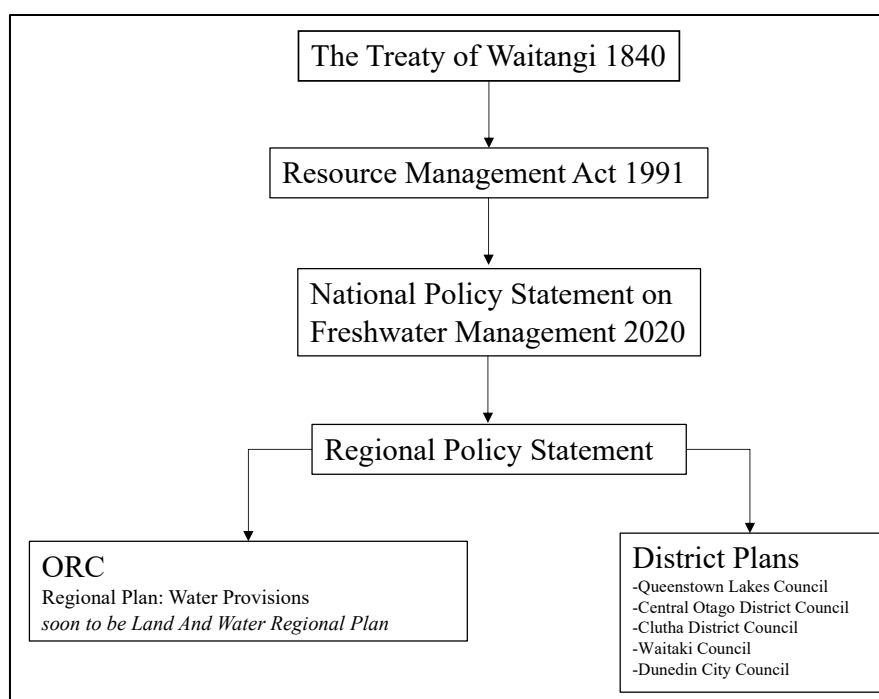
- Middle Quaternary deposits
- Late Quaternary deposits
- Schist
- Southern Alps
- Clyde Dam

**Figure 3: Geological setting**



### Water resource management

Water resource in the Clutha/Mata-Au catchment are managed by the Otago Regional Council (ORC) and land use by the five district councils (Figure 4). The study location specifically focuses on the resources managed by the Central Otago District Council from the top of Lake Dunstan to the Clyde Dam (Figure 2). The current legal framework for water management in Otago is contained in the Regional Plan (2004) which is situated beneath the Treaty of Waitangi (1840), the overarching agreement between the British Crown and Indigenous Māori of New Zealand (Figure 4). The original Māori settlers in the South Island are known as Ngāi Tahu and hold the tribal authority to over 80% of the South Island (Te Rūnanga o Ngāi Tahu, 1997). The Regional Plan (2004) is currently being re-developed in partnership with Ngāi Tahu to include rules and limits on water and land use. Due to be announced in 2024 and relabelled as the Land and Water Regional Plan, ORC engaged the local community between November 2021 and mid-April 2022 asking Otago communities what they value most about their local waterways to guide the structure of the new plan. Including communities perspectives and values into the new plan provide important implications for the future water resource management of the Clutha/Mata-Au catchment.



**Figure 4:** Hierarchy of resource management plans. Adapted from ORC, 2022.

### **Data collection**

#### Historical data

A systematic review of policies, planning documents, photos, videos and newspaper articles made available by Central Otago District Council, University of Otago Hocken Collections, New Zealand Parliamentary website, New Zealand Archives, New Zealand National Library and NIWA are

collated to produce a narrative of the historic decisions that lead up to the construction of the Clyde Dam (Appendix 1, Table 1). These historical documents are used to identify the distributional payoffs between actors and attribute contrasting values towards water use. From the constructed narrative, three historical events are summarised as the main decisions that lead to construction of the dam and catalysts for the subsequent distributional issues.

#### Interview data

Primary interviewees were selected using a convenience sampling method to capture the primary actors who are involved in the management of the Upper Clutha/Mata-Au River at Clyde and Cromwell. These actors were identified through newspaper articles or current planning documents in the Clutha/Mata-Au and contacted via email. To overcome limitations of collating data through isolated networks, snowball sampling methodology was used by asking primary interviewees to recommend other decision makers in the Clutha/Mata-Au that are impacted by the trade-offs of the Clyde Dam (Kowald & Axhausen, 2012). Through using both sampling methods, the interviews captured the multi-scalar governance structures that link the local community across multiple scales (Suhardiman et al., 2017). Signed consent was obtained prior to interviews which were conducted via Zoom or Microsoft Teams based on the participants preference. Interviewee ID is used to replace the names of contributors in Table 1.

**Table 1:** Interviewee ID and Organisation type

<b>Interviewee ID</b>	<b>Organization type</b>
Int 1_EG	Environmental Group
Int 2_EL	Environmental Lawyer
Int 3_RS	Researcher
Int 4_LC	Local Council
Int 5_PS	Public Service
Int 6_AT	Adventure Tourism
Int 7_EC	Energy Company
Int 8_LO	Landowner
Int 9_PS	Public Service



Semi-structured interviews were aimed at understanding the distributional issues perceived by each interviewee across four types of payoffs political, economic, environmental and social. Lasting between 45-55 minutes, the interviewees were asked a series of questions regarding their perspectives on the political, social, economic and environmental trade-offs of the Clyde Dam. The purpose of this was to understand the different values towards the impacts of the dam and how this creates a challenge of collective action. The interviews were audio recorded and saved on the University of Oxford Nexus 365 network before being uploaded to Trint, an automated transcription software. A copy of the interview questions are provided in Appendix 2.

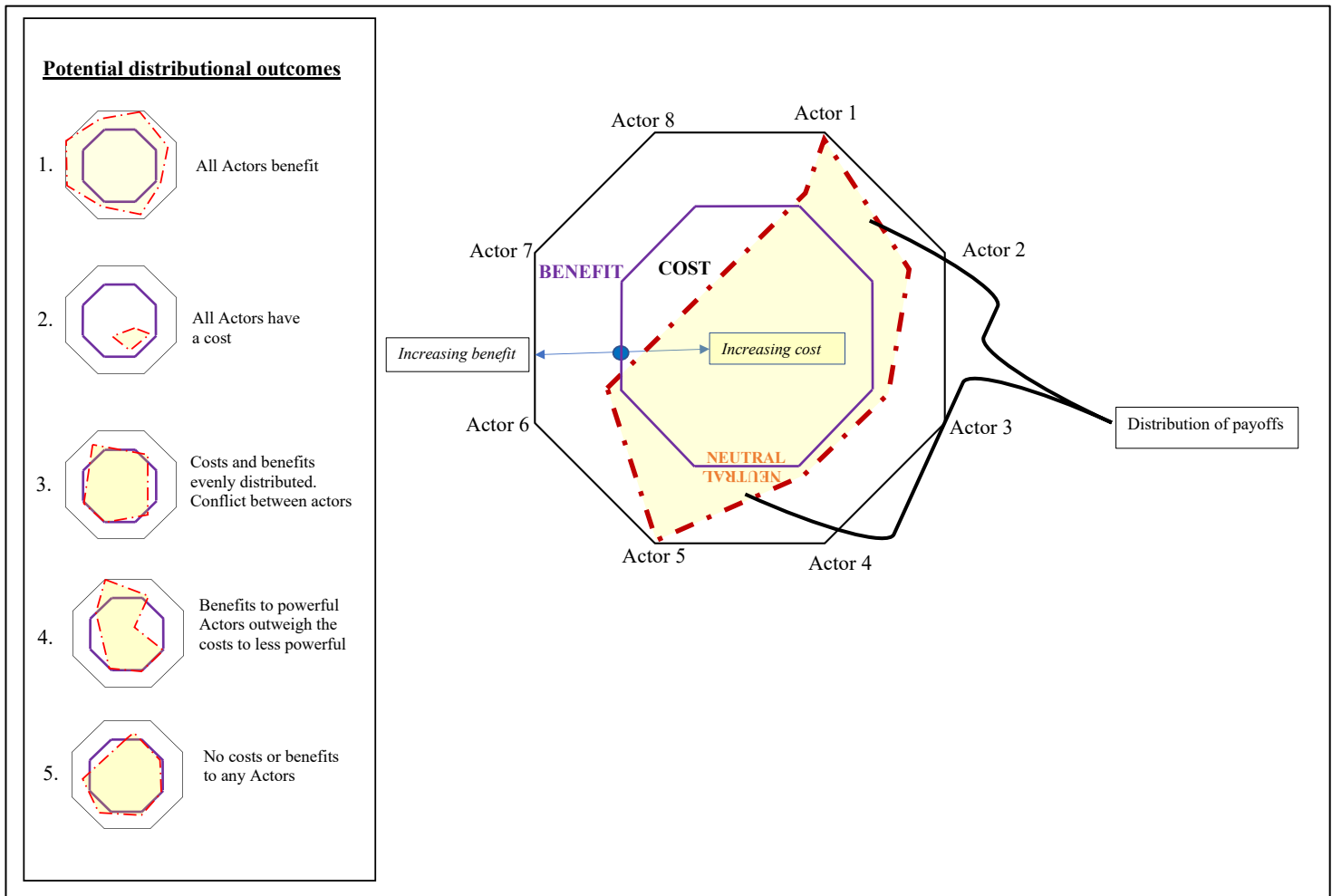
### Ethical considerations

This research was approved under University of Oxford CUREC process SOGE1A2021-073 on 6 June 2022. Indigenous officials have been excluded from this research for ethical reasons. This is because interviewing Indigenous officials requires long-term relationships that exceed the allocated time to complete this research.

### Qualitative Analysis

Payoff surface mapping, adapted from Tellman et al., (2021) is used to visualise the competing values between actors and the associated level of control they have in decision making namely during two time periods, construction and operation of the dam. The transcribed interviews and collated historical information are coded into four payoff categories social, economic, political and environmental based on the values and impacts identified by the actors. Interpretations of these trade-offs required triangulation among interviewees, planning reports and historical academic research where appropriate. The coded information is then used to create an action situation payoff surface between eight decision making groups to show the distribution of payoffs between the actors.

Figure 5 is an example of the distributional payoff map and plausible outcomes (Tellman et al., 2021). The degree of cost (middle octagon) or benefit (outer octagon) for each actor is measured by the distance of their vertex to the neutral line. The edge of the cost and benefits area represents neutral or no payoff. This is where actors have no control in the outcome of the situation or remain neutral in the impact of the payoff. Through connecting the vertices, it results in an octagon representing the distribution of costs and benefits among actors.



**Figure 5:** payoff distribution surface (Tellman et al., 2021)

The interview information was used to produce this distribution in five steps;

1. The nine interviewees were assigned to one of the eight actor groups (Table 2)
2. The payoffs were coded after each interview under the titles i) political ii) economic iii) environmental and iv) social. The following categories for each of the eight actors were qualitatively assigned based on interviewee response.
  - Categories for payoffs (positive = 1, negative = -1 and neutral = 0)
  - Access to information (high= 3, medium = 2 or low = -1)
  - Control in the outcome of the decision (high = 3, medium = 2 or low =1)
3. Where there was insufficient information, media, interview data or government reports were used as supplementary data. This is marked with an \* in the data tables and an X indicates that no evidence was available
4. The distributional surface for each outcome is displayed by multiplying the level of control (on a scale between 1 to 3) by the payoff (on a scale between -1,0,1) to plot the vertex of each

actor and drawing a polygon to connect all vertices. For example, the most powerful actors (control is 3) shape the payoff distribution surface three times of that of the least power actors (control is 1).

5. Payoffs types (social, political, economic and environmental) are detailed in both the institutional matrices (Appendix 1, Table 4 & 5) and indicated in the titles of the payoff service radial plots.

The Interview IDs, Actor ID and actor name during the construction and operation phase of the Clyde Dam are summarised in Table 2.

Please refer to Appendix 1 Table 1 for detailed information into the historical decisions that lead to the Clyde Dam. Table 2 for the coded historical data and Table 3 for the coded interview data. Table 4 and Table 5 detail the institutional matrix used for the payoff maps for the construction and operational phases of the dam, respectively.

**Table 2:** Actor, name and Interview ID used on the payoff distribution surface

Actor #	Actor name in construction phase	Actor name in operational phase	Interview ID
1	Landowners	Landowners	Int 8_LO
2	Environmental Groups	Environmental Groups	Int 1_EG, Int 6_AT
3	Electricity Corporation New Zealand	Contact Energy	Int 7_EC
4	Ngāi Tahu	Ngāi Tahu	*
5	Local Council	Local Council	Int 4_LC
6	Public Service	Public Service	Int 3_RS , Int 5_PS , Int 9_PS
7	Regional Council	Regional Council	*
8	Central Government	Central Government	Int 2_EL

### Quantitative Analysis

As convenience sampling can give bias results, further analysis was used to quantify the degree to which actors shared values. Interviewees were asked to rate their responses to five questions on a scale of 1 to 10 where 1 was low and 10 was high to explore shared values associated with the impacts of the dam. Referred to as a net promoter score (NPS) this method is adopted from Reichheld (2003) who developed the score to understand how individual perspective can influence transparency in collective decision making. This method encourages shared values to be identified as well as areas of disagreement. The purpose of this method is to show the challenges of collective action with different values and motivations.

Questions prompted reflection on relationships with other actors, knowledge of the trade-offs, significance of their role and reflection on whether past decisions of the Clyde Dam inform future decisions. Using Reichheld (2003) as a theoretical foundation, the scores were grouped into three sets, those who responded with a 9 or a 10 labelled as promoters (similar values), 7 or 8 as passives (neutral) and those who responded with a 6 or lower labelled detractors (dissimilar values). Passive responses were not included in the analysis because the passive scores symbolise a neutral rather than an affirmative response. The following equation was used calculate NPS.

$$\text{NPS \%} = \% \text{ promoters} - \% \text{ detractors}$$

The net difference between these two groups was calculated for each question to create a NPS that spans a scale ranged from -100 to 100 with scores above zero as positive. By understanding the NPS between the various actors interviewed, it not only identified the personal values and motivations of the actors towards the operation of the dam but it gives an opportunity to identify the problems of collective action and distributional issues and how they can impact path dependency.

Please refer to Appendix 2 for reference to the quantitative questions asked.

## 4. Results

This chapter presents the findings of the research. It will address RQ1 by identifying critical historical decisions that lead to the construction of the Clyde Dam and subsequent visualisation of the distributional issues at the time of construction. RQ2 is presented through a payoff distribution map to show the changing values of the actors during the operational phase of the dam. Finally, RQ3 will quantify the different ways that water can be valued to help understand how different actors are impacted by the dam because of their different interests and ways to value water.

### RQ 1: Decisions that led to the Clyde Dam

Of the series of decisions made between the investigation, construction and completion of the Clyde Dam, three key decisions have been identified as catalysts for the distributional issues during the construction phase of the dam. These decisions have been summarised from the comprehensive timeline detailed in Appendix 1, Table 1.

To meet the urgent need for power, the Central Government commissioned the Ministry of Works and Development (Government owned department) to begin large scale hydro-development investigations on the Clutha River in 1945. This was the first step towards deciding that hydropower infrastructure would be beneficial on the Clutha/Mata-Au River for the collective good. It was not until 23 years later, in 1968, that the Ministry of Works and Development formed the Clutha Interdepartmental Committee to investigate the overall social and well-being impacts of hydropower development on Central Otago. The outcome of this committee was the Hydro-electric development in the Clutha Report (1968) which identified Cromwell and Clyde to be the best location for a hydropower dam to foster economic and social development. One of the controversial aspects of this decision was that the Clutha Interdepartmental Committee Chairman was also a Ministry of Works employee. The lack of transparency between the Government and community in making these decisions was due to set the controversial narrative that followed.

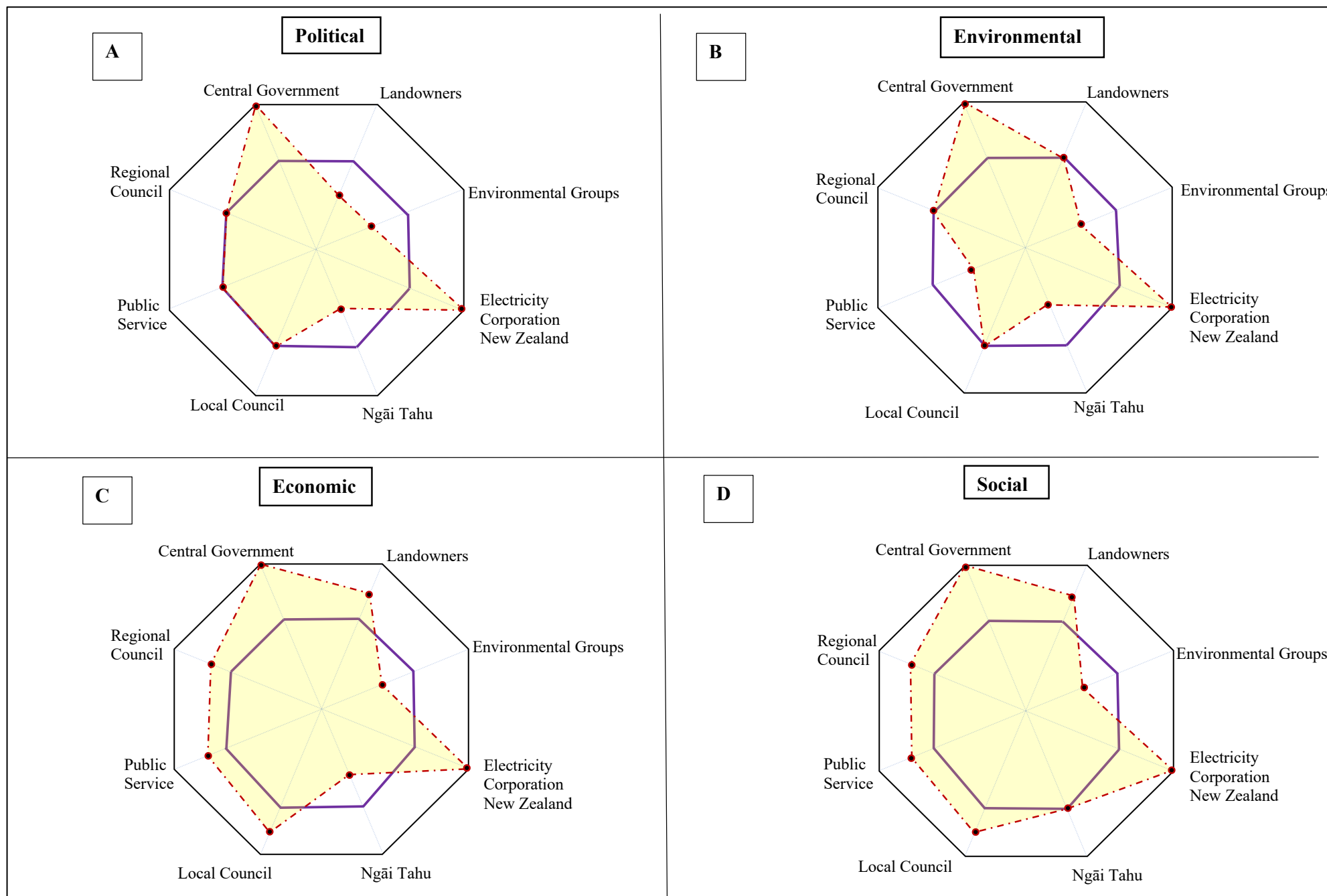
The second crucial decision was made public in 1972 when the Central Government proposed six potential dam locations on the upper Clutha around Cromwell and four for the Lower Clutha further down the catchment. In response to this proposal, the Otago community called for an independent chairman to assess the benefits and costs of development in the Clutha Valley, to which the Government did not respond. With the sole determination to increase employment in the area and foster electricity development, the Central Government decided that the largest dam, labelled Scheme F at the time, situated just above Clyde would be the most beneficial option to New

Zealand's economic development. With no public meeting to discuss potential consequences of Scheme F, which was expected to inundate 86 hectares of the 12 apricot orchards in the Cromwell Gorge. The result of this decision created uneven distribution of costs and benefits between the community of Cromwell and the benefits of the central Government. This decision created immense controversy that is still evident in the story of Central Otago today.

The third and arguably most controversial decision of the building of the Clyde Dam was the 1982 Clyde Dam Empowering Act. Passed on 30 September 1982, this act allowed the Government to obtain a water right to extract, discharge and divert the river. This decision overlooked any environmental warnings of the unstable geological nature of the gorge, social impact on the local community, the Indigenous values associated with the gorge and warnings of the Waikerikeri fault line beneath the dam. Construction continued and Lake Dunstan was filled in 1994, creating the 26.4km<sup>2</sup> lake in the Cromwell gorge as we know it today.

#### [Distributional issues during dam construction](#)

Figure 6 shows the unequal distribution of pay off services formed during the building of the Clyde Dam across political, environmental, economic and social factors indicating conflict in the outcome of the dam. Unpacking the impacts of these distributional issues shows both the different interests and ways of valuing water as well as the challenges of collective action. For reference to the data collated and institutional matrices used to create Figure 6, please refer to Appendix 1, Table 2 and Table 4 respectively.



**Figure 6:** Historical distribution of payoffs during construction phase (adapted from Tellman et al., 2021)

### ‘Rob’s-Mob’

Figure 6.A shows the level of political control that the Central Government had over other actors in the basin as there is an uneven distribution of costs and benefits where the less powerful actors were marginalised in decision making. This distributional surface indicates conflict between actors. When the political trade-offs of the construction period were discussed in the interviews, Int 6\_AT explained the significance of ‘Robs Mob’ (Figure 7) a term used to identify the supporters of Prime Minister Robert Muldoon (1975-1984) who led the construction of the Clyde Dam. It was understood that if you were not a member of ‘Rob’s Mob’, as in you did not follow the same political beliefs, it was a career limiting move. The political control of the Central Government over the other seven actors involved marginalising the perspectives of Environmental Groups, Landowners and Ngāi Tahu in decision making as they had little control. Figure 6.A shows that this created externalities where actors were marginalised based on their political views. For example, Powell (1979) reflects

*“The Clutha Dams issue was more than an assault on the valley: it had swollen to an abomination affecting the foundations of democratic government in New Zealand. In both aspects what was happening in the Clutha Valley was a warning to the nation”.*

This quote suggests that the dam was not just a piece of infrastructure that would bring economic development to New Zealand, rather it was a statement that there was only one way to value water through economic development. This was noted during Int 6\_AT who recalled that a friend had lost their job as a Scientist during the construction of the dam because he published a paper on the environmental impacts of the Clyde Dam on the Cromwell Gorge.



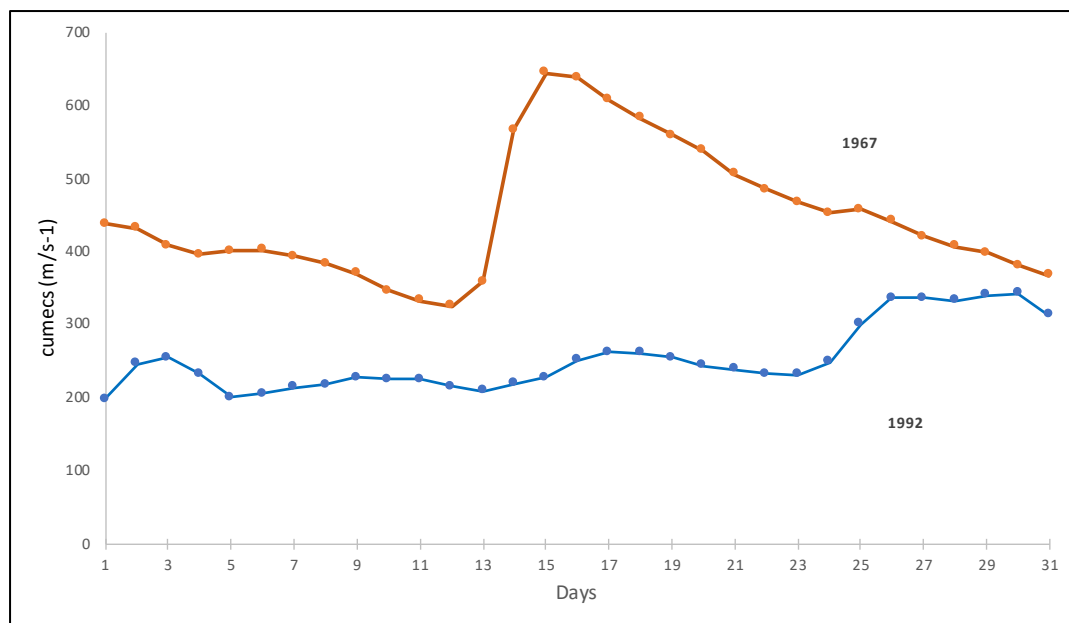
**Figure 7:** Robs Mob supporter badge. Sourced; Museum of New Zealand Te Papa Tongarewa online. (2022).



### Environmental trade-offs

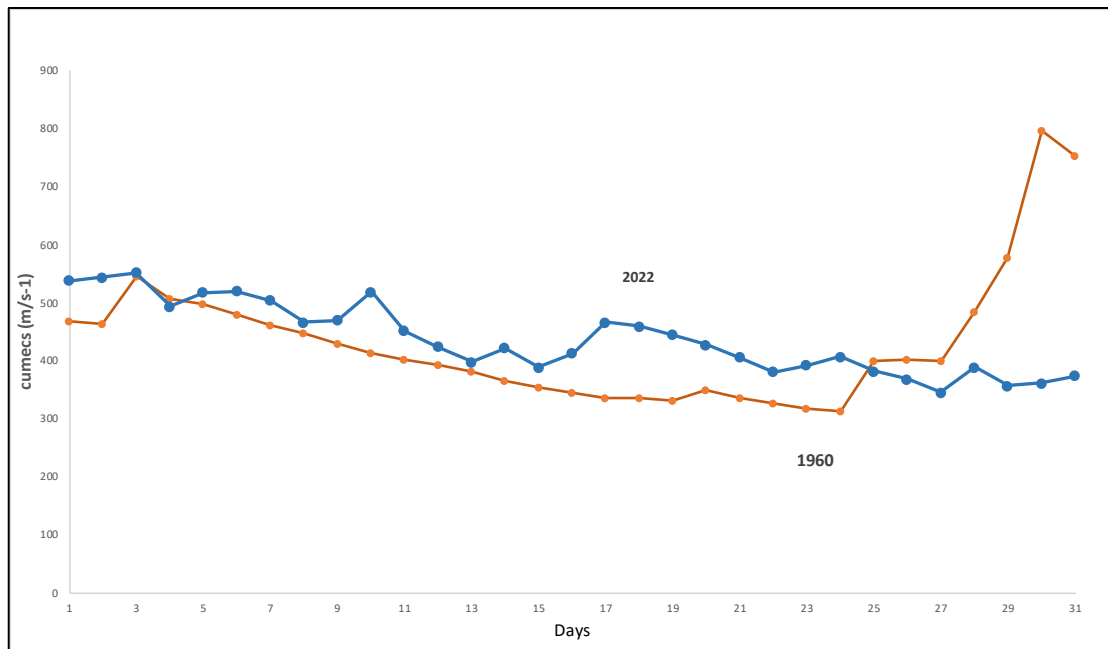
Figure 6.B shows the powerful Government actors, Central Government and Electricity Corporation New Zealand maintain the control over the less powerful actors. The 1977 Ministry of Works Clutha Power Development Flows and Design Floods report (Jowett & Thompson, 1977) notes that when designing the Clutha hydropower scheme, economic and social values were considered but there was no reference to the environmental impacts. Hatton et al., (1987) explains that the presence of the river channel fault line and geological instability was known before construction work began yet in the political nature of the Muldoon government to get the ‘job done’, these factors were disregarded by the Central Government when planning and constructing the dam.

The distributional issues are visualised as costs for the Environmental Groups, Ngāi Tahu and Public Service because there was no acknowledgement or recognition of their value towards the geological instability, microclimate or Indigenous values such as *mahinga kai* (Appendix 1, Table 2). Furthermore, Landowners, Regional Council and Local Council are placed on the neutral line because their values did not express direct concern to the environmental loss. One of the most dynamic changes and explanation behind the small distributional surface was the alteration of the natural flow regime of the Clutha/Mata-Au River that impacted the ecosystem services. Figure 8 quantifies this change in discharge where the flow at Lowburn previously exceeded 600 cumecs in 1967 and lowered to approximately 200 cumecs in 1992. This drastic change in natural flow sheds a light on the loss of environmental values that were not acknowledged during the construction of the dam.



**Figure 8:** Flow distribution of the month of August at Lowburn before and after the Dam was built (1967 vs 1992). Data courtesy of Contact Energy and NIWA.

Figure 9 shows a similar pattern in changes to the natural flow regime at Clyde before (1960) and after the dam was constructed (2022). Compared during the summer month of December, the flow in 2022 fluctuates due to the release of the water from the dam. In comparison to 1960 where the flow is much smoother representing a natural, seasonal flow.



**Figure 9:** Flow distribution of the month of December at Clyde before and after the Dam was built (1960 vs 2022) Data courtesy of Contact Energy and NIWA

The drastic changes to the environmental flows in the Clutha/Mata-Au River due to the construction of the dam show different ways that water can be valued. Due to the dynamic nature of the geology in the gorge, it was predicted that sediment would build up in Lake Dunstan. An investigation report in December 1984 calculated that it would take approximately 130 years to fill the Cromwell Gorge and Kawarau River sections of Lake Dunstan (Hatton et al., 1987). In this light, it was recorded that as the sediment builds up over time, the Kawarau River that joins the Clutha at Cromwell would eventually provide enough sediment to return back to a ‘braided’ river. This foresight did not acknowledge the potential future socioecological impacts.

### Economic compensation

The distribution of economic trade-offs on Figure 6.C shows that the payoff distribution covered a greater number of actors than 6.A and 6.B. This is because economic benefits of hydropower generally benefit a greater number people. Because two government owned agencies, the Ministry of Works and Electricity Corporation New Zealand were responsible for the design, construction and project management, there was no cap on budget for compensation or construction (Hatton et al.,

1987). The control over other actors is shown through the uneven economic distributional payoff surface.

Secondly, externalities created from the construction of the dam predominately affected those actors who did not have control in the decision-making outcome. For example, economic compensation was provided to the 280 landowners whose 2,300 hectares of productive land was lost to the filling of Lake Dunstan. Figure 10 gives insight into what Lowburn and the 5 fruit orchards looked like before Lake Dunstan was filled and Lowburn submerged. A further 12 large orchards on the river terraces of Cromwell Gorge were also relocated to facilitate the completion of the dam. As compensation for the change in land use, the government provided monetary incentives offering land outside of the gorge as well as the ability to transplant 2500 apricot trees from their location in the gorge to the new allocated land (Mighty Clutha Blogspot; Macbeth-Dann, 2022).



**Figure 10:** Lowburn Bridge and Lowburn orchards before it was submerged and became Lake Dunstan. Mid-1970s. Courtesy of NZ Herald. ‘How the Clyde Dam transformed the Cromwell Basin’ Mark Price, 27 January 2022.

#### Social values

Figure 6.D distributional surface suggests that while the level of control differed among actors, the social values were similar. This is most likely through the combination of economic incentives of a new recreational lake, relocated land and a new town centre. Environmental Groups did not have the same social values towards the dam and are therefore the payoff is recorded as a cost. This is reflected in Int 6\_AT who noted, “*the Cromwell gap itself was massive...even the jet boaters were scared of them (rapids), however now it is just a flat lake*”. This quote explicitly refers to the loss of

the recreational and social amenity of the Clutha/Mata-Au River. Because the filling of Lake Dunstan was to 60m above the original water level, it permanently changed the landscape engulfing the famous rapids to which had been created through historic gold mines. Previously these rapids had been labelled by the Indigenous Ngāi Tahu iwi as ‘Okura’, ‘Otakihia’ and ‘te Wairere’ and played an important role in the stories and traditions of Ngāi Tahu (Beattie, pre-1840). Before the Clyde Dam, the river was a hotspot for jet boaters, kayakers and previously contained extensive deposits of gold (Otago Witness, 1897).

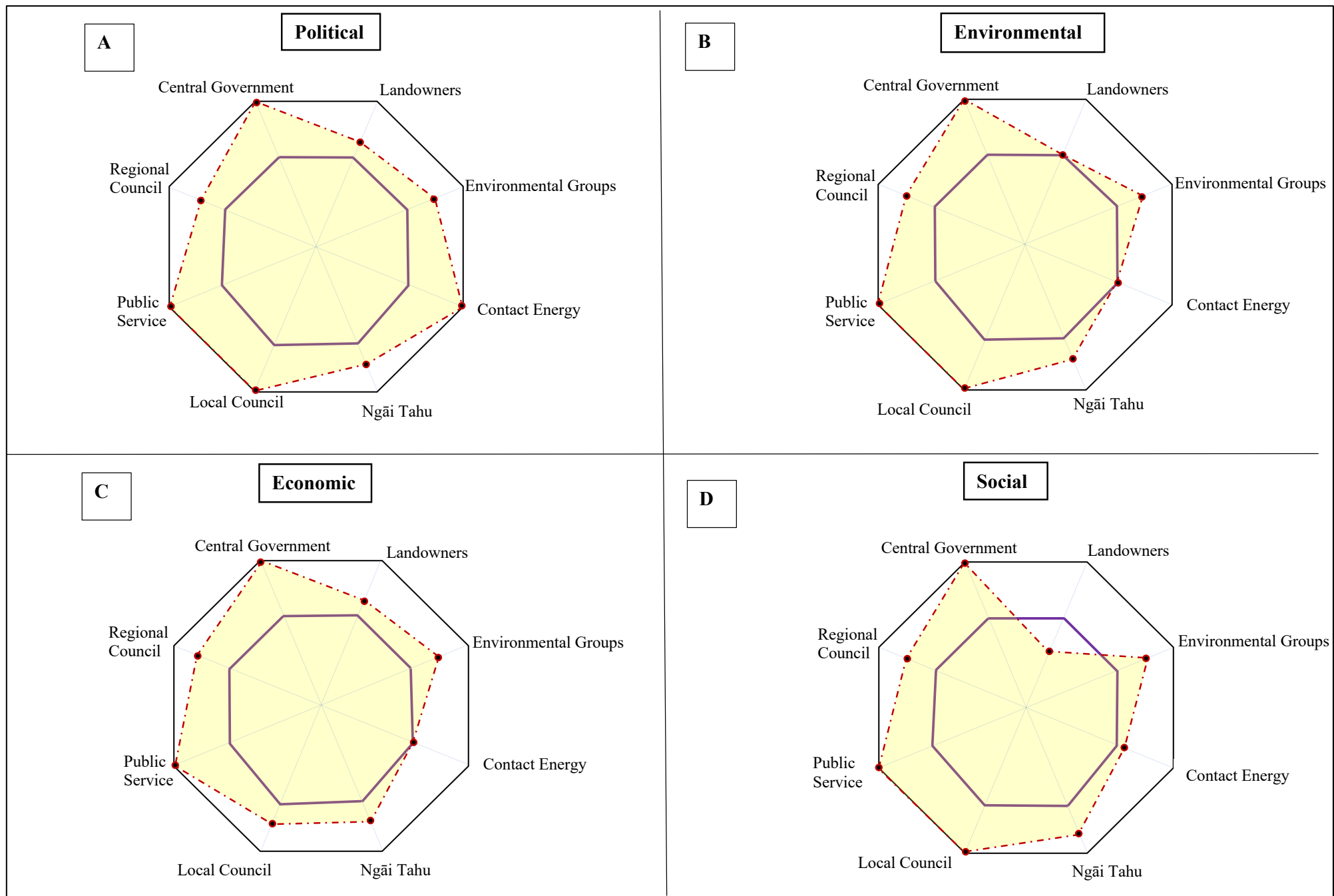
The Clutha/Mata-Au River was originally the main travel route for Ngāi Tahu to connect the inland to the sea and hence it is a special and unique Indigenous landscape referred to as “*our identity and who we are*” (Ellison, 2022). Figure 6.D highlights that this way of valuing the Clutha-Mata-Au River was not included in decision making and as a result Ngāi Tahu had been marginalised from being consulted for any decisions in the construction of the dam. Protests occurred in Cromwell and Clyde in 1977 to show the disagreement with the economic incentive, social and environmental costs towards constructing the Clyde Dam (Figure 11). Powell (1979) quotes a local resident, Rod Pierce who at the time exclaimed “*We are implacably opposed to all the hydro-electric schemes...there is a lot of angry feeling in the lower Clutha*”. This quote gives insight into the complex problems of managing water as a public good and the externalities that it produces in collective action.



**Figure 11:** Public protests against the Clyde Dam in Clyde, 1977. Image courtesy of J.MacGibbon, Hocken Collections, University of Otago.

## RQ 2: Distributional issues during dam operation

Figure 12 distributional payoff map generally shows an increase in cooperation between actors. This is indicated by the larger distributional surface which indicates cooperation among actors across social, environmental, political and economic values. Nonetheless there are still a range of costs and benefits for each actor due to different interests and different ways of valuing water. For full reference to the summarised interview material and institutional matrices used to create Figure 12, please see Appendix 1 Table 3 and Table 5.



**Figure 12:** Current distribution of payoffs during operational phase (adapted from Tellman et al., 2021)

### Political values

Figure 12.A shows that generally all actors have political benefits now that the dam is operational. This is reflected in the recent government funding allocated to assist Environment Groups in the Lake Dunstan area with restoration planting mentioned in Int 1\_EG, Int 3\_RS and Int 9\_PS. This funding is also beneficial to Ngāi Tahu iwi in the region, via an iwi-led environmental charity to plant native nurseries and form restoration projects. The purpose of these projects is to scale-up and foster shared values between the community and the environment to which they live. For example, one of the steps towards the new Land and Water Regional Plan for Central Otago has been to ask the community about how they value water, encouraging cooperation from previously marginalised communities.

Where the payoff surface shows landowners, environmental groups and Ngāi Tahu in the middle of the benefits octagon, it recognises that their values towards water management have been increasingly used in the decision-making context. This was directly acknowledged in Int 4\_LC who noted that Ngāi Tahu are now beginning to become part of discussion and decision-making outcomes. On the other hand, Int 8\_LO noted that there is still a long way to go to ensure that Ngāi Tahu's values are shared and equally represented.

Int 4\_LC and Int 8\_AT both referred to the long-lasting impact of Robert Muldoon's government where the philosophies and brash nature of decision making are still evident in water resource management planning. Int 4\_LC explained that conversations have started among actors regarding how to incorporate the multiple layers of meaning that are embedded in Central Otago in a collective effort to push beyond the historical, political motives of previous governments.

### Environmental trade-offs

Figure 12.B shows a generally positive development in the collective management of the environmental trade-offs as the payoff surface covers a large surface area. This is particularly relevant for environmental groups who are working with Ngāi Tahu representatives, local councils, and public service to manage the build-up of *Lagarosiphon* (genus of aquatic weed) in the basin as well as the accumulation of silt from the dynamic Kawarau River (Int1\_EG, Int 3\_RS, Int 4\_LC, Int 5\_PS, Int 9\_PS). Alternatively, Contact Energy was placed on the neutral line because while they have environmental values identified in the Contact Energy Annual Environmental Report (2002) it is perceived by Int 1\_EG and Int 8\_LO that their environmental values are not upheld.

These different perspectives were expressed through the lack of management focussed on clearing the silt and build-up of *Lagarosiphon* in Lake Dunstan. While perspectives as to who is required to manage these distributional issues of the dam differ between actors, Int 5\_PS had a unique perspective. Int 5\_PS valued the *Lagarosiphon* as a vital component of the ecosystem integral to maintaining ecosystem diversity. In addition, Int 5\_PS was not surprised by the accumulation of silt as were Int 8\_LO because it was planned for during the dam construction period. Regardless of this perspective, this may increase the environmental value but decrease the social value as the river would no longer be deep enough for the community to go boating in the river. In comparison to this perspective, Int 1\_EG, Int 4\_LC and Int 8\_LO requested ‘appropriate management’ of the lake because there had been multiple complaints from the local community about the silt and weed build up restricting boat access to the lake. Visualising these externalities through the payoff map shows how the different interests and ways of valuing water can create conflict but also encourage cooperation.

Finally, regional and local councils have a high degree of control in the environmental payoffs. This is due to the development of the Otago Land and Water Regional Plan (led by Otago Regional Council) that has made clear that Ngāi Tahu are in consultation to ensure that Indigenous values towards water resource management are incorporated. This collective cooperation is noted through the increased distributional surface.

#### Economic values

Figure 12.C shows the immense economic inputs of the government in providing stability for the Upper Clutha/Mata-Au River community. For example, to mitigate the loss of the natural rapids in Cromwell gorge, money was supplied to build a man-made white-water feature on the Hawea River as compensation (Figure 13).





**Figure 13:** standing wave on Hawea River. Image courtesy of James Mitchell, Otago Daily Times, 30 March 2021

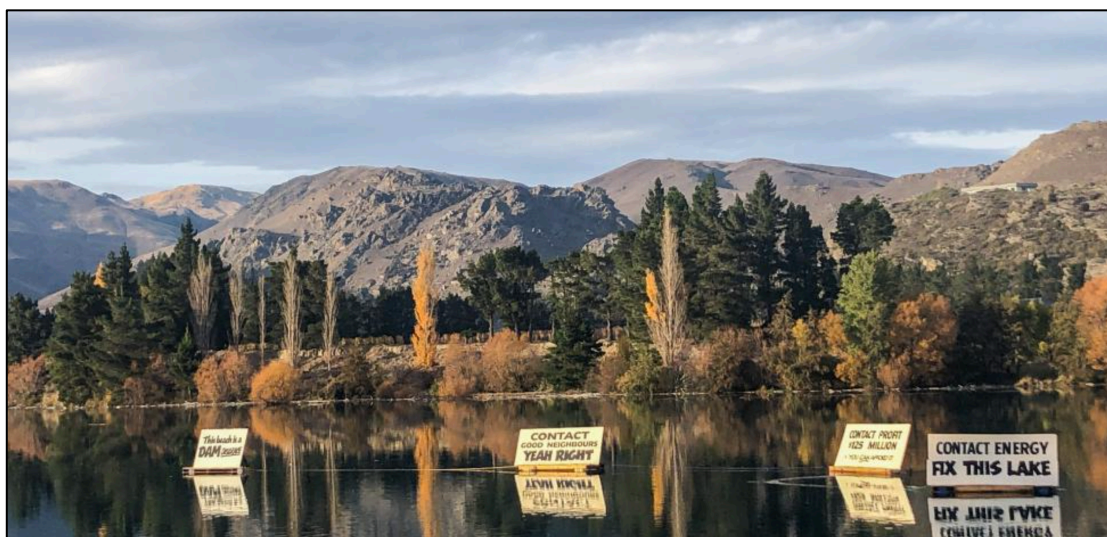
As recalled by Int 2\_EL, the standing wave on the Hawea River was the compensation for the loss of the natural rapids. While it does not replace the rapids, merely mitigates the loss it has been a successful outcome in managing the economic payoffs of the Clyde Dam as it can be used for different activities such as surfing, body boarding and kayaking.

Int 8\_LO acknowledged that the construction of the dam has provided multiple economic benefits that have “*certainly changed the face of the area*”. This has been beneficial to orchardists and winegrowers who have benefitted from the increase in tourism to the area. The Lake Dunstan water supply has ensured that water is easily available for irrigation for the wine grapes and fruit orchards.

Finally, while all actors are distributed in the benefits octagon, public service and central government still remain in the highest control. This shows that knowledge of economic and political factors are institutionalised and the greatest power in decision remains with the Government.

### Evolving social perspectives

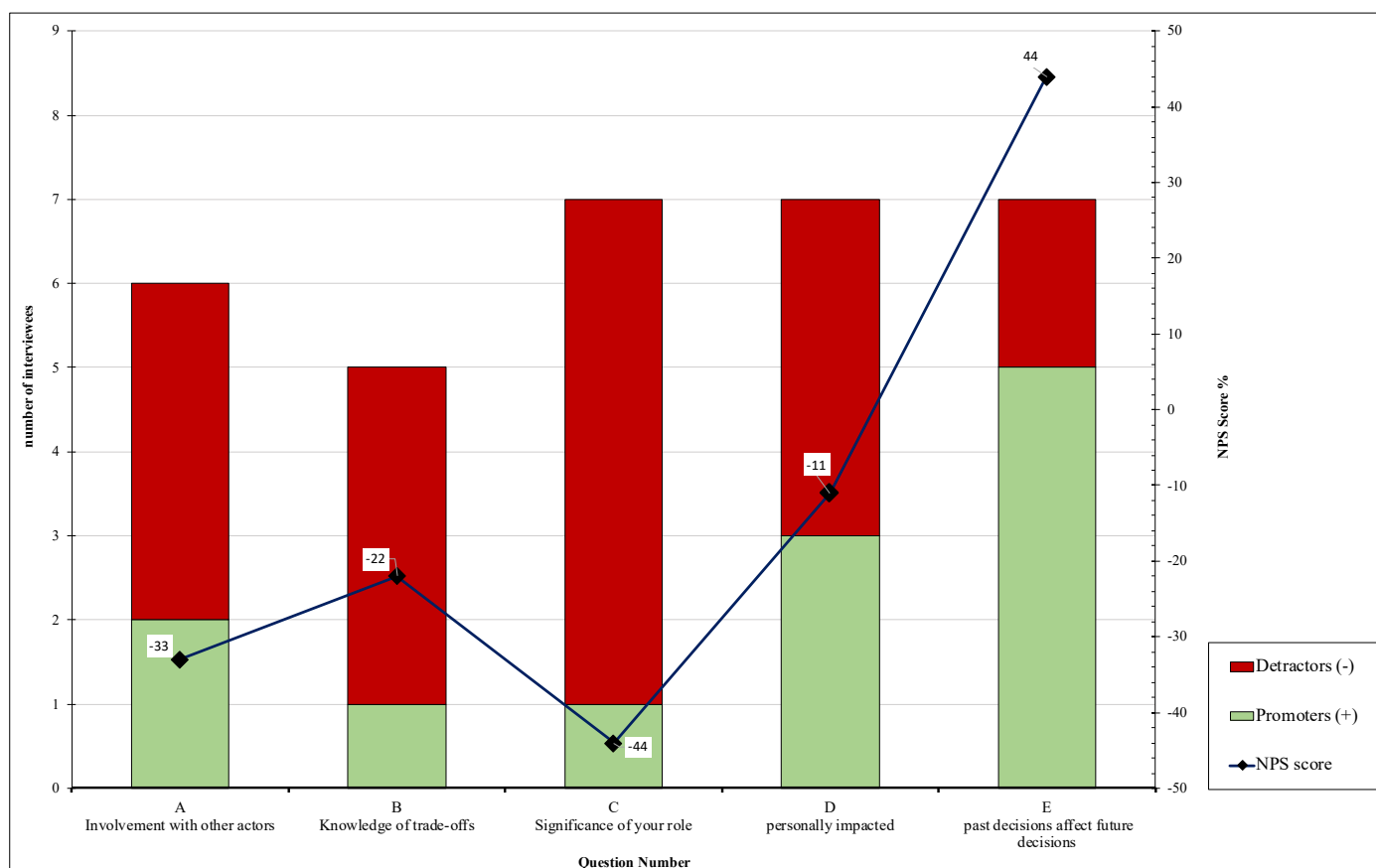
Figure 12.D identifies collective benefits and shared social values for all actors except for Landowners. This externality is due to the concerns raised during the interviews about the accumulation of *Lagarosiphon* and sediment in Lake Dunstan that impacts the recreational amenity of the lake. This was reflected in practice during the opening of the Lake Dunstan Cycling and Walking Trail when placards from local lobbying groups were erected on Lake Dunstan in May 2021 (Figure 14). The placards called for ‘Contact Energy fix this lake’ and ‘Stunning bike track, stinking lake’. While cooperation in the management of the distributional issues of the Clyde Dam is visible, this shows that there is still conflict in the basin between actors because of the different ways in which the distributional issues impact them personally and the divergent ways in which water can be valued.



**Figure 14:** Placards placed in protest against the current management of Lake Dunstan. Image courtesy of Jared Morgan. Otago Daily Times, 31 May 2021.

### RQ 3: Quantifying diverse values in the context of path dependency

Figure 15 quantifies the diverse perspectives of the interviewees regarding the impact of the dam. This helps to understand areas in which actors share similar values (cooperation) and where their values differ (conflict). For full reference to the raw data and analysis of results please refer to Appendix 1, Table 6 and 7. Please refer to Appendix 2 for the quantitative questions used.



**Figure 15:** Distribution of promoter and detractor responses to the four quantitative questions asked. Sourced from Appendix 1, Table 7.

There are five key messages identified from the NPS results in Figure 15;

- Question A showed that four of the nine interviewees rated their involvement with other actors as low, producing a negative NPS score of -33. This suggests that there are contrasting perspectives towards the extent of cooperation in the basin to manage the distributional issues.
- Question B showed that four of the nine interviewees rated their knowledge of the trade-offs of the dam as low. The NPS score of -22 identifies that actors do not share similar values of the knowledge of trade-offs. This proves that diverse ways of valuing trade-offs are not shared across perspectives.

- Five of the nine interviewees rated the significance of their role as low in the management of the distributional issues of the dam (Question C). The range of contrasting values compared to those that are shared produced the lowest NPS score of -44 which shows that actors view their roles as independent from one another. This is because they have their own personal values and motivations to how the distributional issues should be managed. An interesting outcome of this question was that Int 7\_EC, a representative from Contact Energy was the only interviewee who rated their role as significant. This is interesting because historically Contact Energy/Electricity Corporation New Zealand have typically held greater control in decision making outcomes.
- Question D shows an almost equal distribution between actors who were highly impacted by the dam and those who experienced low impact from the distributional issues. A higher NPS score of -11 suggests that the actors agree that they were all impacted in some way because of the construction of the Clyde Dam.
- Finally, Question E showed a positive NPS score of 44 which means that actors generally share the same perspective that past decisions in water infrastructure development are strong indicators for the outcome of future management decisions.

It was generally found that actors who were involved in decision making during the construction of the dam and/or their role was directly impacted by the trade-offs of the dam were more likely to rate their involvement as high during the operation of the dam (Int 4\_EC and Int 7\_EL). In comparison, individuals who were not present during the construction of the dam and/or did not have any involvement in the historical decisions were more likely to rate a lower or neutral response. Furthermore, two interviewees, Int 3\_RS & Int 5\_PS justified their rating of Question B. They acknowledged that while they are aware of the trade-offs their direct knowledge of the trade-offs is poor. Similarly, when reflecting on the personal impact of the Clyde Dam, Int 1\_EG and Int 8\_LO mentioned the importance of aesthetics as a distributional issue.

In summary, Figure 15 provides a compelling contrast to Figure 6 and Figure 12 as it quantifies the contrasting values indicating areas of shared values as well as areas of stark contrasts which could lead to conflict. Figure 15 shows while there are some areas of cooperation there are still contradicting values and perspectives towards how the distributional issues of the dam should be managed.

## 5. Discussion

This chapter discusses each research question synthesising the subject matter into deeper layers of meaning through power inequalities, solastalgia and path dependency. It then contextualises the ways in which water is valued in Central Otago in the context of the Clyde Dam and the implications this has for future water resource management. It will also address the future research directions and limitations of this research.

### RQ1: The historical narrative

Three critical decisions between the construction of the Clyde Dam in 1945 to its completion in 1994 were identified as the main drivers behind the distributional issues that created uneven payoffs between actors. These decisions, driven by the Central Government involved pre-investigation of possible locations, proposal of seven hydropower schemes and the Clyde Dam Empowering Act (1982). Controlled by a myriad of competing political and environmental values, the decisions encouraged the marginalisation of Ngāi Tahu, Environmental Groups and Landowners. When asked about the historical narrative of the Clyde Dam, Int 7\_EC reflects it is

*“ a pretty unique situation with a checkered history”.*

This quote identifies the crux of the collective action problem, the contrasting values and motivations towards water management at the time of construction. The words ‘unique’ and ‘checkered’ indicate a historical fluctuation between conflict and cooperation. This is because whether individuals cooperated with Central Government or opposed their motives was determined by personal values and perspectives to water.

The main distributional issues identified as consequences of the construction of the Clyde Dam were the loss of recreational amenity (creating Lake Dunstan), loss of fertile land in the gorge, the build-up of sediment in Lake Dunstan and the accumulation of *Lagarosiphon* weed. Int 5\_PS who was working in Central Otago at the time recalled that some of the landowners still remain ‘bitter’ regarding the loss of their productive farmland, fruit orchards and homes in the Cromwell Gorge. This is because in the series of proposals made by the Government, there was an option for a low dam that would have preserved some of the fruit orchards and fertile soil. Regardless, for the maximum economic benefit, the Government decided on the high dam option referred to as Scheme F. Despite this payoff, through an economic and social perspective, Lake Dunstan is recalled as *“the making of Cromwell”* (Int 5\_PS). This indicates that for the landowners living in the Cromwell

Gorge the dam was a cost but to those living externally to the Gorge in the historic gold mining towns it brought economic security.

Because there are different values towards the benefits and costs of the distributional issues, smaller groups with less control or contrasting values were marginalised, encouraging protests against the decisions of the Central Government. This conflict is visualised through the little coverage of the radial surface on the payoff map. Insight into the impact of these distributional issues was recalled in Int 6\_AT who use to paddle the rapids before the dam was built.

*“(I was) furious how the government handled it...an environmental project turned economic development project”.*

This quote directly reflects that the full plethora of values were not recognised in the construction of the dam. It also recognises that economic change is not just a matter of hydropower development, but it incorporates community values and power relationships (Suhardiman et al., 2017).

### Power inequalities

One of the outcomes of RQ1 is importance of power inequalities in collective action (Anderson et al., 2012). For example, Int 6\_AT had the opinion that the ‘Think Big’ era in New Zealand had a flawed engineering and economic logic due to the immense political pressure for New Zealand to become economically secure. In this regard, the Clyde Dam was a symptom of the ‘Think Big’ era as the political pressure to produce power for the South Island greatly exceeded any social or environmental costs. Referred to as confirmation bias, Int 6\_AT reflects that this created an imbalance of power between actors so that the Central Governments so that the desired outcome of the Central Government would be achieved at any cost.

Acknowledging that power inequalities play an integral part in collective action dilemmas further validates the intertwined nature of collective action, distributional issues and path dependency when there are multiple ways to value water. In this regard, scholars typically look to historical practices to understand the drivers for potential bias in decision making (Beck et al., 1994; Zienkowski, 2017; Fairclough & Chouliarak, 1999).



The findings of RQ1 show that collective benefits promised by the Central Government (increased jobs, economic growth, secure power supply) were not beneficial for all actors involved and rarely extended to marginalised populations. While the past shows conflict between competing values, the distributional issues identified during the construction phase are also mirrored in the operational phase. This is a reflection that the distributional issues of the Clyde Dam are path dependent.

### RQ2: Contrasting values

The interview results recognised that expectations towards the collective management of the basin were siloed. This is because motivations were driven by personal values and experiences with the Clyde Dam. Actors who shared the same values Int1\_EG, Int2\_PS, Int 3\_RS and Int 6\_AT agreed that there had been no recognition to the loss of social and recreational values when the dam was constructed. Because of this, Int1\_EG explained that the local community would like to see designated swimming areas and removal of silt and *Lagarosiphon* to improve better access to Lake Dunstan. A contrasting perspective from Int 5\_PS valued the presence of *Lagarosiphon* in a positive way as it provides an adequate habitat for macroinvertebrates and macrophytes to maintain a healthy and diverse lake ecosystem.

On the contrary, these competing values can be viewed as affordances (Gibson & Carmichael, 1966). For example, Int 3\_RS explains that there are benefits created by the dam in the form of a lake. This means that the affordances are multiplied from a social perspective but are decreased from an environmental perspective. Where affordances are multiplied and others diminish, they do not replace what was lost but merely mitigate the impact. Looking at contrasting values through this lens reflects on the complex challenge of working collectively towards a common goal when there are different interests and perspectives towards water.

These perspectives are fuelled by the different ways to value water. They encourage both cooperation and conflict between who makes the decision and whose values are marginalised. Int7\_EC referred to these conflicts as being “*a little ugly*” as it has created a certain “*awkwardness*” for who is supposed to “*look after*” Lake Dunstan. Regardless of the competing values towards the distributional issues, all actors were aware of each other’s motivations, particularly those of indigenous Ngāi Tahu, who had been marginalised from decision making in the past. This was evident during Int 4\_LC who stated

*“They (the community) want to have the iwi (Ngāi Tahu) story there and embrace it as it is the part of the Central Otago conversation that is missing”.*

Int 2\_EL reflected that while it is important to utilise indigenous values in water policies, it is an evolving area of law and is strictly place based because values can differ between regions. During the research, a nuanced approach was revealed towards understanding the contrasting values of water. This explored the physical loss of the landscape and the emotional impact that the construction of the Clyde Dam has had on the actors interviewed.

### Solastalgia

Interviews looked beyond the relationship between collective action and distributional issues and brought to life the concept of solastalgia. Solastalgia is a form of emotional distress caused by environmental change. This was identified through personal, passionate and emotional accounts of what the Clutha/Mata-Au River was like before the construction of the dam (Albrecht et al., 2007).

Int 6\_AT who use to paddle the rapids in the Cromwell Gorge reflects

*“...take 80 meters of water out of the lake and there are rapids at the bottom of them waiting to come back. Every time I go past, I shed a tear”.*

This quote explains that the distributional issues were not simply a social impact that were valued through costs and benefits but also an emotional impact and loss of place. This loss of place was noted again during Int 6\_AT who reflected that there was

*“...no environmental feeling or empathy (when the dam was built)”.*

Solastalgia can also be used to explain feeling powerless towards influencing the outcome of a changing process (Albrecht et al., 2007). This observation is consistent with the findings of RQ 2 where the distributional payoff maps identified conflict during construction of the dam when actors could not influence changing processes. Similarly, this was observed during the operational phase where cooperation is encouraged to manage the trade-offs so that all actors in the Clutha/Mata-Au can benefit.

Regardless, the different motivations and ways in which water is valued in the Clutha/Mata-Au River indicates that there is still conflict between actors because of diverse perspectives towards water.



This collective action problem proves that it is not possible to satisfy all values and motivations when making decisions where there are costs, benefits and marginalisation of individuals/groups are inevitable (Ostrom, 1990; O'Donnell & Talbot Jones, 2018).

### RQ:3 Institutional change in the context of path dependency

Quantifying how actors valued water and whether they share these values proved that costs and benefits can never truly be distributed equally in collective action. This means that certain individuals or groups will always be marginalised based on the level of control they have in decision making (Villamayor-Tomas, 2019). The implications of the distributional issues showed that actors value the significance of their roles, their knowledge and the level of interaction they have with one another very differently. These findings exemplify the importance of collectively integrating environmental values with social, economic and cultural values when constructing and managing hydropower infrastructure (Brouwer & van Ek, 2004). One of the key findings from RQ3 was the shared perspective that historical decisions that led to the construction of the Clyde Dam and associated trade-offs have influenced and will continue to influence future decisions around the management of the Clyde Dam trade-offs. This corresponds to scholars who emphasise that institutionalised knowledge fosters path dependency making any type of institutional change extremely complex (Turley, 2021; Sorensen, 2015).

### Path dependency

While cooperation between actors has increased, it is clear that the historical narrative has had a constraining effect on future decision making (Heinmiller, 2009). For example, it had been planned that the sediment from the Kowarau Arm would build up in the lake but during construction there was no foresight as to how the sediment would be managed by the community in the future. Consequently, this facilitated a lock-in where public service, environmental groups, regional and local councils are now committed to establishing policies and plans to collectively manage the build-up of sediment. To contextualise this, North (1991) explains that path dependence is the accumulation of historical decisions, knowledge and values that foster institutional lock-in. This is recognised between the actors in the basin, specifically Int 7\_EC who acknowledged

*“many of the challenges that Cromwell faces today are a result of the construction of the Clyde Dam”.*

This quote expresses that the distributional issues identified are path dependent as they have shaped the current management frameworks, perspectives and narratives of the actors interviewed.

## Contextualised approaches to valuing water in Central Otago

### *Implications for water science*

The challenge to connect scientific knowledge with environmental decision making is an ongoing problem (Van Kerkhoff & Pilbeam, 2017). This is addressed in the Otago Shaping our Future report that was published in August 2022. Its purpose is to combine public values, perspectives and motivations towards Lake Dunstan to facilitate a clear community centred plan that incorporates science into environmental decision making through partnerships. These partnerships involve environmental groups (Lake Dunstan Charitable Trust), public service (Land Information New Zealand), Indigenous groups (Te Tapu o Tane) working collectively on lake side restoration, planting native trees and wetlands to foster natural ecosystems, drawing together multiple value threads. It is planned so that by 2050, the management of Lake Dunstan is led wholly by the community (Shaping our Future, 2022).

Incorporating socially valued ecological characteristics that are flexible and resilient to changes in the hydrological cycle are key indicators of the Central Otago Land and Water Regional Plan (expected, 2024) (Poff et al., 2018). These characteristics will help to set environmental flows for the Clutha/Mata-Au River with the aim to benefit both the natural and cultural environment (Otago Regional Council, 2022). The unique nature of this report is that has engaged with the local community as well as Ngāi Tahu to discuss how their ways of valuing water can be incorporated into Regional Plan. In contrast to this, Int 2\_EL identified a current conflict in collectively producing the plan. This is the contrasting perspectives towards how Indigenous and non-Indigenous fish should be managed. Currently, salmon and trout (non-Indigenous fish) are protected under the Resource Management Act (1991) but predate heavily on Indigenous fish that are not protected in the 1991 Act. This has created tension when developing the new Regional Plan regarding how to manage both fish populations equally while maintaining ecosystem diversity and resilience. This collective action problem is currently being worked through for the new Otago Land and Water Regional Plan (2024).

Van Kerhoff & Pilbeam (2017) suggest that that to overcome these tensions, knowledge governance can bridge the gap between science and decision making. This involves using formal and informal rules that shape how individuals engage in knowledge processes in hope to overcome the historic narrative that water should be ‘used’ rather than ‘wasted’ (Bakker, 1999). Contrary to this scholarship, while knowledge sharing is an integral part of collective action, this dissertation has identified that to truly bridge the gap between science and decision making, contrasting perspectives

of how ecosystems are valued must be across multi-sectoral entities in policy and planning documents (Watson & Perkins, 2022).

### *Implications for water policy*

Both Int 1\_EG and Int 4\_LC referred to the importance of looking back at local values of Ngāi Tahu and Māori when managing water resources to facilitate cooperation in a way that all value streams are heard and represented. This was discussed in a similar nature in Int 2\_EL who explained that Māori perspectives towards water are an all-embracing concept. The Te Mana o te Wai concept was first added on to the New Zealand National Policy of Freshwater Management in 2014, amended in 2017 and in 2020, Te Mana o te Wai was placed at the forefront of the Policy and is now slowly becoming recognised as driving force behind freshwater management (Ministry of Environment, 2021). Te Mana o Te Wai is a hierarchy of obligations given to water. It prioritises the health and well-being of water first before providing water for human health needs and the last priority is for other consumption such as recreation, provided that such use does not adversely impact the *mauri* or ‘essence of life’ of the freshwater. By lifting the standard for how regions across New Zealand must care for water, it gives light to two sets of values, implementation of good governance and inclusion of social, environmental, economic and political factors.

Implementing the Te Mana o te Wai narrative to manage the distributional issues of the Clyde Dam could have profound political impacts. A shift in water values from predominately human use to focussing on water as its own entity, with environmental needs as the first priority will create a multi-scale shift in the way that water is perceived. This will challenge the political and economic values that the Clyde Dam and previous hydropower projects in New Zealand have been built upon. This is a truly exciting yet challenging time for Central Otago and to a larger extent New Zealand water resource management as it navigates ways to effectively implement Te Mana o te Wai and give a voice to previously marginalised indigenous communities. While changes to the National Policy on Freshwater Management (2020) have encouraged departure from historical narratives and facilitated change towards shared values, Heinmiller (2009) warns that adapting current policies with new rules means that institutions take on old characteristics with the new. This can further facilitate path dependency where the old characteristics ‘lock-in’ the new policies so institutional change cannot progress, a reflection on the complex components of collective action problems (Sorensen, 2015). It is with these components in mind that I elaborate on the implications of these findings for water resource management in Central Otago.

### *Implications for water management*

Understanding the multiple values of water as a barrier for collective action is beneficial for future hydropower developments in New Zealand. In practice, incorporating these multiple values into decision is complex but critical to the success of water security, especially in the dry climate of Central Otago (referred to in Int 4\_LC and Int 8\_LO). As the New Zealand government now looks to make multi-scalar changes to water resource management at a national scale through the Three Waters Reform (2024), regional scale through implementing the Te Mana o te Wai principles and at a local scale in Central Otago with the development of the Land and Water Regional Plan. With these changes on the horizon, integrating different interests in water use and different ways of valuing water is ever more pressing.

While the Te Mana o te Wai principles have been recognised by actors in Central Otago, predominately through prioritising restoration and volunteer projects that embrace different values and encourage transparency (Int1\_EG, Int 2\_EL, Int5\_PS and Int 9\_PS). It is still evident that the “*genes of Muldoon*” are entrenched in the institutional framework (Int6\_AT). This indicates that changing institutional frameworks and altering policy statements will not be enough to incorporate multiple values and interests when planning for future water infrastructure.

These research findings are reflective of Knight (2019) who stated that new rules that are built on old policies encourages institutions to remain path dependent which could have implications for new water infrastructure built in Central Otago. For example, plans for a pumped hydro storage lake in Central Otago are underway. Named ‘The Lake Onslow Battery Project’, it proposes a large reservoir to be used for electricity supply and demand when generation from solar wind and existing hydropower are not enough due to unforeseen changes in the hydrological cycle (Bardsley et al., 2022). The project promises to provide between 3,500 to 4,500 jobs and will ensure that New Zealand is carbon neutral by 2030 (Ministry of Business, Innovation & Employment, 2022). To achieve this goal and break away from the institutionalised ‘genes of Muldoon’ mentality, it will require cross sectoral knowledge of the multiple ways to value water.

### Limitations

There are four limitations to this research. Because the interviews were conducted online, it could limit the degree to which knowledge is shared and interpreted. Access to historical information was restricted to digitised versions due to completing the project outside of New Zealand. Another limitation is the interviewee conflict of interest. In particular, Int 7\_EC representative from Contact

Energy is also identified as the Deputy Mayor of Central Otago District Council. While the interview was conducted from the perspective of their role at Contact Energy, it is possible that some information could be biased. Finally, the NPS score used was an even number (scale on 1 to 10) rather than on an uneven scale such as 1 to 5. This limitation gave the interviewees the option to position their responses as neutral, in the middle of the scale. If this research was to be completed again perhaps using an uneven scale (1 to 5) would produce a different outcome of results.

### Future directions

There are three promising future research directions for this research. It can be used as a foundation for a quantitative analysis of the scientific values to determine environmental flows at Lake Dunstan to contribute to the Otago Land and Water Regional Plan (2024). The scope could be increased to a detailed regional qualitative study to compare the perspectives of the trade-offs of Clyde Dam within the community and those of the decision-makers in the Clutha/Mata-Au. This would be facilitated through in-person interviews, surveys and field work. In addition, it is a starting point for a comparative review between how regional councils value water in New Zealand. This research direction would determine leverage points towards institutional change. In particular, identify where values towards water are shared and where they are different between regions to understand how to best implement the Te Mana o Te Wai principles in coordination with the Three Waters Reform in 2024.

## 6. Conclusion

This research has found that because there are different interests and different ways of valuing water, trade-offs are inevitable in collective action and are typically distributed unevenly between groups. Using the construction and operation of the Clyde Dam as an example of a collective action problem, this research has three outcomes.

Three decisions were summarised as contributing to the construction of the Clyde Dam. These decisions, driven by political and economic values towards water created a myriad of distributional issues for the Cromwell, Clyde and Bannockburn communities. The distributional issues across social, political, economic and environmental factors were presented on a payoff map that identified a highly uneven distribution of benefits between the Central Government and communities in the study location. The consequences of this uneven distribution resulted in conflict through community protests further exacerbating power inequalities when making decisions. The outcome is that when

making collective decisions regarding a common pool resource, different ways of valuing water should be accounted for so that benefits can be distributed somewhat evenly to all involved.

The distributional issues identified during the construction period are also evident during the operational phase. The payoff map identified a greater distribution of benefits between actors which showed that there is greater cooperation towards managing the distributional issues of the Clyde Dam. It was also found that these issues were valued differently between actors because of their personal motivations. This reinforces that people's attitudes towards environmental changes are often emotional which is likely to result in opposing beliefs. This research has shown that water is an excellent example of these conflicting perspectives because it has multiple characteristics that make it challenging to measure and reflect its full range of benefits in decision making. As a result, these findings show that distributional issues and collective action problems are deeply intertwined institutional frameworks.

Further quantitative analysis showed that despite the payoff map indicating an increase distribution of benefits between actors, their perspectives towards water use are siloed because they do not share the same values. This proves that it is difficult to work in a collective manner when there are multiple ways to value water. A beneficial outcome of this analysis was that all interviewees acknowledged that past decisions inform future decisions and spoke of implementing small changes to break away from previous marginalised management frameworks.

As the New Zealand Government look to make changes to water policy and planning documents specifically towards Three Waters Reform (2024). It must be recognised that these changes are building upon institutionalised perspectives and norms towards water use. As explored in this research, these values have historically marginalised indigenous and smaller communities.

In conclusion, this research shows that issues around contrasting values will not be resolved by legislative change alone. Motivation to overcome the institutionalised right to use water as an economic or political resource in will need to be replaced with a stronger perspective that accepts the diverse values of water across economic, political, social and environmental uses to overcome collective action problems. This will involve a counter narrative to traditional engineered hydropower infrastructure, turning away from mitigating distributional impacts and towards shared motivations and outcomes.

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## Appendix 1: Supplementary data

**Table 1:** History of the Clyde Dam

Year	Decision	Reference
13 <sup>th</sup> Century	Nga Tahu settled in Cromwell / Maori mining in Central Otago Region	Int 4_LC
1903	Clutha River possible area of hydropower development after the Gold Rush.	Lonie (1984)
1945	There was an urgent national need for power. Surveys began on Clutha and Kawarau rivers. Ministry of Works begins large scale hydro investigations on Clutha River	Lonie (1984) ; Martin (1998); Powell (1979)
1948	Construction started at the Roxburgh site without detailed investigation on environmental or social issues.	Lonie (1984); Powell (1979)
1963	The Manapouri Te Anau Development Act passed	Powell (1979)
1968	Ministry of Works (MOW) sets up Clutha Interdepartmental committee. Concerns over lack of transparency of committee members and public. Hydro-electric development in the Clutha Report published	Lonie (1984); Powell (1979)
1970	Nation-wide campaign against raising of Lake Manapouri	Powell (1979)
1972	Six dam proposals for Upper Clutha, four for the Lower Clutha. Otago locals call for independent Chairman to assess multi-purpose development of Clutha Valley	Lonie (1984); Powell (1979)
1973	Central Government sets up Clutha Valley Development Commission and disbands Clutha Liaison Committee.	Powell (1979)
1974	Right Hon N.E. Kirk (prime minister) announces 12.5 acres out of 790 acres to be flooded under Scheme H. This would create a greater capacity for energy production	Parliamentary Debates (1974); Lonie (1984)
1975	Clutha River Dam Schemes F, H and NV1 explored.	Lonie (1984); Powell (1979)
1976	Government refuses to lower height of dam in Cromwell Gorge. Clutha Valley Advisory Committee advised against Scheme F and favours Scheme H. 20 December Cabinet approved Scheme F	Lonie (1984); Parliamentary Debates House of representatives (1974); Martin, (1998); Powell (1979)
1977	Otago Catchment Board votes overwhelming rejection of Scheme F. Public meeting at Cromwell rejects Scheme F and votes no-confidence in Government Clutha Policy.  MOW information centre at Cromwell fire-bombed and Cromwell Gorge orchardists form a picket-line against MOW intrusion on their land.  Clutha Rescue group invade MOW high dam site at Clyde MOW. Caught by surprise, MOW tells Clutha Rescue group to leave but group refuses. Public reaction against scheme F increases	Martin (1998); Lonie (1984); Powell 1979
1978	Commission for the Environment protested because an impact report on Scheme F was not provided. MOW had already started earthworks.  Dissatisfaction in Cromwell community with MOW compensation arrangements.  Government claim that dam-threatened orchards could be successfully transplanted. Refuted by orchardists.  30 January, Otago Catchment Board reverses its previous opposition to Scheme F. By Feb there were 17 appeals from people affected by Clyde high dam proposal. 20 April environmental impact report on Clyde high dam proposal released by MOW. This impact report comes under hard hitting attacks from environmental groups	Martin (1998); Powell (1979)
1980	Clutha Catchment Water Allocation Plan provides a basis for multiple purpose planning.	Lonie (1984)
1981	Govt approved construction of high dam despite no legal water right. Scheme F (high dam) continued	Powell (1979)
1982	Faultline discovered beneath dam and spillways. Geologist Gerald Lensen resigned as risk was not being listened to by Central Government  Water right obtained due to the Clutha Development Empowering Act 1982. This fast track legislation overrode legal protection of land owners	Clutha Development Empowering Act (1982); Lonie (1987); Martin (1998)

1983	combination of engineering and environmental problems with lower power planning forecasted may limit development to one dam on the Clutha	Lonie (1984)
1984	Investigation report in December 1984 calculated that it would take approximately 130 years to fill the Cromwell Gorge and Kawarau River sections of Lake Dunstan. This was justified on the grounds that was approximately 1.3 million cubic metres of silt comes down the Kawarau River each year and there is 200 million cubic metres in volume available.	Hatton et al., (1987)
1986	Artesian water discovered beneath dam location prompting serious environmental concerns	Martin (1998)
1989	Landslide issues identified and dam capacity is reduced. ECNZ admitted that dam is cost ineffective	Martin (1998)
1992	Clyde Dam is commissioned, filling begins in stages	Mighty Clutha Blogspot
1993	Clyde Dam is completed	Lonie (1987)
1994	Clyde Dam is opened 23 April	Lonie (1987)
1998	Ngāi Tahu Claims Settlement Act	Ngāi Tahu Claims Settlement Act (1998)
1999	ECNZ changes name to Contact Energy	Mighty Clutha Blogspot

**Table 2:** Summary of social, environmental, economic and political trade-offs identified in through historical documents

Organisation	Social trade-offs	Environmental trade-offs	Economic trade-offs	Political trade-offs
Central Govt	<ul style="list-style-type: none"> <li>- Provided compensation to individuals who were required to move out of the Cromwell gorge including transplanting 2500 apricot trees (Macbeth-Dann, 2022).</li> <li>- Provided new land for the town (Powell, 1979)</li> <li>-Prime Minister Robert Muldoon (1975-1984) driving force behind the ‘Think Big’ epoch. Supporters of the Muldoon Government labelled themselves ‘Rob’s Mob’ (Te Papa Museum, 2022)</li> </ul>	<ul style="list-style-type: none"> <li>- Since investigations began in 1945, the first comprehensive environmental report was released in 1975. The hazard of landslides, fault lines or natural aquifers were not recognised in planning documents prior to the dam building (Powell, 1979).</li> </ul>	<ul style="list-style-type: none"> <li>- Monetary compensation directly to those individuals who were impacted by the building of the dam.</li> <li>- Provided boost in jobs to the market especially if the high dam option was accepted (which it was). Government controlled the design, construction, contract management and quality assurance of all civil, hydromechanical and architectural aspects (Hatton et al., 1987)</li> </ul>	<ul style="list-style-type: none"> <li>- The Clyde Dam Empowering Act was passed in 1982 to bypass protests and other planning difficulties.</li> <li>- Prior to this, the Clutha Interdepartmental Committee which made the decision on which dam was to be built was chaired by an employee of the Ministry of Works, despite the request for an independent regulator. (Lonie ,1984; Powell,1979)</li> </ul>
Regional Council	<ul style="list-style-type: none"> <li>-Loss of prime agricultural land</li> <li>- Lake Dunstan (60m above original levels) created for extra recreational activities</li> <li>-Lake Dunstan meant there was water to irrigate the Cromwell flats for further fruit growth (Fielding Star, 1917)</li> </ul>	<ul style="list-style-type: none"> <li>-investigations for Regional Council in 1984 noted that it will take approximately 130 years to fill the Cromwell Gorge and Kawarau River sections of Lake Dunstan. It has 200 million cubic metres in volume and there is 1.3 million cubic metres of silt that comes down the Kawarau River each year (Hatton et al., 1987)</li> </ul>	<ul style="list-style-type: none"> <li>- Compensated via monetary means to build new features for the town including Town Hall and indoor swimming pool (Powell, 1979)</li> </ul>	<ul style="list-style-type: none"> <li>-followed the political motives of the Central Government, risked losing their job if they spoke against the motives (Int 6_AT)</li> </ul>
Local Council	<ul style="list-style-type: none"> <li>-Protests against decisions of Central Government</li> <li>-Positive potential for Lake Dunstan to be a lake used for recreation (Powell, 1979)</li> </ul>	<ul style="list-style-type: none"> <li>-Had no weight in the outcome of the 1975 environmental report (Powell, 1979).</li> </ul>	<ul style="list-style-type: none"> <li>- Compensated via monetary means to build new features for the growing Town (Powell, 1979)</li> </ul>	<ul style="list-style-type: none"> <li>- followed the political motives of the Central Government, risked losing their job if they spoke against the motives (Int 6_AT)</li> </ul>
Ngāi Tāhu	<ul style="list-style-type: none"> <li>-The Clutha Mata-Au was one of the main routes of travel from inland to the coast. And fundamental in the operation of the Kai Tahu Mahinga Kai system (Mahinga Kai refers to places where food and other resources were gathered or produced) (Ellison, 2022)</li> </ul>	<ul style="list-style-type: none"> <li>-Beattie (pre-1840) identifies the plethora of mahinga kai or abundance of native plants and animals within the gorge</li> <li>- The rapids between the now top of Lake Dunstan to Clyde were named Otakihia (leading with a line or tracking a canoe), Te Wairere which is before the junction of the Kawarau and Clutha River and then below the junction the famous and most difficult rapid was Okura (Department of Mines, 1906)</li> </ul>	<ul style="list-style-type: none"> <li>- No compensation. Historical settlement had been agreed through the Treaty of Waitangi (1840)</li> </ul>	<ul style="list-style-type: none"> <li>- No evidence ‘X’</li> </ul>
Electricity Corporation New Zealand	<ul style="list-style-type: none"> <li>-Provided jobs for those in the Upper Clutha area (Powell, 1979)</li> </ul>	<ul style="list-style-type: none"> <li>-Built dam on top of Faultline</li> <li>-Plans developed for a fish hatchery</li> <li>-little information regarding environmental flows of the river when designing and implementing the dam (Lonie, 1984)</li> </ul>	<ul style="list-style-type: none"> <li>- Electricity Corporation of New Zealand responsible for the supply and installation of all equipment and owner of station. Full control over project management and operations as state owned enterprise (Hatton et al., 1987; Lonie, 1987)</li> </ul>	<ul style="list-style-type: none"> <li>-Originally a state-owned enterprise in 1987, ECNZ changes its name to Contact Energy in 1999. (Int 1_EG)</li> </ul>
Environmental Group	<ul style="list-style-type: none"> <li>-Concerns regarding the social impact on recreational activities such as kayaking were not listened to.</li> <li>-Rapids formed by remains of an ancient mine (Int 6_AT)</li> </ul>	<ul style="list-style-type: none"> <li>- 1977 Ministry of Works Clutha Power Development Flows and Design Floods (Jowett &amp; Thompson, 1977) where economic and social judgement was utilised but no mention of environmental impacts.</li> </ul>	<ul style="list-style-type: none"> <li>- Environmental reports focussed on the economic trade-offs of design floods (Jowett &amp; Thompson, 1977)</li> </ul>	<ul style="list-style-type: none"> <li>- Job loss if you did not follow the governments political agenda. (Int 6_AT)</li> </ul>
Landowners	<ul style="list-style-type: none"> <li>- Loss of land compensated with land outside of the gorge as well as opportunity for year-round irrigation</li> <li>-Orchardists claimed the soil outside the gorge was not as good for growing fruit.</li> <li>- Received new swimming pool, town hall and creation of Lake Dunstan (Macbeth-Dann, 2022; Powell, 1979).</li> </ul>	<ul style="list-style-type: none"> <li>- Landowners specifically in the gorge were asked to relocate elsewhere. Compensation occurred through transplanting 2500 apricot trees and monetary considerations.</li> <li>-Landowners were disappointed as soil was not as good outside of the gorge. One orchardist took soil out of the gorge to ensure growth of apricots (Kevin Jackson, 2022)</li> <li>- Cromwell Gap Rapids disappeared loss of kayaking</li> <li>-At the time of filling in 1992, 280 landowners were directly affected (Macbeth-Dann, 2022).</li> </ul>	<ul style="list-style-type: none"> <li>- Cromwell locals banned compensation negotiations with Ministry of Works in 1977. Once the Clyde Dam Empowering Act passed, they were required to relocate (Powell, 1979).</li> </ul>	<ul style="list-style-type: none"> <li>- Protests against the dam occurred in 1977 and the public vote no confidence towards the National Governments (Muldoon Government) Clutha Policy. (Martin, 1998; Lonie, 1984; Powell, 1979)</li> </ul>

**Table 3:** Summary of social, environmental, economic and political trade-offs identified in the interviews

Int ID	Organisation	Social trade-offs	Environmental trade-offs	Economic trade-offs	Political trade-offs
Int 1	Environmental Group	-Community values have not changed -lead to believe that nothing could be done to change the landscape -community recognises that there needs to be more done by Contact Energy and Council -working to focus on local values of iwi in the region	- Asked community what they would like to see, main response was increased amenity values such as increased swimming areas and access to the lake - would like to see a plan to manage the silt and lagarosiphon in Lake Dunstan - community would like to see the lake margins maintained/restored	- Contact Energy contribute \$50,000 NZD a year towards the management plan which is minimal. -responsibility lies on other actors to remove the weed. -historical consent conditions allow Contact Energy to store silt behind the dam.	- Restoration projects have started with funding from the Central Government via Jobs for Nature/ Shaping Our Future. -lost promises where a huge overspend occurred to build the dam as ‘things’ didn’t get implemented and then the change of ownership from ECNZ to Contact Energy occurred.
Int 2	Environmental Lawyer	-several ‘pretty cool’ rapids were drowned. -no regard given to the loss of recreational values -two new waves at the bottom of Hawea Lake as compensation for loss of natural rapids.	-tension between protecting indigenous fish over Trout and Salmon -Lake Dunstan does not act as a storage lake, which is what it was meant to be, rather it is a run of the river generation	- To mitigate the loss of the natural rapids, money to build a white-water feature on the Hawea River was granted. It was a success but does not replace what was originally lost because of the filling of the Gorge.	-The Clyde Dam Empowering Act (1982) is still in force today. - Otago Regional Council is the regulator so they have the most power.
Int 3	Researcher	-the river was once free-flowing, it was and easy to access -benefits created in the form of a lake. -affordances are multiplied -Te Mana o Te Wai is important in the development of the new Land and Water Regional Plan	-issues of lagarosiphon build up -issue of silt build up impacting recreational amenity -link to theory of ecological perception of how we perceive the environment around us (affordance)	- no accounting for recreation loss or gain in terms of amenity value -recreational values are an afterthought below economic productivity	-when physical attributes change there is an affect for the affordances. Outcomes are influenced by local politics. Recreation amenity values are required of the Environment Court
Int 4	Local Council	-community is upset about the silt build up. -drive to embrace iwi values as it is a missing part of the conversation. -need to get ahead of the tipping point by breaking old habits and ‘treating our water right’	-understand that the Kawarau Arm is turning back into a braided river has caused debate over further management and silt removal -since introducing water meters, the community has started to value their water usage.	- there is an infrastructure gap -Cromwell was compensated well as the Ministry of Works bought blocks of land for the new town centre which now benefits the community.	-Local Council must work closely with Land Information New Zealand (LINZ) and Contact Energy. Working with Ngai Tahu to assist the community to have the conversation about understanding the layers of meaning of Central Otago to push past historical political motives
Int 5 / Int 9	Public Service	-silt build up is a concern to those not aware that it was a feature of the development -removal of debris to increase aesthetic -change in perspective, and focus on advocacy	-historical ‘relic’ is the mining privileges in Otago -Lagarosiphon was in the rivers before the dam plays a key role in the ecosystem of the lake -orchardists and landowners did not want to be relocated -as the Kawarau Arm becomes narrow there are suggestions are boardwalks. It is the start of a new process in visual amenity	-clear at the start that Lake Dunstan was going to fill in with silt. -Contact Energy should have a much greater obligation to provide recreational amenity	-there is strong pressure from those people who were not involved in the early Clyde Dam consents for Contact to do more than they have done in the past. -Clyde Dam was built in the middle of ‘Think Big’ epoch. As such the priority was to provide power for the future.
Int 6	Adventure Tourism	-from a recreational view, the promises were not kept -the legacy of the Dam is not on the water -the recreation is almost zero	-no environmental feeling or empathy -need sediment flow to maintain ecological diversity	-it previously was a top-down approach of management. There was no budget, and the focus of the Dam was an economic development project	-big protest movement -friends had lost their scientific careers over the Cromwell Gorge. -‘Robs Mob’ no matter what the Prime Minister did, it was right.
Int 7	Contact Energy	-when the Dam was being built there was little environmental awareness -community engagement is important as well as understanding the history	-Kawarau Water Conservation order stopped any further development in the Kawarau River. This was implemented by Int 6_AT. -there were a lot of technical issues with landslides and the geology of the area	-the decision was made not to progress with further hydropower dams because cost > benefit -it is a run of the river dam so it is a natural process -there was a community fund that came out the decision-making process which the community benefits from	-Contact Energy inherited the Dam so it is a difficult management issue. There is an awkwardness for who looks after Lake Dunstan -Contact Energy use of Lake Dunstan is permitted through the lease from the Crown.
Int 8	Landowners	-there are cycling trails around Lake Dunstan which is a recreational benefit -the smell from the exposed mud flats when the lake is low is unpleasant	-Our first vineyard we had issues with the silt and used a bore hole to extract water for irrigation. -lots of driftwood over summer because of little rain which is not attractive for tourists -lots of volunteers working to clear up the lagarosiphon	-As winegrowers who planted first vines in 2000, there have been many economic benefits of the Dam that have changed the area.	-there needs to be cohesive management of the river involving Ngai Tahu especially when the Dam was built, the big picture was not taken into account
*	Central Govt	- building the Lake Dunstan Trail -provided jobs and economic security	- funding projects to increase biodiversity and restoration planting along the edges of Lake Dunstan	- funding projects to increase biodiversity and restoration planting along the edges of Lake Dunstan	-Three Waters Reform (2024)
*	Regional Council	X	X	X	-Land and Water Regional Plan expected 2024
*	Ngāi Tahu	-evidence of iwi narrative in the region via place names and recognition in local and regional council plans (Int 4_LC)	-loss of identity of ‘who we are’ (Ellison, 2022)	X	-No say in policies. Treaty of Waitangi (1840) marginalised any indigenous cooperation

**Table 4:** Historical Institutional matrix compiled from Table 1 & 2

<b>Institutional actors</b>	<b>Information</b>	<b>Control</b>	<b>Political payoffs</b>	<b>Environmental payoffs</b>	<b>Economic payoffs</b>	<b>Social payoffs</b>
Central Govt	High	High	1	1	1	1
Regional Council	Low	Low	0	0	1	1
Public Service	Low	Low	0	-1	1	1
Local Council	Medium	Low	0	X	1	1
Ngāi Tahu	Low	Low	-1	0	-1	0
Electricity Corporation New Zealand	Medium	High	1	1	1	1
Environmental Group	Low	Low	-1	-1	-1	-1
Landowners	Low	Low	-1	0	1	1

**Table 5:** Current Institutional matrix compiled from Table 3

<b>Institutional actors</b>	<b>Information</b>	<b>Control</b>	<b>Political payoffs</b>	<b>Environmental payoffs</b>	<b>Economic payoffs</b>	<b>Social payoffs</b>
Central Govt *	High	High	1	1	1	1
Regional Council *	High	Medium	1	1	1	1
Public Service	Medium	High	1	1	1	1
Local Council	Medium	High	1	1	1	1
Ngāi Tahu *	Medium	Medium	1	-1	1	1
Contact Energy	High	High	1	0	0	0
Environmental Groups	High	Medium	1	-1	1	1
Landowners	Low	Low	1	0	1	-1

**Table 6:** NPS results

		<b>response</b>				
<b>Interview ID</b>	<b>Organization type</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>
Int 1	Public Service	8	6	5	5	10
Int 2	Public Service	4	5	7.5	7.5	7
Int 3	Local Council	10	8	4	6	9
Int 4	Energy Company	8	10	10	10	10
Int 5	Environmental Group	7	2	1	10	2
Int 6	Landowner	1	5	1	7	1
Int 7	Environmental Lawyer	10	7	5	5	7
Int 8	Adventure Tourism	1	7	1	9	10
Int 9	Researcher	2	4	1	2	10

**Table 7:** Contextualised NPS results

<b>Question</b>	A	B	C	D	E
<b>Promoters</b>	0.2	0.1	0.1	0.3	0.5
<b>Detractors</b>	0.4	0.4	0.6	0.4	0.2
<b>Net Promoter Score</b>	-22	-33	-55	-11	33
<b>Interpretation</b>	Low involvement with other actors in the basin	Low knowledge of the trade-offs	low rating of significance of role in management of dam and trade offs	Majority not impacted by dam	Strongly agree that the past informs the future

## Appendix 2: Interview questions

### Guided qualitative questions

#### General

1. Could you please explain what your role is?

#### Environment

1. What are the environmental issues facing Lake Dunstan because of the Dam?
2. Expand on water quality and recreational amenity issues
3. What do you see as the future risks for water resource allocation in the Central Otago area?

#### Social

1. How has the community changed their values/norms since the building of the dam?
2. What is your perspective on the 'Think Big' era? Do you think history will repeat itself?
3. What do you perceive the highest social cost of the building of the dam? Good/bad

#### Political

1. What is your involvement with regional council, community?
2. Do you work closely together?
3. What changes would you like to see in future?

#### Economic

1. What are the economic impacts of the dam?
2. Who has the most power in implementing change in the region?
3. What is your perspective on the current governance structure?

#### Future Management

1. What are the gaps in the management of Upper Clutha river basin?
2. How do you think it should be managed in the future?

#### Closing

1. Do you know of anyone that you think I should speak to for further details that you may be able to put me in touch with?
2. Any further comments?

### Quantitative questions

**A: How much involvement do you have with other actors in the basin i.e council, public service or environmental groups?**

*On a scale: from 1 representing low, through to 10 representing high involvement*

**B: How much knowledge do you have of the economic, environmental and social trade-offs of the Clyde Dam?**

*On a scale: from 1 representing low knowledge, through to 10 representing high knowledge*

**C: How significant is your role in the management of the Clyde Dam and associated trade-offs?**

*On a scale: from 1 representing no significance, through to 10 representing high significance*

**D: How strongly has the Clyde Dam impacted you? (this can be economic, social, environmental)**

*On a scale: from 1 representing low impact, through to 10 representing high impact*

**E: How strongly do you agree that decisions that were made in the past effect future decisions of water resource management in Central Otago?**

*On a scale: from 1 representing strongly disagree, through to 10 representing strongly agree*