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Understanding the Co-evolution of Land, Water, and Environmental Governance in Victoria, Australia during 1860 – 2016

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Abstract

There are many cases where the changes in government interventions have resulted in considerable negative consequences to social-ecological systems (SESs) instead of promoting improvement. Difficulties occur in guiding governance change in order to steer SESs onto desirable pathways. However, the linkage between degradation of SESs and the failure of their governance remains unclear. In order to address this gap, this research aims to understand the co-evolution of land, water, and environmental governance through integration of policy into social-ecological system frameworks (SESFs). This research is presented into three chapters to answer the following three research questions:

Research Question 1: How does land, water, and environmental governance steer the SES condition?

Research Question 2: How have policy instruments for land, water, and environmental governance developed from 1860 to 2016 in Victoria, Australia?

Research Question 3: How have the policy instruments for land, water, and environmental governance co-evolved? Is there any association with biophysical changes?

Chapter 3 developed a SES framework by extending the SES frameworks proposed by Ostrom and Anderies (Anderies, John. M, Janssen & Ostrom 2004; Ostrom 2007). In the proposed framework, SES condition is viewed as the product of the accumulation of policy instruments used in land, water, and environmental governance to rule the interaction between and among components of biophysical and social systems. Policy instruments can help policy analysts explain the linkages between resources, resource users and public infrastructure providers and which has a significant role in enhancing the robustness of SES. The framework provides a new way to develop a wider recognition and appreciation of dynamic, site-specific biophysical and social system conditions in influencing the government intervention, and in turn have been shaped by them. In particular, the framework can help policy makers elucidate: (1) how the biophysical system has been understood in SES governance as represented by the relevant policy instruments; (2) how the social system has been set up in SES governance; and (3) how the synergies and trade-offs between the biophysical and social systems have been managed in

the governance of the SES. It can help for systematically analysing SES governance through the configuration of policy instruments.

Chapter 4 used the proposed framework to investigate the evolution of policy instruments used in the land, water, and environmental governance in Victoria, Australia. The content analysis of Victorian Acts related to land, water, and environment practices between 1860-2016 was conducted. The investigation found that policy instruments to manage the behavior in resource utilization (substantive and procedural policy instruments) did not vary. However, they were differences in the circumstances in which they were implemented, in this case, differing interactions among components of the biophysical and social systems. The policy instruments held a particular focus in managing components of SESs in different periods and the evolution of each policy instrument has its own pathway. Four regimes were identified in the evolution of policy instruments used in water governance: reserve, authority, information and integration regimes. Whilst, policy instruments used in land governance experienced three regimes (authority, information and integration regimes) and policy instruments used in environmental governance experienced two regimes (information and integration regimes).

Chapter 5 associated the co-evolution of land, water, and environmental governance and biophysical changes. The co-evolution was analyzed by unpacking the integration of policy instruments used in land, water, and environmental governance. The integration was analysed by examining the relationships between SES components covered in policy instruments. Represented by the subtle changes in their integration, the analysis showed the Victorian government's learning process in adapting and accommodating the natural system and its desire to avoid significant negative impacts in land, water and environmental conditions has resulted in the inclusion of the dynamic interaction within SES as the consideration in formulating its policy instruments. Comparing the co-evolution of policy instruments used in land, water, and environmental governance with state-wide changes within the biophysical system, it is found that there is a strong association between the integration of land, water, and environmental governance and the change in SES condition in Victoria during 1860 -2016.

This longitudinal study of Victoria land, water, and environmental governance developed a new way to explain the linkage between natural resources governance and SES condition. Re-constructing government intervention through policy instruments implemented in land, water, and environmental governance, the study found the way policy instruments were designed and

implemented varied with the state of understanding of the dynamic interactions within the SESs. Looking back over Victoria's history in developing policy instruments used in land, water, and environmental governance, the study suggests that policy instruments should be formulated to address the interactions among components within SES - policy instruments as managers of interaction within SES. This is crucial to steer SES condition onto desirable condition.

Declaration

This is to certify that:

1. this thesis comprises only my original work towards the degree of Doctor of Philosophy,
2. due acknowledgment has been made in the text to all other material used,
3. the thesis is fewer than 100,000 words in length exclusive of tables, maps, bibliographies and appendices

Rr. Ratri Werdiningtyas

Melbourne, November 2019

Preface

All the work presented in this thesis is original and was conducted by the candidate during her Ph.D. candidature from 2015 to 2019. This research was supervised by Assoc. Prof. Yongping Wei from the University of Queensland and Prof. Andrew William Western from the University of Melbourne.

A list of publications produced based on the study are given below.

JOURNAL

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- Ratri Werdiningtyas, Yongping Wei, Andrew Western, 2019. The Evolution of Policy Instruments Used in Water, Land, and Environmental Governance in Victoria, Australia during 1860 – 2016. *Environmental Science and Policy* (under review)
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Chapter 1

Introduction

1.1 Background

Natural ecosystems typically respond to perturbations in a way that avoids major changes to their characteristics without human intervention. That is, they vary around and tend to return to some typical condition (Scheffer 2009; Scheffer & Carpenter 2003). However, the global human population has been growing, putting additional pressure on nature to maintain healthy catchment systems (Broderick 2005; Goudie 1981; Link et al. 2017; Will, Paul & John 2007). Globally, over two thirds of catchment systems have been degraded due to human intervention. It is acknowledged that the degradation of land, water and other environmental systems is linked with the failure of their governance (Acar 2017; Young, OR 2002). Thus, urgent action is required to improve human's capacity to govern these natural resources now, and in a future, dominated by socio-economic and climatic change (Ekstrom & Young 2009; Foerster 2011; Mitchell 2005; Rouillard et al. 2013; Thomas, Elinor & Paul 2003).

When considering how natural resource governance might be guided towards ensuring social-ecological systems (SES) are set on desirable pathways several difficulties can be identified (Bason 2014; Petit 2016; Richard 1992; Thiel 2015; Wildavsky & Peters 2017). In a number of cases, changes to governmental resource management policy has resulted in considerable negative impacts on the whole SES instead of the promotion of sustainable conditions (Docker & Robinson 2013; Dovers 2000; Young, A 2000). In order to ensure that sustainable SES conditions are being met, governments need guidance to improve policy creation and implementation around land, water and environmental governance.

In most cases, natural resource governance is shaped by reactions to environmental problems that have already arisen, instead of preventative attitudes around influence or management (Bingeman, Berkes & Gardner 2004; Borrás & Edquist 2013; Salamon & Elliott 2002; Sterner & Coria 2012). Thus, most policy instruments, such as license, permit, management boundary, rule, user, plan, institution creation, developed by governments aim to cope with specific problems at a particular point in time. Governments often have a tendency to leave things until they reach a crisis point and as problems change, the policy instruments lag behind the problem (Department of Water Resource Victoria 1988). Governments are therefore challenged to accurately define problems in order to prescribe appropriate policy instruments (Linder, S, H. & Peters 1989; Linder, SH & Peters 1988). This is critical for the development of sustainable natural resource governance.

Understanding land, water and environmental governance cannot be achieved for each resource in isolation (Walker, J, Dowling & Veitch 2006; Wallis, RL & Robinson 1991). A policy instrument used in the management of one resource could affect the management of other resources, even if that instrument does not interact specifically with a policy instrument for another resource. For instance, a number of policy instruments in forest protection policy that are primarily aimed at maintaining a healthy forest ecosystem could also result in improved watershed management and biodiversity (Colin 1998; Farley, Jobbágy & Jackson 2005; Hogl, Kleinschmit & Rayner 2016). In contrast, policy instruments implemented in land governance can induce massive land clearance, which could give rise to negative impacts on water systems (Farley, Jobbágy & Jackson 2005; Fay, Erickson & Allan 1997; Raini 2009; Zhang, Dawes & Walker 2001). Due to the interconnected nature of natural resource management, if one or more resources is overused or undervalued, it could result in the state of the whole SES losing its equilibrium (Scheffer 2009; Scheffer & Carpenter 2003). Policy instruments implemented in the governance of land, water and the environment are a nested phenomenon (Howlett, Michael 1991). In other words, human interventions directed by policy instruments in the case of land, water and environmental governance may not only change the conditions of the targeted resources, but also create “downstream” impacts on other resources, and on the whole system.

In addition to the problem of interconnectedness between natural resources themselves, the other most challenging issue in resource governance is dealing with the increasing scale of and interrelations between actors or various stakeholders. These include both resource users and the public infrastructure providers responsible for managing the resources, all of whom are

involved in social systems where managing the trade-offs amongst them becomes imperative to effectively governing the use of the resources (Christiansen & Bunt 2014; Grimble & Wellard 1997; Wallis, P. J. & Ison 2011). Policy instruments used in land, water and environmental governance need to be arranged so that the values and interests of different actors can be accommodated, and contradictory outcomes amongst them can be avoided (Borrás & Edquist 2013; Bressers & O'Toole 1998; Flanagan, Uyarra & Laranja 2011). In designing policy instruments used in land, water and environmental governance, the capacities of policy instruments to respond to the complex interactions of components within the SES need to be considered. There are increasing literature in econometrics on modelling the endogeneity of a policy (Gunawardena et al. 2018; Lorenzo, G.B. & Rosaria 2009; Nicolaisen et al. 1991), however, most of them consider bio-physical changes as dummy variables or using a very simple representative, which could not comprehensively reflect the change of bio-physical systems. In addition, only the impact of some policy instruments can be simulated by econometric models, and in most cases, these models are too complicated to be directly used by natural resources managers.

The development of socio-ecological system frameworks (SESF) in the last three decades has been motivated by the need for greater understanding of the linkages between governance and SES (Anderies, John M. & Janssen 2013; Anderies, John. M, Janssen & Ostrom 2004; Anderies, J. M. et al. 2007). The SESF literature has provided a diagnostic approach that examines SES by structuring issues, problems or conditions of SES (Thiel, Adamseged & Baake 2015; Werthmann 2015). However, the potential of governance to make or break social-ecological traps or steer SES onto desirable pathways remains unclear in the current SESF model (Thiel, Adamseged & Baake 2015). Little is known about the interplay: how the condition of land, water and environment systems has been shaped by their governance and how the governance in turn has been shaped by the condition of the natural resource.

In natural resource governance, policy instruments affect the behaviour of actors in their interactions with land, water and environment systems and their ability to cope with problems and changing conditions (Howlett, Michael 2005, 2010; Ostrom 1990; Sterner & Coria 2012). Problems related to land, water and environment systems are complex and interconnected and can rarely be solved by a single policy instrument (Briassoulis 2005; Flanagan, Uyarra & Laranja 2011; Hogl, Kleinschmit & Rayner 2016; Rouillard et al. 2013). Across the world, a selection of policy instruments (policy mix) has been used to cope with intertwined problems

related to land, water and environment governance (Borrás & Edquist 2013; Howlett, Michael 1991, 2010; Sterner & Coria 2012). Additionally, policy instruments are specific to the cultural context, and when the scope of analysis is extended to examine a longer period of time their change is deeply embedded in the historical context (Foerster 2011; Mahoney & Thelen 2010; Marshall & Alexandra 2016). The same policy instrument can produce different outcomes when it is implemented in different biophysical and social contexts (Borrás & Edquist 2013; Ingold et al. 2018; Knieper et al. 2010; Linder, S. H. & Peters 1989; Mukhtarov et al. 2015). Understanding the efficacy of multiple policy instruments in the management of SES requires a systemic approach using a long-term framework rather than a partial short-term analysis. There is still a lack of knowledge on how a policy instrument can be effectively improved when regarding its relationships with other previous and existing policy instruments (Collins & Ison 2009; Dovers 2001; Foerster 2011; Juhola et al. 2016; Peter 1981; Richard 1992; Thiel 2015).

Together, policy instruments and SES have played important roles in the theoretical development of resource governance systems. These tools, however, have generally been considered in isolation from one another. Examining the interstices between these two fields encourages an elaboration of the extent to which the policy instruments implemented in land, water and environmental governance can be considered a core mechanism in changing SES conditions through their co-evolution. Differentiating the policy instrument function in land, water and environmental governance and its association with the changes in SES would appear to be a highly promising approach to understanding their interlinkages.

In this thesis, Victoria, Australia is chosen as a case study. Massive changes in the Victorian landscape (land, water and environment systems) from 1860 to 2016 are a reflection of human intervention regulated by policy instruments as these systems have been occupied and natural resources have been utilised by the state.

1.2 Research objectives and questions

The overall aim of this study is to understand the co-evolution of land, water, and environmental governance through integration of policy and social-ecological system frameworks. There are three specific objectives and related research questions which will be used to achieve this overall aim. They are as follows:

Research Question 1: How does land, water, and environmental governance steer the SES condition?

A conceptual framework, which allows policy instruments to be examined within the SESF, has been developed by extending the current SESF proposed by Anderies and Ostrom (Anderies, John. M, Janssen & Ostrom 2004; Ostrom 2007). In land, water and environmental governance, policy instruments affect human perceptions and behaviours with regards to resource utilisation. Thus, the conditions of the SES depend on the interactions between policy instruments used in land, water and environmental governance to influence all components of the biophysical and social systems. To understand the dynamic and complex interactions between SES conditions and governance, the framework aims to ensure that every policy instrument used can be presented and assessed alongside all other instruments within SES context rather than as a singular entity. This would provide for wider recognition and appreciation of the dynamics of biophysical and social system conditions in influencing governmental interventions, and how these interventions have, in turn, been shaped by them. In particular, the framework is deliberately designed to recognise the condition of each SES component and how it relates to the conditions of other components.

Research Question 2: How have policy instruments for land, water, and environmental governance developed from 1860 to 2016 in Victoria?

Using the framework established in Research Question 1, the second objective of this thesis is to investigate how policy instruments used in Victorian land, water and environmental governance have been developed to steer the SES conditions through its evolution. Policy instruments are tools designed to allow governing bodies to cope with problem and targeted goals. As problems and resource governance objectives related to land, water and environment management change over time, policy instruments also change. Every policy instrument has its own pathway in affecting change, which is deeply embedded in historical context. To understand the evolution of policy instruments used in land, water and environmental governance in Victoria, a longitudinal study of each policy instrument was conducted to track its evolution. Policy instruments were extracted from Victorian Acts related to land, water and environment practices enacted from 1860 to 2016. Content analysis of separate Acts was conducted to understand how policy instruments in the context of governance SES have evolved.

Research Question 3: How have the policy instruments for land, water, and environmental governance co-evolved? Is there any association with biophysical changes?

The third research question attempts to elaborate the co-evolution of policy instruments used in land, water and environmental governance and changes to land, water and environmental conditions. This thesis conducts three analyses to answer the third research question: (1) analysing the co-evolution of land, water and environmental governance; (2) collating and analysing data on biophysical changes in Victoria; and (3) analysing the association between the co-evolution of land, water and environmental governance and the change in biophysical conditions. To understand the co-evolution of land, water and environmental governance and the condition of natural resources, the integration of policy instruments in these three interdependent resources was analysed. Changes in biophysical condition were represented by changes in land cover, land use, water resource condition and environmental water. In addition, population and drought occurrences were also included as external perturbations, which led to increased pressure on SES conditions.

1.3 The structure of the thesis

This thesis consists of six chapters. It begins with a general introduction (Chapter 1) followed by a literature review (Chapter 2). Chapters 3 to 5 address the three research questions listed above separately and are presented in the format of journal publications. Therefore, in Chapters 3 to 5, each chapter contains further research questions that can be integrated into the overall objective of this study. These chapters have their own literature reviews and methods that are relevant to the particular research questions in each chapter. Finally, general discussion and conclusions relating to the study's overall objective have been provided in Chapter 6, which is also the closing chapter.

Chapter 2 presents a review of the relevant literature to develop a strong theoretical background for investigating the association between resource governance and SES conditions. This chapter details resource governance theories and the challenges of resource governance to accommodate the complex dynamic of SES. The review also examines the previous literature, which attempts to acknowledge the complexities involved in SES governance. Finally, the insights and shortcomings found in the literature, in the context of the thesis objectives, are highlighted to define the knowledge gaps existing in land, water and environmental governance and the ability of governance to steer SESs towards desirable conditions.

Chapter 3 provides a foundation for the thesis through establishing a new SES framework by extending the existing SESF model. The framework was designed to address the limitations of the current SES frameworks in explaining the relationship between dynamic conditions of biophysical and social system components and changes in resource governance. In the proposed framework, policy instruments are situated within the SESF as ‘managers’ of the interactions among and between components of biophysical and social systems. The framework established in this chapter provides the basis for understanding changes in land, water and environmental governance through policy instruments and SES condition, which will be discussed in the subsequent two chapters.

In Chapter 4, based on the framework developed in Chapter 3, policy instruments used in land, water and environmental governance were analysed to understand how the dynamic interactions between biophysical and social systems have been managed in Victoria between 1860 and 2016. Through a content analysis of Victorian Acts related to land, water and environmental practice, four regimes were identified: reserve, authority, information and integration regimes. Policy instruments can be differentiated based on consideration of the interactions among components of the biophysical and social systems. The regimes point out the circumstances under which interactions among components of biophysical and social systems deserve attention as contributory shapers of policy instruments. The policy instruments identified in this chapter are then used as data to analyse the co-evolution of policy alongside natural resource conditions in SES governance.

In Chapter 5, the co-evolution of policy instruments identified in Chapter 4 is analysed before it is collated with changes to Victoria’s biophysical conditions. This chapter shows that there was a strong association between the co-evolution of land, water and environmental governance and the journey of SES conditions in Victoria. These findings provide empirical evidence that changes to each component of the biophysical system (land, water and environment), and changes to their governance have their own pathways but are interlinked over time. Represented by the subtle changes in this co-evolution, it is demonstrated that the learning processes of the Victorian Government has adapted to accommodate natural systems. The government’s desire to limit significant negative impacts on land, water and environmental systems through human intervention has resulted in the inclusion of dynamic interactions

within SES as a primary consideration in formulating policy instruments in land, water and environmental governance.

Chapter 6 provides a final discussion and the conclusion of this study. It integrates the results from Chapters 3 to 5 and discusses the broader implications of all individual chapters in the context of the study objective. The findings of the research are outlined against the thesis objectives. The study suggests that to steer SES towards a sustainable condition, there is a need to change the government mindset in formulating policy instruments. Policy instruments ought to be prescribed as ‘managers’ of interactions within the SES instead of as external problem solvers. In order to achieve this, each policy instrument should consider, and be aimed at, leveraging the interactions between the components of biophysical and social systems in which they operate. Integrations in land, water and environmental governance can be built if every policy instrument considers all related objects, goals and actors, integrates the procedure in the implementations of policy instruments, and uses integrated data and analysis in its implementation. Finally, future research directions are identified at the end of the chapter.

Chapter 2

Literature Review

2.1 Introduction

Improving social-ecological system (SES) governance requires an understanding of how complex interactions between components of biophysical and social systems have been regulated in the past and present. For SES within water catchments, the status quo condition of land, water, and environment is not only a product of nature but also the accumulated impacts of the previous land, water and environmental practices as moderated by governance systems. This chapter examines the literature which paints a picture of the complexities of SES governance. The insights and shortcomings found in the literature, in the context of the thesis objectives, are highlighted to define the knowledge gaps existing in the known research to improve the capacity in land, water, and environmental governance.

Section 2.2 investigates governance responses towards land, water, and environment and their interdependencies. Section 2.3 examines how governance has been understood in contributing to SES conditions within the broader SES framework (SESF). In Section 2.4, studies of the policy process (which translates problems into solutions) are examined. Then, mechanisms for designing policy instruments and their use to steer SES onto desirable pathways are reviewed. Approaches for policy instrument integration in the areas of land, water, and environmental governance is discussed in Section 2.5. The condition of land, water, and environmental governance in Victoria as the case study in this thesis is described in Section 2.6. Finally, in Section 2.7, the gaps in the literature are summarised.

2.2 Land, water, and environmental governance

2.2.1 Interactions between land, water, and environmental conditions

Without human intervention, nature has an inherent capacity to reverse negative environmental conditions without creating regime shift (Scheffer & Carpenter 2003). However, population growth and the associated increase in resource utilisation has created additional pressure on nature (Goudie 1981; Scheffer 2009; Steffen 2009; Will, Paul & John 2007). Human intervention has passed the tipping point for natural systems in some parts of the world, leading

to permanent and irreversible change (Dovers 2000). There is now much evidence of regime shifts occurring in natural systems (Scheffer 2009; Scheffer & Carpenter 2003). Globally, over two thirds of catchment systems have been degraded, with large, usually negative, impacts on the capacity to supply ecosystem services.

In the catchment SES, land, water, and environment are interrelated resources (Hornberger et al. 1998; Walker, J, Dowling & Veitch 2006). Evidence has shown that clearing of catchment areas and riparian vegetation has substantially changed the evapotranspiration and infiltration rate, influencing the water balance in the catchment. Large-scale vegetation clearing results in transformative changes to river catchments (Walker, BH et al. 2009; Walker, J, Dowling & Veitch 2006). However, the impact of land use changes on hydrologic condition differs between areas. It depends on the scale of such disturbances, the distribution of different land uses coupled with the connectivity and continuity of drainage routes.

Moreover, land use change is often associated with water use change, which in turn can have feedback effects on the catchment's biophysical system (Elmhagen, Eriksson & Lindborg 2015). A decision to create a new residential, commercial, or agricultural area will create increasing water demands to support the activities in that areas. The construction of dams to boost agricultural production results in the alteration of water flow patterns (Middelkoop et al. 2001). However, for countries located in dry climates like Australia, water resources will determine the ultimate limits of physical developments. Thus, the conditions of the water balance also may trigger or limit land use change.

Increasing water demand creates pressure on both surface and ground water. Massive water exploitation and the attempts to change its nature is associated with the poor ecosystem conditions (Davies et al., 2010), which eventually reduce its capacity to support human activities (Colin 1998; Scheffer 2009; Scheffer & Carpenter 2003). In an area which depends on surface water, water users in the catchment typically divert water directly from river flows (regulated or non-regulated water diversion) creating substantial and large negative effects on ecosystems as the river flow regimes are altered (Dovers 2000; Pittock & Connell 2010). In the same way, ground water exploitation can create several problems such as water sea intrusion, land subsidence and reduced water for groundwater dependent ecosystems (White et al. 2016). Moreover, research into the impacts of vegetation clearance and excessive water exploitation indicates their significant influence on salinity problems (Brown & Lubchenko

1990; Goode 2013). Moreover, according to Sala et al (2000), land use changes associated with their impacts on hydrology are the most important drivers of global ecosystem change after climate change. It changes the structure and function of ecosystems which, in turn, affects the ecosystem services.

Ecosystem responses to management and other disturbances are highly varied and depends on the feedback within the system. Changes vary from reversible changes where the ecosystem recovers when the disturbance is removed to sharp changes where the systems transitions to a new regime as presented in Figure 2.1 below (Sclar, Volavka-Close & Brown 2013). Figure 2.1A shows linear shifting caused by perturbation given to the system, and Figure 2.1B shows the condition where a non-catastrophic event crosses the tipping point, but the system still recovers when the disturbance is removed. In contrast to cases A and B, Figure 2.1C expresses non-linear shifting. It shows that changes and conditions are bonded together to create new alternative states.

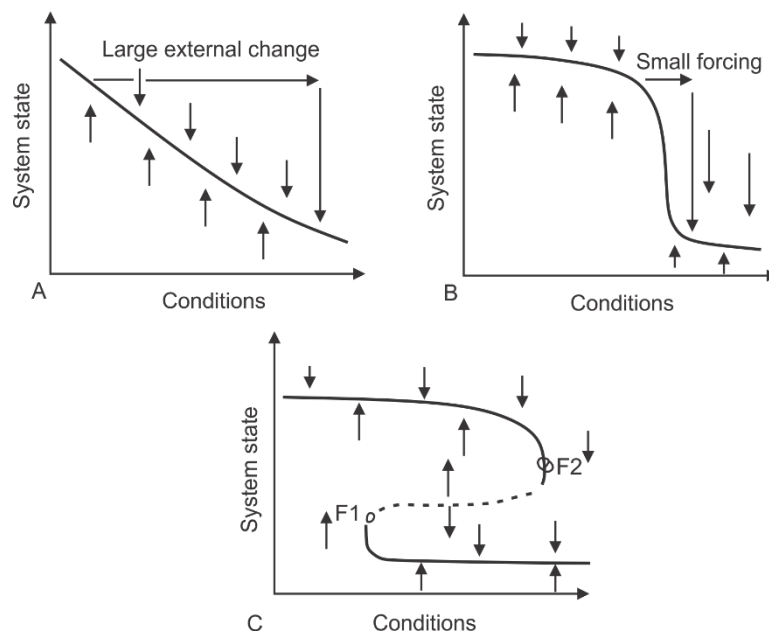


Figure 2. 1 Transition in equilibrium state: response to different types of perturbations. A. Affecting an almost linearly responding system; B. Across a non-catastrophic threshold; C. Across a catastrophic bifurcation threshold to alternative stable state (a critical transition). (Sclar, Volavka-Close & Brown 2013)

The magnitude of the changes caused depends on the conditions of the biophysical systems (Acar 2017; Adams & Pressey 2014), as well as social systems and their governance (Baker, Murray & Agyare 2018; Ekstrom & Young 2009). The conditions of components of the

biophysical and social systems are context specific. For example, the magnitude of drought impact on the condition of land, water and environment will be different between arid, semi-arid and humid areas or between developed, developing or under developing countries (Acar 2017). Resource and their actors differ between regions in their characteristics, capacities, and vulnerabilities to cope with the hazards. As a consequence, their response to perturbation would be also different. In this case, pareto optimization is context specific and dependent on the conditions of actors and resources.

2.2.2 Governance response to problems related to land, water, and environment in catchment SES

In recent decades, catchment degradation has pushed humans to re-think their approach towards resource utilisation. Catchment degradation has received much political and scientific interest as the cost to reverse catchment degradation (for example, decline in land productivity as the result of soil salinity, decline in the quality of water resources) is high and tends to mount up when the degradation rate cannot be reduced (Blaikie, Brookfield & Allen 2015; Colin 1998; Department of Water Resource Victoria 1988).

Water catchments have been regarded as biophysical entities governed by hydrological processes – areas from which rainfall flows into a river (Smith & Stopp 1978). However, when it is related to the activities within the area, catchments encompass the sum of human interventions on land, water, and environmental conditions (Hatfield-Dodds 2006; Mostert, Craps & Pahl-Wostl 2008; Pahl-Wostl et al. 2010), combining both planned intervention and human intervention impacts. Both new interventions and the impacts of previous interventions have intended or unintended consequences on land, water, and environmental conditions due to the nature of their interrelationship in catchment systems (Baker, Murray & Agyare 2018; Bärlund, Lehtonen & Tattari 2005; Kiczko, Romanowicz & Osuch 2011; Prishchepov et al. 2012).

Interventions into resources – for example water resource development (e.g. dam construction), environmental water regulation, changes in land tenure, ownership, and dominant use – can trigger significant changes in related governance systems, because these changes often result in fundamental changes to governance objectives. As interdependent resources, large changes

in one resource (e.g. dam construction) will not only be followed by changes in the water governance system but also influence land and environmental governance as it triggers changes in land and environmental conditions. Analysis of land, water, and environmental governance needs to accommodate these dynamic changes both in physical conditions and their governance.

Despite the interrelationship between land, water, and environmental conditions, most of the authorities responsible for their governance have traditionally been set up with mandates for only a single resource. Hence, different authorities are responsible for land, water resources, and environment respectively. The overlap in responsibilities without awareness of or cooperation with other agencies responsibilities has resulted in counter-productive actions among them (Heathcote 2009). In addition, the approach generally taken in land, water, and environmental governance is to cope with specific problems (incremental or reactive approach) instead of avoiding problems in the first place (preventative or holistic approach). A reactive approach to dealing with problems makes governance solutions an ‘end point’ (Christiansen & Bunt 2014), assuming that the social and biophysical systems to which policy is applied is a stable system. As a consequence, to cope with problems related to land, water, and environment, most governance authorities conduct actions incrementally rather than in an interconnected way to promote wider sustainability goals. This phenomena is explained by Schlüter et al. (2010) in their attempts to explain the linkages among actions in water management to cope with extreme events and the ecosystem demands for water in Uzbek. Schlüter et al. (2010) argue that two interventions are linked when one produces an institution (i.e. law, rule, regulation, etc) or an operational outcome that influences the other (in a series or process). In contrast, interventions that are conducted in parallel do not always take linkages or interactions with one other into account. The Uzbek water management’s attempts to cope with extreme events illustrates how interventions can roughly be divided into two parallel strands – coping processes and reform processes – which operate separately from each other (see Figure 2.2). The conditions for Uzbek water management is one example of common governance responses where a problem has been coped with via multiple interventions.

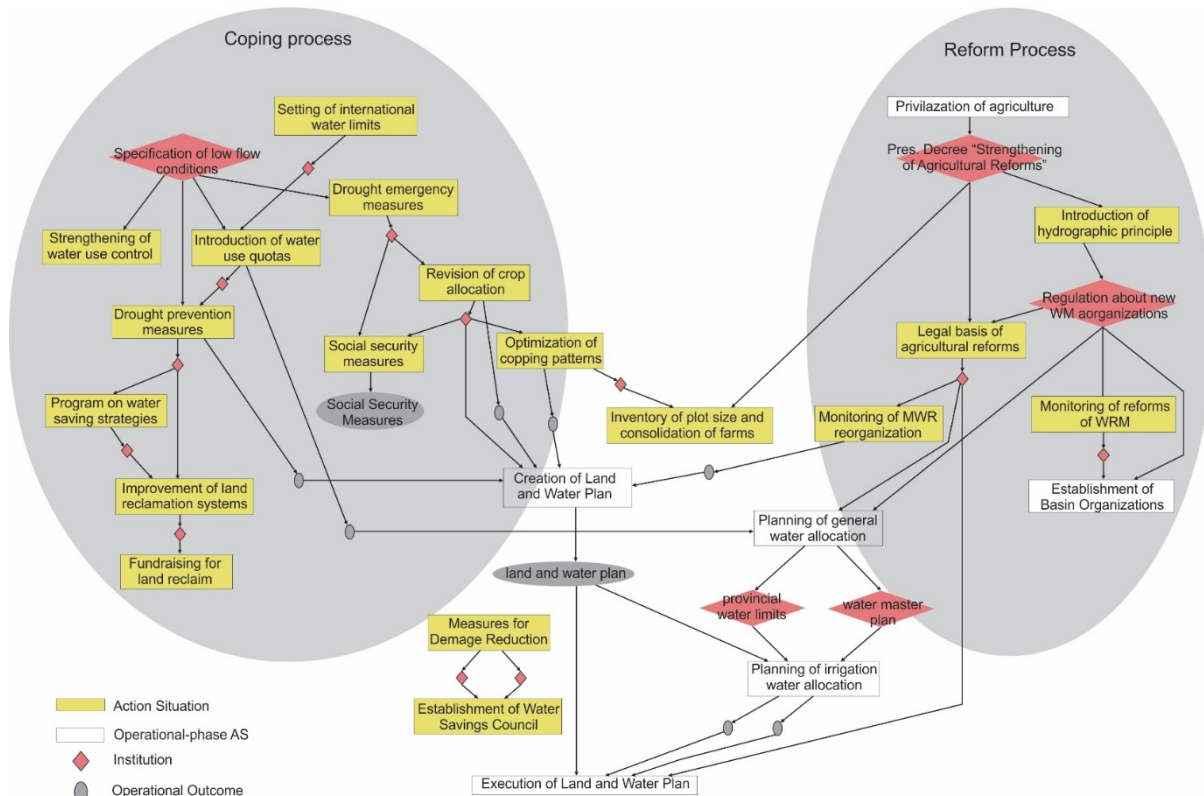


Figure 2. 2 Action situations of the “Coping with extreme events” policy processes and their linkages through institutions and operational outcomes in Uzbek water management (Schlüter, Hirsch & Pahl-Wostl 2010)

Thus, it becomes necessary to take into account the role of policy processes in translating problems into government interventions (Kisser & Ostrom 1982). The lack of government understanding of the interdependency between land, water, and environment in their interventions has resulted in common issues in resource governance (Department of Water Resource Victoria 1988). First, in most cases, governance institutions see their ‘problems’ as things that happen to them rather than things that they can influence or manage. As a consequence, the interventions conducted tend to lag behind the system changes as interventions focus on narrow outputs rather than wider sustainability goals. The current focus is mostly on short-term gains rather than on long-term issues. Governance approaches tend to leave things until they reach crisis point. To an extent, this is due to the government preference towards maximising resource utilisation for short-term benefit instead of optimising resources utilisation for long-term – a reflection of a lack of understanding of the nature of environmental systems in their policy making. The common government way of thinking is that resource conditions need to be prescribed according to what is set in their governance framework,

instead of prescribing or adapted governance frameworks to accurately reflect resource conditions.

In addition, as the problems and conditions change, the approach of government interventions also changes. For example, in investigating human water interaction by tracing the balance in water utilisation between agriculture and the environment over the last 100 years, Kandasamy et al. (2014) argues that government approaches in resource management have evolved like a ‘pendulum’ which swings between environmental and economic values. Thus, resource governance is perceived as bound by the conceptualisations and judgements of human/political agreements as to what constitutes an improvement (through certain actions) for the ‘problem’ as defined by the government. The approach in government interventions to cope with these interrelated land, water, and environment conditions is an important aspect of the system.

The development of a social hydrology model has been triggered by the need to understand and predict the dynamics and co-evolution of coupled human–water systems (Lu et al. 2018, Troy et al. 2015). To make hydrological prediction requires not only models that are robust to non-linear change of hydrological systems but also understanding the interactions between hydrologic and social subsystems within the overall system and how they co-evolve (Sivapalan et al. 2003; Thompson et al. 2013). Many studies have confirmed the role of gender (Baker et al. 2015), human agency (Ertsen et al. 2013), norms and values (Roobavanna et al. 2017), and cultural politics (Boelens 2014) in shaping social responses to change in hydrological systems. However, there is still lack of understanding of the role of governance, which significantly influences and is influenced by social responses to deal with changes in hydrological systems. As land, water, and environmental conditions are interlinked, the actions implemented in terms of governance to cope with changing conditions and problems need to take these interactions into account. Little is known about how the interactions between land, water, and environmental conditions have been shaped by governance effects and, in turn, shape governance effects.

2.3 Understanding land, water, and environmental governance within a social-ecological system framework

In the previous section, it was explained that resource governance needs to take into account the specific resource’s conditions including interdependencies with other resource conditions.

In the literature, there is considerable evidence of a relationship between impaired social ecological system (SESs) and failures in governance. To reverse catchment degradation, it is important to understand the linkage between land, water, and environmental conditions in their governance. The governance systems in the resource management field has been investigated in an attempt to improve SESs (Duit et al. 2010; Ebbesson 2010; Ekstrom & Young 2009; Folke et al. 2005; Koontz et al. 2015). However, the way in which governance impacts or is impacted by SESs is unclear (Araral 2013). In this section, the framing of resource governance in the SES literature will be explored and how the SES frameworks can help policy makers in their attempts towards sustainable resource governance will be elaborated.

2.3.1 SES framework

The development of the social-ecological system framework (SESF) in the last three decades has highlighted the need for greater understanding of human-nature interactions in SESs. Figure 2.3 shows that dynamic interactions between resources, resource users, resource systems and governance systems are the core of Ostrom SES framework. Such system dynamics are sensitive to external changing conditions and play an important role in directing outcomes (Ostrom 2007). The outcome can also be explained in the Institutional Analysis and Development Framework (IAD) by identifying and structuring the situation around actions and resulting outcomes (Ostrom 2011). Ostrom (2011) specifically defines the situation as including:

“(i) the set of actors, (ii) the specific positions to be filled by participants, (iii) the set of allowable actions and their linkage to outcomes, (iv) the potential outcomes that are linked to individual sequences of actions, (v) the level of control each participant has over choice, (vi) the information available to participants about the structure of the action situation, and (vii) the costs and benefits.”

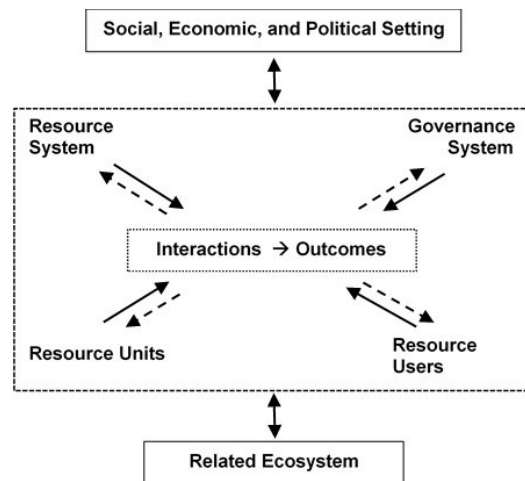


Figure 2. 3 Ostrom's Social Ecological System (Ostrom 2007)

By transforming the situation into variables that shape individual behaviour across the three tiers (see Figure 2.3), the Ostrom SES framework provides a diagnostic approach which seeks to disaggregate environmental issues, identify problems that are significant from a problem-solving perspective and reach conclusions about SES conditions (Thiel, Adamseged & Baake 2015). The framework classifies hierarchically resource systems, resource units, actors, governance systems, and social-ecological political settings (see Table 2.1) based on a set of collectively agreed upon rules (Basurto & Nenadovic 2012).

Table 2. 1 Three-tier variables in framework for analysing an SES

Social, Economic, and Political Setting (S)	
S1-Economic development. S2- Demographic trends. S3- Political stability. S4- Government settlement policies. S5- Market incentives. S6- Media organization.	
Resource System (RS)	Governance System (GS)
RS1- Sector (e.g., water, forests, pasture, fish)	GS1- Government organizations
RS2- Clarity of system boundaries	GS2- Non-government organizations
RS3- Size of resource system	GS3- Network structure
RS4- Human-constructed facilities	GS4- Property-rights systems
RS5- Productivity of system	GS5- Operational rules
RS6- Equilibrium properties	GS6- Collective-choice rules
RS7- Predictability of system dynamics	GS7- Constitutional rules
RS8- Storage characteristics	GS8- Monitoring & sanctioning processes
RS9- Location	

Resource Units (RU)	Users (U)
RU1- Resource unit mobility	U1- Number of users
RU2- Growth or replacement rate	U2- Socioeconomic attributes of users
RU3- Interaction among resource units	U3- History of use
RU4- Economic value	U4- Location
RU5- Size	U5- Leadership/entrepreneurship
RU6- Distinctive markings	U6- Norms/social capital
RU7- Spatial & temporal distribution	U7- Knowledge of SES/mental models
	U8- Dependence on resource
	U9- Technology used
Interactions (I) Outcomes (O)	
I1- Harvesting levels of diverse users	O1- Social performance measures (e.g., efficiency, equity, accountability)
I2- Information sharing among users	O2- Ecological performance measures (e.g., overharvested, resilience, diversity)
I3- Deliberation processes	O3- Externalities to other SESs
I4- Conflicts among users	
I5- Investment activities I6- Lobbying activities	
Related Ecosystems (ECO)	
ECO1- Climate patterns. ECO2- Pollution patterns. ECO3- Flows into and out of focal SES.	
(Ostrom, 2007)	

The framework aims to establish a common language (classificatory system) for SESs, however, the application of the SESF is not consistent from case to case (Thiel, Adamseged & Baake 2015). Before a SES is diagnosed using the SESF to develop policy recommendations, problem definition for every component (resource systems, resource units, actors, governance systems, and socio-ecological political setting etc) needs to be conducted (Cox 2011). However, it is unclear how these explanatory variables were selected to represent the problem in the diagnosis (Thiel, Adamseged & Baake 2015). Across cases, different variables of the SESF have been used from the first, second, and third tiers. Every SES consists of interacting dynamic biophysical and social conditions with their own unique conditions. With reference only to the potential explanatory variables, it is difficult to recognise embedded patterns (that are commonly considered to be the basis of diagnosis) when comparing conditions across SESs. As a consequence, systematic cross-examination of commonalities and differences between cases is not possible. Whilst the framework can be used as a tool for structuring inductive research in analyzing SESs, the causal relations and pattern explanations are hardly

considered. Problems emerge because actions are not always rational (for example, following the cost and benefit criteria). The discourses, power dynamics and the way these shape action situations are not sufficiently addressed. Although, it is acknowledged that individual interactions within SESs may fail (Figure 2.4) and thereby reduce the robustness of the system (Anderies, John. M, Janssen & Ostrom 2004).

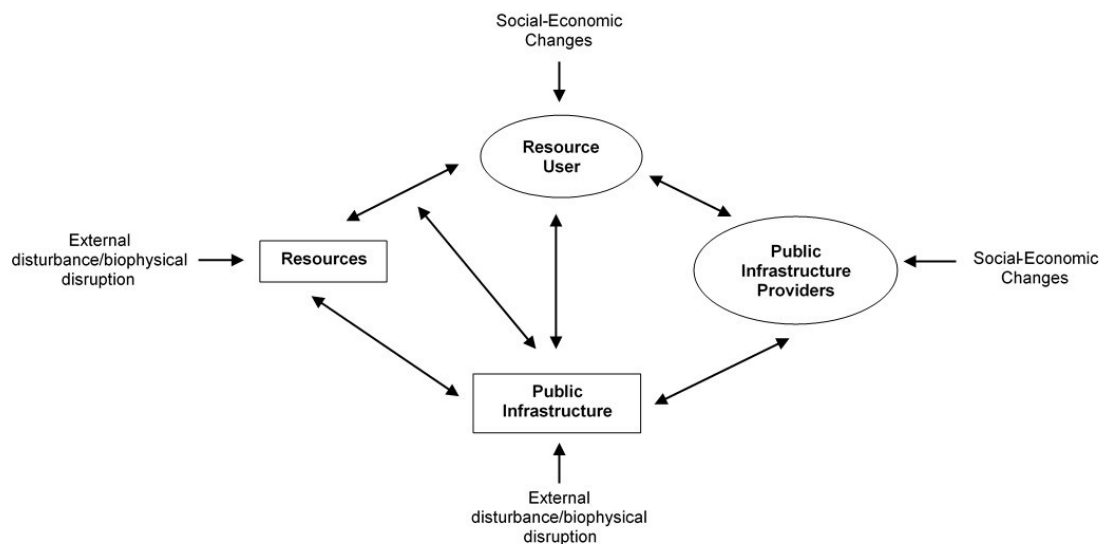


Figure 2. 4 The Social-Ecological System Frameworks (Anderies, John. M, Janssen & Ostrom 2004)

Further, the SESF does not consider the role of the governance system in directing the interactions (Armitage 2008; Travers et al. 2011). In the framework, the governance system is considered as an exogeneous factor. How different approaches in resource governance can shape the conditions of resource systems, resource units, actors and their interactions and, in turn, be shaped by them does not play an important role (Thiel, Adamseged & Baake 2015). The current SES framework therefore cannot provide further explanations as to how changes in governance systems impact SES conditions.

As has been explained above, the development of the SES framework was intended to increase understanding of the mutual dependency between social and biophysical systems. In the framework, the components of both systems are intricately linked and affect system dynamics. While the significance of dynamic interactions is acknowledged, existing frameworks fail to explain the specific interactions among components when adapting to external drivers. Every SES component has its own unique role in the system. They have different capability to adapt to problems and changing conditions. For example, changes in biophysical systems are more obvious (Scheffer & Carpenter 2003) than those occurring in social systems (Mahoney &

Rueschemeyer, 2003). Moreover, even though the frameworks take into account the number and variation of components, the manner in which each component of biophysical systems and social systems work when adapting to external change remains unclear. It is not yet clear whether changes to either individual or multiple components have impaired or promoted SES conditions and vice versa. The current frameworks give no explanation of interactions among components in their extent and significance. For example, in elaborating the social system which is the result of cooperation and collective action from a growing number of resource users (RUs), public infrastructure providers (PIPs) and the increasing scale and interconnectedness of their actions, a much more systemic framework capable of identifying interactions among and between RUs and PIPS is required. The role and bargaining position of each user and public infrastructures provider (such as farmers, environmentalist, private sector, public sector) in their interactions in SES, which vary and are context specific, need to be understood. Further elaboration is required in order to understand the dynamic relation among components in the SES frameworks.

2.3.2 The function of the SESF

As most of the world's socio-ecological systems are now degraded, it is not surprising that seeking the 'best governance approach' is a continuous concern of scholars and decision-makers (Acar 2017; Ekstrom & Young 2009; Fish, Ioris & Watson 2010; Foerster 2011; François 2008; Hogg, Kleinschmit & Rayner 2016; Mitchell 2005; Rouillard et al. 2013; Thomas, Elinor & Paul 2003; Underdal 2012).

To evaluate an SES, Ostrom's SESF (Ostrom 2007) is applied through static analyses of performance levels of the collective actions in the SES. Evaluating the implementation of Ostrom's SESF, Thiel et al. (2015) found that most of studies used the framework to explain outcomes of collective actions. Careful application of the framework can enable analysts to do justice to the complexity and specificity of particular cases while at the same time allowing aggregate conclusions to be generated (Werthmann 2015). However, it is difficult to relate the resulting qualitative comparative analysis (QCA) to the richness of the specific historic or cultural context (Mahoney & Rueschemeyer 2003), which can be an important factor in explaining current performance levels. In Ostrom's approach, governance is considered to be exogenous to the context. In contrast, the way in which policy makers envision policy is deeply embedded in the relevant historical and cultural context. This implies that governance needs to

be tailored to the specific historical context in which it is situated. It therefore comes as a no surprise that, the SESF does not seem to have added to explanation of change in governance impacts or been impacted by SES within the specific context. This lack of capacity to involve historical and cultural context, limits our understanding of how change in governance system needs to be directed.

Although several principles of sustainable resource governance include Ostrom's design principles – listed in Table 2.2 (Ostrom 1990) – a significant number of papers illustrate that these principles often fail to be transferred into practice (Blomquist, W & Schlager 2005; François 2008; Head, Ross & Bellamy 2016; Nkhata & Breen 2016; Wallis, P. J. & Ison 2011). Therefore, designing governance change in order to steer SESs onto desirable pathways is challenging. In many cases changes in government interventions have resulted in considerable negative consequences for the whole SES.

Table 2. 2 Design principles for governing sustainable resources

1. Clearly defined boundaries	The boundaries of the resource system (e.g., catchment system and the actors with rights to harvest resource units are clearly defined)
2. Proportional Equivalence between Benefits and Costs	Rules specifying the amount of resource product that a user is allocated is related to local context and to the rules requiring labor, material and money
3. Collective-choice arrangements	Rules are modified by most of individuals affected by harvesting and protection rules
4. Monitoring	Monitors are conducted by the users themselves who actively audit biophysical conditions and user behaviour
5. Graduate sanctions	Rules enacted are supported by law enforcements
6. Conflict-resolution mechanisms	Users have rapid access to low cost actions to resolves conflict of interests
7. Minimal recognition of rights to organize	The rights of users to devise their own institutions are not challenged by external governmental authorities, and users have long-term tenure rights to the resource.
8. Nested enterprises (for resources that are parts of larger systems)	Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.

(Ostrom, (1990)

Governance systems are the core mechanism in changing SES conditions, which not only have the potential to shape SES conditions but are also embedded with specific contexts. However, how governance changes impact the whole SES and its individual components within a specific context cannot be explained with the current SES framework. Thus, there is a need to put the relevant governance system as an endogenous factor in the SES framework.

2.4 Designing policy for land, water, and environmental governance within SESs

In the previous section, it has been discussed that the governance system can influence causal relations and patterns of the interaction between components within SES, and it should be treated as an endogenous variable and its changes are deeply embedded in the historical context. In land, water, and environmental governance, policy instruments affect the behaviour of actors in their interventions on land, water, and environment to cope with problems and changing conditions (Howlett, Michael 2005, 2010; Sterner & Coria 2012). Thus, how the problems related to land, water, and environment are translated into policy instruments is possibly the most significant factor characterising understandings of land, water, and environmental governance. This section will investigate how such problems are translated into policy instruments.

2.4.1 The fitting between problems and solutions

Governance is about the arrangement of policies across different levels of governments (Howlett, Michael 2010). Every policy is structured around problems and objectives to be achieved, with a range of policy instruments to achieve objectives (Hood 1983; Howlett, Michael 2005, 2010). Policy design practice highlights the need for consistency of policy objectives and policy instruments selected to achieve the objectives (Howlett, M. & Lejano 2013; Linder, S, H. & Peters 1989; Linder, SH & Peters 1988; Schneider & Ingram 1997).

In policy studies, the policy cycle has been widely represented using a ‘stagist’ model with construction providing a road map in the policy process (Parsons 1995). The process is comprised of gathering knowledge to identify the problems, followed by the prescription of actions and evaluation (Howlett, Michael, Ramesh & Perl 2009). There are many models that have attempted to reconstruct the policy making process (Frohock 1979; Howlett, Michael 2010; Howlett, Michael, Ramesh & Perl 2009; Parsons 1995). All models describe the policy

making process as a series of interrelated stages which flow in a sequence and is a linear process in nature (Easton 1953, 1965). The policy cycle is a heuristic device, allowing different stages of the policy making process to be investigated on their own merits as well as in relation to others. Overall, the policy cycle posits that policy making is a never-ending process responding to the problem and objectives as they change over time.

Policy consists of two significant distinctive elements: policy content and how it is applied to achieve the goals (or the means). Policy content and policy means differ when applied at different levels of government. They are formulated based on their context at each level. For example, the content and means to cope with climate change differ between national, state and local policy. At the national level, the policy contains a high-level abstraction of goals. Most policy ideas at the macro level are generated based on a world view, such as the Millennium Development Goals (MDGs), Sustainable Development Goals (SDGs) or national ideologies such as capitalism, liberalism or communism. At the municipal level, the goals are likely to have been translated into a programme for its operationalisation. At the local level, policy is more specific to on the ground measures. In the same vein, policy means, which define the way to achieve the target objectives, differ from general policy preferences to specific policy instruments and their adjustments (see Table 2.3). Policy means at the micro level concern how the programme can achieve the objectives – to be adjusted in accordance with local conditions or context-specific problems.

Table 2. 3 Policy content and policy means at different levels of government

	Macro (for example: National, state, regional policies)	Meso	Micro (for example: specific area)
			
Policy content	High-level abstraction	Programme-level operationalization	Specific on-the-ground measures
Policy means	General policy implementation preferences	Operationalizable policy instruments	Specific policy instrument calibrations

Adapted from Howlett (2010)

At every level, once the problem has been recognised, a policy process will start, and the policy will be formulated according to the context. Although a policy cycle provides a road map for

the policy process, it is not sufficient in itself to understand how policies at each level are made or connected considering the highly distinctive nature among levels. The tension to accommodate precision and inclusiveness at the same time (Figure 2.5) becomes apparent at this stage in the policy making process (Elmore 1983; Linder, SH & Peters 1988). The outcome of this mismatch often results in ill-defined problem and solutions.

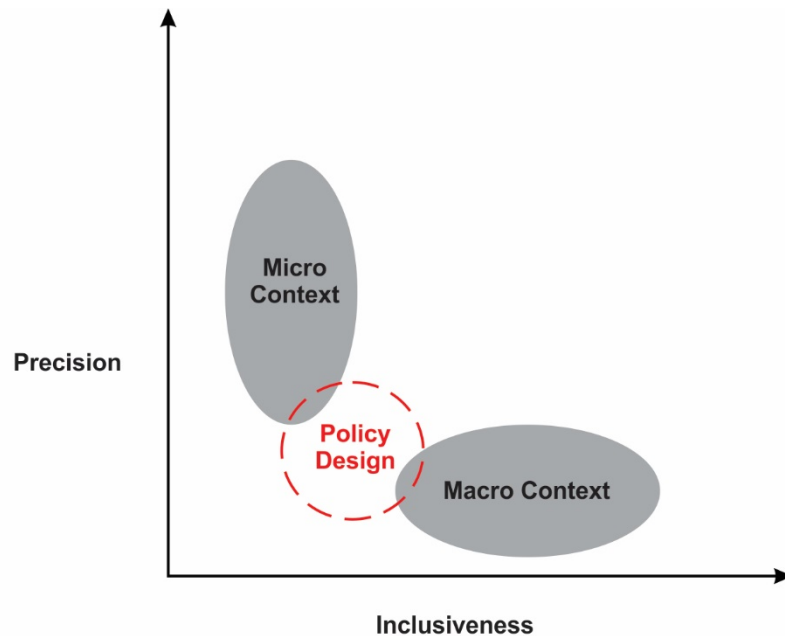


Figure 2. 5 Trade-offs between precision and inclusiveness (Linder, SH & Peters 1988)

Thus, the challenge of coping with intertwined problems, such as problems related to land, water, and environment, is not limited to accuracy in problem definition (Bason 2014; Christiansen & Bunt 2014; Junginger 2014) – which depends on the policy makers understanding of macro, meso and micro contexts – but also relies on the problem being successfully translated into action, in this case policy instruments (Ekstrom & Young 2009; Folke et al. 2007; Mitchell 2005; Ostrom 2005). Acknowledging these limitations in the policy process, it is understandable that policy makers at the local level tend to focus on formulating policy instruments in line with micro-level issues instead of focusing on the broader policy making context (Eliadis, Hill & Howlett 2005). On the other hand, the formulation of policy instruments which are specific and contextually appropriate is not a focus of the current policy making process.

2.4.2 Designing policy instruments

Policy instruments often include a myriad of techniques for government interventions to implement their policy in practice (Howlett, Michael 2010). The over-consumption of water resources, pollution of waterways, decline in aquatic ecosystems and many other social issues (such as conflicts of interest among resource users, imbalances or disparities in water allocation, and political tensions among regions) are the consequences of policy instrument failures in shaping the behaviours of complex and dynamic human-environment interactions (Cooper & Crase 2016; Dovers 2000; Nyberg et al. 2014; Robison et al. 2014). Salamon et. al (2002) shows massive proliferation in the form of policy instruments used by governments.

Policy instruments exist at all stages in the policy process (Bijker, Hughes & Pinch 1987; Howlett, Michael 2005). Every stage has specific tools linked to the activities in that specific stage (see Figure 2.6). Policy instruments are thus in a sense of ‘multi-purpose’, since one tool (for example, a regulation) can serve different purposes when it is used in different areas such as land, water, and environmental practices. In addition, one tool can have a different purpose when it is applied in different stages of the policy cycle. For example, a survey in the agenda setting stage has a different purpose and function from when it is applied in the evaluation stage (e.g. consultation with relevant actors/stakeholders).

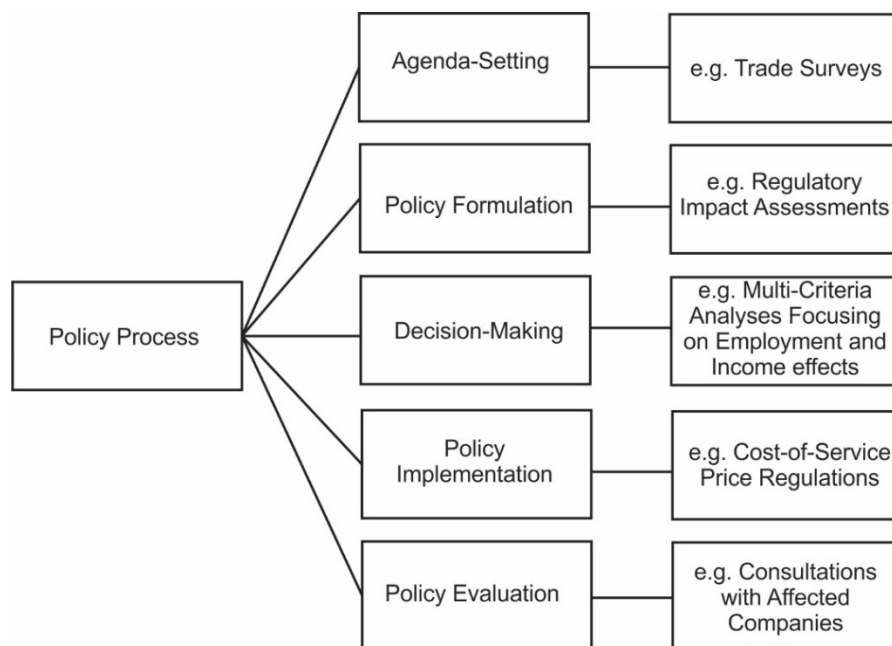


Figure 2. 6 An example of the range of policy instruments by stage of the policy cycle. Adapted from Howlett (2010)

The use of policy instruments at all stages of the policy process is important to achieve policy objectives, however Wu et al. (2010) argues that the key is for policy instruments to be specifically linked to two policy phases in particular: policy formulation and policy implementation. In the implementation phase, policy instruments are set to alter or affect the delivery of goods and services (Salamon & Elliott 2002) – later discussed as ‘substantive policy instruments’, while in the policy formulation phase, policy instruments are designed to alter and affect the nature of policy deliberations and the consideration and assessment of policy alternatives (Turnpenny et al. 2009) – later discussed as ‘procedural policy instruments’.

The role of policy instruments is crucial as they determine the feasibility of policy goals. A policy instrument is the product of the government learning processes in coping with targeted/specific problems and in adapting to changing conditions (Borrás & Edquist 2013; Bressers & O'Toole 1998; Landry & Varone 2005; Linder, S. H. & Peters 1989). Previously, there have been several academic attempts to classify policy instruments (Hood 1983; Howlett, Michael 2005; Ripley 1966; Schneider & Ingram 1997). The two types of policy instruments – substantive and procedural policy instruments – formulated by Howlett (2005) will be discussed in the following section. Substantive and procedural policy instruments are used to affect the content or process of policy implementation and the manner in which policy making is undertaken respectively.

Substantive policy instruments

Substantive implementation instruments are those used to directly affect the actual substance of the kinds of day-to-day production, distribution and consumption activities carried out in society (Howlett, Michael 2005; Kaufmann, Majone & Ostrom 1986). They are techniques or mechanisms which are designed to alter the behaviour of actors involved in those activities (Anne & Helen 1990). Below are examples of the ways in which substantive policy instruments determine and influence production and consumption in society (Howlett, Michael 2005):

Production effects, for example, include determining or influencing:

- Who produces it – for example, via licensing, bureaucracy/procurement, or subsidies for new start-ups;

- The types of goods and services produced – for example, through bans, limits or encouragement;
- The quantity of goods or services provided – for example, via subsidies or quotas;
- The quality of goods or services produced – for example, via product standards or warranties;
- Methods of production – for example, via environmental standards or subsidies for modernisation;
- Conditions of production – for example, via health and safety standards, employment standards acts, minimum wage laws, or inspections; and
- The organisation of production – for example, via unionisation rules, anti-trusts legislation, securities legislation, or tax laws.

Consumption and distribution, for example, include determining or influencing:

- Prices of goods and services – such as regulated taxi fares or wartime rationing;
- Actual distribution of produced goods and services – affecting the location and types of schools or hospitals, forest tenures or leases;
- Level of consumer demand for specific goods – for example, through information release, nutritional and dangerous goods labelling (cigarettes), export and import taxes and bans and similar activities; and
- Level of consumer demand in general – via interest rate, or monetary and fiscal policy.”

Procedural policy instruments

While substantive policy instruments are used directly to alter the behaviour of actors involved in policy implementation to achieve targeted outcomes, procedural policy instruments structure the way in which various actors are involved in policy making (without determining the outcome) (Klijn, Koppenjan & Termeer 1995). They affect and alter aspects of policy-making behaviour (Knoke 1990). Klijn and Koppenjan (2007) provide some example of activities that can be affected by the use of procedural policy instruments including:

- Changing actor policy positions, setting down, defining, or refining actor positions;
- Adding actors to policy networks;
- Changing access rules for actors to governments and networks;
- Influencing network formation, promoting network self-regulation, or modifying system-level policy parameters (e.g. levels of market reliance);

- Changing evaluation criteria for assessing policy outcomes, success and failure;
- Influencing the pay-off structure for policy actors;
- Influencing professional and other codes of conduct affecting policy actor behaviour regulating inter-actor policy conflict;
- Changing policy actors' interaction procedures;
- Certifying or sanctioning certain types of policy-relevant behaviour; and
- Changing supervisory relations between actors.

In environmental and natural resource management, policy instruments should be efficient, minimise uncertainty and information asymmetry, promote equilibrium in the effect and distribution of costs and have power in its enforcement (Stern & Coria 2012). However, designing policy instrument is a highly constrained process. The choice of policy instrument is constrained by the context (Borrás & Edquist 2013; Bressers & O'Toole 1998; Linder, S. H. & Peters 1989). In comparing policy instruments, it cannot be assumed that the same policy instrument, if used in one context, would necessarily produce the same outcomes in a different context (Stern & Coria 2012). In policy literature, the criteria to evaluate policy instrument choice has evolved over time aligning with government learning processes to understand the success or failure of policy instrument in their implementation (O'Toole 2000). The criteria include technical and political feasibility (Peter 1981; Sydney 2007), problem recognition, and the feasibility of policy instruments during implementation (Majone 1989). In summary, the choice of policy instruments depends on the interplay among three criteria suggested by Howlett (2010): organisational capacity (knowledge, enforcement, money, administration), resource availability (information, authority, treasure, organisation) and user adoption requisites (credibility, legitimacy, trust).

Moreover, policy instrument selection is dependent and driven by the situation involving multiple actors (Mukhtarov et al. 2015). It cannot be freely designed as it also depends on the precedence of past problem definition and the existence of past interventions by previous actors (Junginger, 2014). Better policy instruments occur when its design is consistent with and appropriate for the context in which it will be applied. Anderson in Howlett (2005) calls the policy process as 'the art of the possible'. In this regard, the function of a policy designer is to find appropriate possible instruments or methods, which are best suited to achieve their goals by considering the particular condition in which the policy instrument will be applied (Howlett,

Michael, Ramesh & Perl 2009). It is an experimental process to bring together knowledge and specific conditions (Margolin & Buchanan 1995) in order to achieve desired objectives (Jonas 2007). It is more than evaluation or assessment of the available policy instrument alternatives. As May (2003) argues, designing policy instruments is about synergising networking among actions of different actors involved in both policy formulation and policy implementation.

In summary, policy instruments are never fixed. Policy instruments need to adapt to changing problems, conditions and objectives. A policy instrument that is formulated to cope with a specific issue is not able to forever respond to dynamic problems, conditions and objectives. Thus, there is an opportunity to re-define policy instruments according to their capacity to engage with, and respond to, dynamic problems and conditions in land, water, and environmental governance.

2.4.3 Purposeful institutional change

In the previous section, it has been discussed that policy instruments are government tools used to cope with problems and achieve targeted conditions. Policy instrument can change just as problems and conditions also change. Understanding what enables the successful governance of land, water, and environment is essential for purposeful change – in particular, the way in which institutions modify existing policy instruments or create new policy instruments. Although there are many barriers to successful institutional change (Ostrom 2007; Rammel, Stagl & Wilfing 2007), the number of academics exploring how such change can be approached is increasing. In the current literature, the understanding of purposeful institutional change is polarised between two approaches: objective institutional design and subjective institutional design (Thiel 2015).

In objective institutional design, the formulation of policy instruments is exogenous to actor behaviour. The formulation process is based predominantly on scientific knowledge. In environmental and natural resource management, policy instruments selected should be efficient, minimise uncertainty and information asymmetry, promote environmental equilibrium, and promote the distribution of costs (Sternier & Coria 2012). In this deductive approach, policy instrument formulation is an ad hoc process selecting from the available policy instruments listed for the specific problems. Policy makers consider the likely success of policy instruments in solving a specific problem. From this perspective, institutional change

can theoretically be produced independently from its context. As a consequence, it is rare that policy instruments are selected based on their effectiveness under the specific conditions of the SES. Most of them are adopted based on familiarity, preconceived views or perceived best practice (Borrás & Edquist 2013; Jordan, AJ & Turnpenny 2015).

In contrast, in subjective institutional design approach, policy instruments are conceptualised as being endogenous to actors, and intended change becomes effective if it is aligned with the human learning process. This perspective recognises that problems related to resource management cannot be dissociated from human values relating to the resources, which evolves over time (Kandasamy et al. 2014; Wei, Wei & Western 2017). Human learning to cope with problems and changing conditions reshapes human perceptions and understandings through knowledge co-production (Blackmore 2007; Blackmore, Ison & Jiggins 2007; Collins & Ison 2009). Thus, knowledge co-production in SES governance can be understood as a collaborative process of reconciling pluralistic interests through construction of shared perspectives on a system, incorporating multiple forms of knowledge, subject to revision given the evolving understandings of that system (Gómez-Baggethun et al. 2012).

2.4.4 Learning Process in SES governance

Resource governance aims to create the social system conditions that facilitate ecosystem-based management (Martinez-Harms et al 2015; Ostrom 1990; Sterner & Coria 2012). It involves resolving trade-offs and providing vision and direction for sustainability among interactive components in an SES (Howlett, Michael 2010). The governance system directs trade-offs among components of biophysical and social systems through policy instrument deployment in order to cope with problems and achieve targeted goals. In complex SESs, ‘perfect’ knowledge of problems and conditions is never possible (Blackmore 2007; Blackmore, Ison & Jiggins 2007). SES governance is challenged by the increase number and variation of components resulting from the increasing scale and interconnectedness of resources and the growing number of actors involved in the system. How problems are defined, and solutions are prescribed is related to the knowledge about them. Governments are therefore challenged to accurately define the ‘actual state’ of problems and conditions in order to prescribe policy instruments in coping with intertwined problems in SESs. From this perspective, the development of policy instrument in SES governance can be understood as a collaborative process reconciling pluralistic interests through construction of shared

perspectives on a system, incorporating multiple forms of knowledge, and subject to revision given the evolving understandings of that system (Gómez-Baggethun et al. 2012).

As has been discussed in the previous section, policy making (policy content and policy instrument) is a never-ending process responding to problems and objectives as they change over time. As an interactive process of collective action and reflection, it is a gradual process with change and stability bound together (Mahoney & Thelen 2010). It takes its own evolutionary direction (Rotmans, Kemp & Van Asselt 2001). However, changing political agendas or crises (such as flood or drought) can change the pathways by implementing new agendas or innovations. For example, Huiteima and Meijerink (2009) observed that major transitions in water policy tend to occur only after disastrous events. The Millennium Drought in Australia is an example of such a crisis for the relevant institution (Cummins & Watson 2012; Docker & Robinson 2013; Quiggin, Mallawaarachchi & Chambers 2012; Ross & Connell 2016).

As both policy content and policy instrument pathways are historically situated (Mahoney & Thelen 2010; Marshall & Alexandra 2016), this memory complements current science and technology in creating governance systems relevant to local contexts, contributing to long-term socio-ecological resilience. The nature of ‘knowledge transfer’ from the past in SES governance therefore needs to be further explored.

Against the background discussed in Section 2.4.1 to 2.4.4, it can be seen why policy instruments should be sensitive to the context in which they will be implemented. As targeted goals are always changing with changes in the problems and conditions of the SES, design of policy instruments needs to expand to not only find appropriate possible instruments or methods, which are best suited to achieve their goals by considering the particular condition, but also to improve its capacity to reconcile trade-offs of increasing scale and interconnectedness of resources and with a growing number of actors involved in the system. The consideration of the ‘actual state’ to which policy instruments will be applied is currently a blind spot in the policy making process. There is still a lack of knowledge of how a policy instrument can be most effectively improved in the context of its relationships with other previous and existing policy instruments. As a consequence, most policy instruments are adopted based on familiarity, preconceived views or perceived best practice to address a

particular problem and goal, instead of facilitating trade-offs among components involved towards sustainable conditions. Knowledge of the ‘actual state’, especially for reflection in policy making, is scarce. Therefore, the nature of ‘knowledge transfer’ from the past have been used in SES governance needs to be explored.

2.5 Policy mixes and policy integration

As has been discussed in Section 2.2, the approach adopted by government interventions to cope with problems and changing conditions of land, water, and environment rely on government understanding of their dynamic interactions within their specific contexts. This section will discuss two approaches that are commonly adopted by governance institutions to cope with intertwined problems related to land, water, and environment: policy mixes and integrative governance.

2.5.1 Policy instrument mixes in land, water, and environmental governance

In recent years, policy studies have faced the challenge of providing innovative approaches that can cope with the growing complexity faced by current governments. The complexity challenge has not only occurred in the context of defining ‘wicked’ or nebulous problems (Bason 2014; Christiansen & Bunt 2014; Junginger 2014) but also in deciding how those problems can be addressed (Ekstrom & Young 2009; Engle & Lemos 2010; Folke et al. 2007; Ingold et al. 2018).

The proliferation of mixed instruments has been triggered by the increasing complexity of problems. Most policy instruments formulated to cope with such intertwined problems are not deployed in isolation – they are always part of a mix (Cohen, March & Olsen 1972; Flanagan, Uyarra & Laranja 2011) and must work in combination with other instruments (Flanagan, Uyarra & Laranja 2011; Landry & Varone 2005). Thus, evaluating an individual policy instrument as if it were stable, discrete and independent entity would be misleading (Howlett, Michael 2005). The policy instrument should be evaluated based on ‘its actual state’ – including its interactions and trade-offs with other policy instruments. This is significant for policy design where policy instruments remain focused on specific problems and where their selection was based on alternative policy instruments available for the problem instead of its specific context (Witt 2003).

Recent studies have attempted to assess how policy instruments interact with one other (policy mixes) within governance systems (Cohen, March & Olsen 1972; Flanagan, Uyarra & Laranja 2011). Four types of policy instrument interactions in environmental policy are hypothesised:

- Policy instruments that are inherently complementary;
- Policy instruments that are inherently incompatible;
- Policy instruments that are complementary if sequenced correctly; and
- Policy instruments which are complementary within specific contexts.

In more detail, Bressers and O'Toole (2005) categorise how policy mixes occur in practice in five forms (see Table 2.4). Possible sources of tension between policy instruments in the policy mix may occur when policy instruments are formulated based on different rationales, goals or procedures (Flanagan, Uyarra & Laranja 2011).

Table 2. 4 Five forms of policy instrument mix and their causes

Causes	Form of mix	Example
Increased intensity of public intervention	Multiple policy instruments targeting a specific actor or a group of actors	Various policy instruments related to land utilisation, water extraction and environmental impacts applied simultaneously to farmers
Integration of multiple instruments into one interactive process between governance and target group	Multiple policy instruments targeting different actors involved in the same process	Catchment management plan applied for different actors in a catchment area
Instruments and actions at different levels of governance	Interactions between policy instruments and actions taken at different levels of governance	Various policy instruments formulated by different levels of government (national, state, region, municipal, city, etc) in an area
Competition and co-operation between different but interdependent policy fields	Interaction between policy instruments and tension across policy areas/domains	Various policy instruments related to land utilisation, water extraction and environmental impacts applied simultaneously on an area
Mutual strengthening or weakening of the effects of interventions at different points of actions in the broader system	Interactions mediated through processes between policy instruments in a broader system	Policy instruments applied in up-stream and down-stream areas of a catchment Policy instrument used for implementing policy and policy instruments used for monitoring policy implementation

Adapted from Bressers and O'Toole (2005)

Based on the table above, literature has acknowledged the possibility of interactions between policy instruments across fields (e.g. water, land), actors (e.g. water authority, farmers), and geographic areas that occur in practice. However, less attention has been given to the time dimensions of policy instruments (Pollitt 2008). More specifically, both goals and policy instruments evolve over time aligning with changing problems and situations – in other words, the environment in which they operate. In the long-term perspective, policy instruments are limited to a pre-existing policy instrument mix which has been shaped through successive policy changes (Uyarra 2010) and, as discussed in Section 2.4.3, they contain accumulated knowledge and routine. Policy instruments create their own pathways based on the human learning process in their implementation. Therefore, learning from the previous policy instruments can have an impact of future policy instrument choices (Ellis et al. 2016; Ross & Connell 2016; Underdal 2012; van der Brugge, Rotmans & Loorbach 2005). However, there is still a lack of knowledge regarding how a policy instrument can be most effectively improved in the context of its relationships with other previous and existing policy instruments. In addition, the reality that every policy instrument takes time to implement and to produce impacts and that this time varies between instruments has not been accounted for in studying their interactions (Kay 2006; Pollitt 2008). This gap in the literature presents a remarkable challenge to understanding cause and effect in policy analysis (Witt 2003).

2.5.2 Policy integration

Given that an individual policy instrument does not work alone in isolation, the urgency of policy integration has been frequently invoked in resource governance (Briassoulis 2005; Carlsson & Sandström 2008; Macleod, Scholefield & Haygarth 2007b; Varis, Enckell & Keskinen 2014). Policy integration is a well-established concept which considers natural linkages between land, water, and environment to promote coordination and minimise conflicts among interventions in land, water, and environment (Heathcote 2009).

A policy is not a single, discrete, unitary, disembodied phenomenon, but a result of a series of policy processes (see Section 2.4.1). Policy consists of its object (the characteristics of the problem considered and the theory about it), interested or involved actors/stakeholders, their goals (reflecting their value systems), the available structures and procedures (for formulation and implementation), and the instruments used to achieve the goals set (Briassoulis 2005).

Policy integration is a process either of coordinating and blending policies into a unified whole, or of incorporating concerns of one policy into another. To develop operational expressions for policy integration, it is necessary to clarify what should be integrated among policies and how this should be done. According to Briassoulis (2005), to explain what should be integrated, policy integration can be conceptualised based on the interactions among components of the policy itself. Operationally, this concerns the cross relationships among the objects, goals, actors, procedures and instruments of two or more policies (see Figure 2.7).

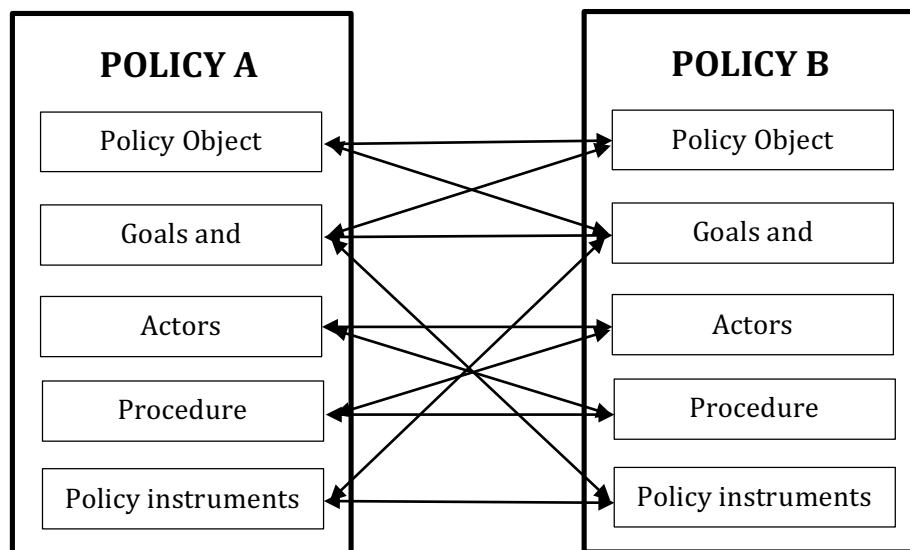


Figure 2. 7 The object of policy integration (Briassoulis 2005)

Moreover, Briassoulis (2005) also urges analysis of policy integration based on the dimensions covered: substantive, analytical, procedural, and practical. *Substantive* dimensions of policy integration encompass the thematic, conceptual, and value dimensions that relate to the constitution of the policy objects to be integrated. The thematic dimension negotiates the essential relationships among policy objects that usually concern the selected characteristics of a problem (such as environmental degradation, conflict in resource use, flood, drought, etc). *Analytical* dimensions of policy integration entail spatial, temporal and methodological considerations whose operational expressions depend on the substantive framing of policy instruments. In a geographic sense, spatial policy integration relates to the congruence of the spatial units used in applying the policies. In practice, policies do not always share congruent spatial units. Most use administrative units which are not suitable for addressing cross-cutting problems such as drought, flood, and other environmental problems. For example, government boundaries typically do not coincide with catchment boundaries. The temporal dimension of policy integration concerns the congruence in time between policies. Lack of temporal

integration often leads to ineffective and wasteful policy interventions. Similarly, the methodological dimensions of policy integration concern the compatibility of relationships between the methods and techniques used for policy analysis. Methodological integration dictates the need to use of integrated, multidimensional methods and techniques at all stages of the policy process.

Procedural dimensions of policy integration refer to the structural and procedural relationships between policies. However, integration in structures and procedures of policies does not automatically imply their suitability for all cases of policy integration, nor their adoption and implementation, nor their effectiveness with respect to the goals of policy integration. For example, the establishment of a catchment management authority to promote coordination of actions in catchment area is not always followed by positive outcomes. Ideally, substantive and analytical integration should lead to suggestions as to what procedural arrangements are needed. Lastly, *practical* dimensions of policy integration concern practical issues related to compatibility, consistency and congruence of data and information used. For example, substantive, analytical and procedural integration is not always informed by spatially, temporally and conceptually integrated data and analysis.

Further, the literature on how policy integration can be achieved is polarised into two approaches: (1) vertical/intersectoral integration; and (2) horizontal/intersectoral integration (Nilsson & Persson 2003; Persson 2004). Vertical integration has a spatial dimension. It promotes interaction among different administrative levels. Policy integration in terms of goals can be easily achieved at a higher level while ensuring that actors at lower levels comply with the goals is difficult. If vertical linkages among actors do not exist or are not fully operational, the intention to integrate the policy will not materialise on the ground. Horizontal integration concerns relationships between policies addressing the same or interlinked problems/issues at the same level. Horizontal integration does not necessarily lead to a single integrated policy, rather it can involve coordination among policies. Horizontal integration requires negotiation of trade-offs among different sectors, for example between environmental and economic objectives.

Taken together, there are no clear prescriptions as to how policy integration can be achieved (Engle & Lemos 2010; Medema, McIntosh Brian & Jeffrey Paul 2008; Nathan et al. 2011). In particular, policy integration to promote sustainability is diverse in its implementation

(Briassoulis 2005) because of different understandings of what sustainability means in resource governance (Bischoff-Mattson & Lynch 2017). Collier (1994) defined the aim of policy integration to be: (a) achieving sustainable development and preventing from environmental damage; (b) removing contradictions between as well as within policies; and (c) realising mutual benefits and the goal of making policies mutually supportive. The gap between policy prescription and its implementation remains challenging (Blomquist, W & Schlager 2005; François 2008; Nigel, Gordon & Will 2007). McGinnis (1999) argues that this is because there is no agreement among policymakers on their object (scope of problem covered), goals, contributing actors, procedures and policy instruments. In reality, a policy integration process is often conducted based on human preferences which starts with policy components which are on-hand, convenient, and easy to manipulate while trying to build reasonable linkages with the other components (Briassoulis 2005).

As a government tool to achieve targeted goals, a policy instrument does not work in isolation (see Section 2.5.1). It mixes with other policy instruments in reaching an outcome. However, in general, a policy instrument is designed to reflect the definition of the policy object (problems covered) and the associated goals of the actors participating in policy formulation and procedures in its implementation. During implementation, policy instruments are combined (see Section 2.5.1) to achieve their goals or solve the problem in context-dependent ways that can be neither anticipated nor specified precisely or unambiguously during policy instrument formulation. A responsive and effective policy instrument requires an understanding of the inherent problem context (Borrás & Edquist 2013; Ingold et al. 2018; Knieper et al. 2010; Linder, S, H. & Peters 1989; Mukhtarov et al. 2015). In SES governance, ‘there is no single, universally accepted way of formulating the linkage between social systems and natural systems’ (Olsson, Folke & Berkes 2004). Thus, policy instruments cannot simply be imposed. Instead they must emerge from the interactions which occur within the system. By capitalising on the complex human-environment systems in land, water, and environmental governance, integrative governance is a reflexive process which brings together SES components in formulating policy instruments.

In summary, problems related to land, water, and environment governance are complex and interconnected. This implies that a single or isolated policy instrument is not sufficient. Failure to understand how policy instruments fit within the relevant portfolio of policies creates inefficiency in their implementation. Policy integration has been proposed as a panacea in

recent decades to address the challenge of policy mixes. However, the concepts of policy integration and their implementation are still ambiguous and difficult to apply in practice. Policy integration ideally starts from the integration of policy objects and moves to the integration of policy instruments, ensuring the consistency of the overall process. However, in reality, the process may start from policy components that are on-hand, convenient, or easy to manipulate as policy makers try to build reasonable linkages with the other components. Ultimately, the efficacy of integration is dependent on how policy instruments work together within a system. As human understandings of complex human-environment systems in land, water, and environment evolve, understanding the co-evolution of policy instruments implemented in SES governance appears to be another avenue worth exploring to build knowledge of policy integration.

2.6 Land, water and environmental governance in Victoria

Located in south eastern Australia, Victoria is Australia's smallest state. Post-European settlement, Victoria was part of New South Wales until 1851, and then it became the Colony of Victoria before 1901 when it became a state. Nowadays, its population is the second largest after New South Wales, making Victoria as the most densely populated state in Australia. Early during European colonisation, population growth in Victoria was triggered by gold mining. Immigrants arrived from all over the world to search for gold. Decreased mining activity in Victoria was replaced by agricultural expansion. Victoria significantly contributes to the national agricultural production total gross value. The amount of agricultural land has steadily increased and now comprises around 60 per cent of total Victorian land surface. The acceleration of changes to natural landscapes has led directly to an acceleration in negative environmental consequences.

As part of a dry climate continent, the high rate of evaporation together with transpiration from land cover returns about 85 per cent of total water to the atmosphere; approximately 14 per cent is discharged to the sea as run-off and less than one per cent reaches underground aquifers. Water governance is prominent compared to all other resource governance in Victoria as the availability of water resources determines the ultimate limits of physical developments.

At the federal level, the governance of natural resources in Australia is multi-jurisdictional involving cooperative arrangements across the three spheres of government – national,

state/territory and local (Dovers & Wild River 2003; Head, Ross & Bellamy 2016). Responsibility for the legislative and administrative framework within which natural resources are managed lies with the State governments, who in turn have traditionally devolved some responsibilities, particularly relating to land use and development planning, to local governments. The shared responsibility between the Commonwealth and the States is referred to as ‘cooperative federalism’. Although, in practice, all three spheres of government in Australia (local, state and federal) have demonstrated significant involvement in natural resource management (NRM) policy initiatives, such initiatives have generally developed independently of each other in an ad hoc way (Connor & Dovers 2004; Head, Ross & Bellamy 2016; Moore & Rockloff 2006). This has led to a diversity of NRM institutional arrangements existing across Australia and within any one state/territory or region. Each state or region’s approach towards NRM has evolved in different ways, for different reasons, in varying contexts and at different rates in terms of resource governance, including in Victoria. How the Victorian government has responded to NRM and addressed State-specific problems is recorded in Victorian legislation and policy documents.

Victoria has moved in a positive direction in its management frameworks for water and promoting the environmental condition since the first management used frameworks following European settlement. At the beginning, resource governance, in this case land, water and environment, was focused on promoting economic and population growth and creating jobs. From 1980 onward, there was a change in focus for water governance. Decisions related to water need to consider not only hydrological system constraints but also the social, environmental and regional economic consequences of their decision. To elaborate the linkages between governance and SESs, it is critical to provide narratives associated with how the occupation and use of the land, water diversion and other interventions in natural resources have changed Victoria and produced varied conditions over time. The Victorian government’s historical approaches towards its biophysical and social systems, beginning from European settlement, and its successes and challenges in supporting population growth over time, are key to understanding the evolution of the government’s strategies.

Conducting a historical analysis will provide insights into the historical continuities of the complex interactions among biophysical systems, social systems and governance. Reflecting on the historical processes to explain how things came to be the way they are enables the development of a broad dialogue between SESs and governance.

2.7 Summary and knowledge gaps

This chapter provides a review of the background, previous research, developments and challenges in governing interdependencies in resources within SESs, in this case between land, water, and environment. Several key points can be drawn from the discussion in this chapter, as follows.

First, governing SESs is not only a challenge due to the sheer complexity both in defining interconnected problems and in formulating solutions. The efficacy of solutions to cope with these intertwined problems and changing conditions relies on understanding their dynamic interactions. As problems and conditions related to land, water, and environment change over time, governance also changes. Little is known about how the interactions between land, water, and environmental conditions have been shaped by their governance, nor how governance is, in turn, shaped by them.

To reverse degradation in SES catchment areas, it is important to understand the linkages between land, water, and environmental conditions and to account for this in their governance. Natural resource governance systems have previously been researched in order to improve SES conditions. However, the way in which governance itself impacts on, or is impacted by, SESs remains unclear. In Ostrom's SESF, the role of governance to direct SES conditions is not sufficiently accounted for. This framework views SESs in a 'static' way. Governance systems are treated as exogeneous factors in the system. However, in policy literature, a governance system is deeply embedded in its unique historical and cultural contexts which is dynamic and specific to each case. Therefore, understanding the differences of the governance system in directing dynamic interactions among SESs appears to be a highly promising approach in order to understand the linkages between governance and SES conditions.

Policy instruments, as government tools, can influence the way humans think about and approach achieving their targeted goals. Thus, consideration of policy instruments implemented in SESs is important to understand broader SES governance. Acknowledging the limitations of the current policy process, it is clear that developing policy instruments at the micro level is preferable, while keeping in mind macro dynamics and objectives (see Section 2.4.1). However, most policy instruments act as a 'problem solver' instead of as a manager of

the dynamic problems and conditions within an SES, and engagement with context-specific conditions continues to be a blind spot in policy design. Thus, there is an opportunity to analyse policy instruments based on their responses to dynamic conditions within the system. This gap is addressed in Chapter 3.

Changes in policy instruments to promote improvements in land, water, and environmental conditions do not always result in impactful, positive consequences. Purposeful institutional change aims to steer SES onto desirable pathways; however, there is still a lack of knowledge about how a policy instrument can be most effectively improved to achieve the desirable conditions. In many cases changes in policy instruments have, in fact, resulted in considerable negative consequences for the whole SES. Any improvements to policy instruments need to occur in, and are dependent on, the context of the relationships with other previous and existing policy instruments. Understanding how policy instruments have been improved in the past, in terms of their capacities to accommodate dynamic interrelated interactions within the system, would be useful and could be achieved through case studies. This gap is addressed in Chapter 4.

Lastly, socio-ecological memory in terms of the government learning process in policy instrument selection contributes strongly to SES resilience literature. Tracing the SES condition and the co-evolution of its governance as represented by a policy instrument would provide further insights into the extent to which changes in land, water, and environment can be considered as a core mechanism in changing SES conditions. Research on the linkage between SES governance and its condition, especially over long-time frames, is rare. Policy instruments implemented for the governance of land, water and the environment are a nested phenomenon requiring systemic rather than partial analysis in order to understand their impacts on SESs. Policy integration has been proposed as a ‘panacea’ in the face of the challenge of policy mixes, however, the concepts of policy integration and its implementation are still ambiguous and difficult to apply in practice. As human understandings of complex human-environment systems in the context of land, water, and environment evolve, understandings of co-evolution among policy instruments implemented in their governance is another avenue worth-exploring to improve knowledge about policy integration. This gap is addressed in Chapter 5.

Chapter 3

Understanding Policy Instruments as Rules of Interaction in Social-Ecological System Frameworks

This chapter will be re-submitted after revision as the following article:

Ratri Werdiningtyas, Yongping Wei, Andrew W. Western, Understanding Policy Instruments as Rules of Interaction in Social-Ecological System Frameworks, World Water Policy (to be re-submitted after revision)

3.1 Abstract

Government interventions to manage and improve synergies and trade-offs in social and ecological systems are made through various policy instruments. The conditions of the social ecological system (SES) are a function of the cumulatively implemented policy instruments. Although both policy instruments and social ecological system frameworks have played important roles in theoretical developments in resource management, they have largely been considered in isolation from each other. This article attempts to develop a framework in which it is argued that policy instruments can help policy analysts explain the linkages between resources, resource users and public infrastructure providers and that their configuration has a significant role in enhancing the robustness of SES conditions. It provides a diagnostic method to examine the current policy instruments and their role in resource governance to promote robustness of social-ecological system. Through policy instruments representing the interactions in SESs, the proposed framework can help elucidate: (1) how the biophysical system has been understood; (2) how the social system has been set up; and (3) how the synergies and trade-offs between biophysical and social systems have been managed in the governance of an SES.

3.2 Introduction

Resource governance aims to create the social system conditions that facilitate ecosystem-based management (Acar 2017; Elinor Martinez-Harms, et al. 2015; Ostrom 1990). It involves resolving trade-offs and providing vision and direction for sustainability among interacting components in SES (34). The governance system directs trade-offs among components of

biophysical and social systems through policy instrument deployments in order to cope with problem and achieve targeted goals. As most of the world's social-ecological systems are now degraded, it is not surprising that seeking the best governance systems and the best policy instruments for the management of natural resources is a continuous concern of scholars and decision makers (Acar 2017; Fish, Foerster 2011; François 2008; Thomas, Elinor & Paul 2003; Underdal 2012).

SES governance is challenged by the increasing number and variation of components resulting from the increasing scale and interconnectedness of resources and the growing number of actors involved in the system. How problems are defined and solutions are prescribed is related to the knowledge about them. Governments are therefore challenged to accurately define 'actual state' of problems and conditions in order to prescribe policy instruments in coping with intertwined problems in SESs. In practice, a singular policy instrument may not be sufficient to address complex, cross-cutting social-ecological problems. Policy instruments do not work alone but rather as a part of wider policy instrument configuration implemented for resource governance (Cohen, March & Olsen 1972). When resources are interdependent, the governance of one resource, including its policy instruments, affects the governance of the other resource(s). Inadequate understanding of policy instruments deployed to manage the complexity of SESs has resulted in uncertainty in measuring the effectiveness of selected policy instruments (Alkemade, Hekkert & Negro 2011). Overlap and incompatibility among policy instruments is often only apparent after a problem has occurred, instead of being predicted in the selection process (Briassoulis 2005). The condition of a Social-Ecological System (SES) is a function of resource governance compounded by accumulated policy instruments.

In contrast, designing policy instruments tends to lead to instruments or methods, which are best suited to achieve their particular goals by considering a specific condition rather than improving capacity to reconcile trade-offs at the increased scale and interconnectedness of resources and with growing numbers of actors. In the literature, there is still a lack of knowledge of how a policy instrument can be most effectively improved in the context of its relationships with other previous and existing policy instruments. Most of policy instruments are adopted based on familiarity, preconceived views or perceived best practice to cope and achieve to a particular problem and goal (Bressers & O'Toole 1998; Linder, S. H. & Peters 1989).

Without reflection, there is a high risk of perverse outcomes in making SESs sustainable over time. In a number of cases, changes in government intervention has resulted in considerable negative impacts on the whole SES, instead of the promotion of sustainable conditions (Docker & Robinson 2013; Dovers 2000; Young, 2000). There is no guarantee that an intervention through a policy instrument which gains success in one context will lead to similar successes in other contexts. Every SES consists of interacting, dynamic biophysical and social conditions with their own unique contexts. Therefore, the same policy instrument can generate different outcomes depending on the conditions of the SES to which they are applied (Blomquist, W, Dinar & Kemper 2005; Ekbja & Evans 2009; Nickson & Vargas 2002). Governance of SESs is complex and context-specific (Baker, Murray & Agyare 2018; Duit et al. 2010; Ebbesson 2010; Folke et al. 2005; Harris 2007). In order to ensure that sustainable SES conditions are being met, governments need guidance to improve policy creation and implementation. Knowledge of these ‘actual state’, especially for reflection in policy making, is needed.

The governance system has been extensively investigated in an attempt to improve SES performance (Duit et al. 2010; Ebbesson 2010; Ekstrom & Young 2009; Folke et al. 2005). Although there is considerable evidence of the relationship between impaired SESs and poor policy instrument efficacy, a clear explanation of how a policy instrument affects a SES remains unclear (Araral 2013; Bingeman, Berkes & Gardner 2004; Harris 2007; Quinn, Reed & Keller 2017). This makes it difficult for a decision-maker to evaluate the governance system in promoting the robustness of SES conditions. The development of SES frameworks in the last three decades has highlighted the need for greater understanding of the impact of governance on biophysical systems. In Ostrom’s SES framework, the inclusiveness of policy processes and their components are fundamental SES properties. By transforming the situation into variables that shape individual behaviour across the three tiers (see Figure 2.3), the Ostrom SES framework provides a diagnostic approach which seeks to disaggregate environmental issues, identify problems that are significant from a problem-solving perspective and reach conclusions about SES conditions (Thiel, Adamseged & Baake 2015). However, the SESF does not consider the role of the governance system in directing the interactions (Armitage 2008; Travers et al. 2011). In the framework, governance system is considered as an exogenous factor. How different approaches in resource governance can shape the conditions of resource systems, resource units, actors and their interactions and, in turn, be shaped by them does not play an important role (Thiel, Adamseged & Baake 2015). The current SES

framework therefore cannot provide further explanations as to how changes in governance systems impact SES conditions.

Meanwhile, interactions among each component of biophysical and social system directed by the governance system may fail and thereby reduce the robustness of the system (Anderies, John. M, Janssen & Ostrom 2004). Every SES component has its own unique role in the system. They have different capability to adapt to problems and changing conditions. In addition, even though the frameworks take into account the number and variation of components, the manner in which each component of biophysical systems and social systems work when adapting to external change remains unclear. It is not yet clear whether changes to either individual or multiple components have impaired or promoted SES conditions and vice versa. The current frameworks give no explanation of individual interactions which are significant, and whose existence is undeniable. These power dynamics and the way they shape action situations are not sufficiently addressed. Rather than defining the best context-specific interventions for SES governance, greater attention needs to be focused on the capacity of governance system to reconcile trade-offs of the increased scale and interconnectedness of resources and the growing number of actors involved in the system.

This article aims to develop a SES framework by extending the SES frameworks proposed by Ostrom and Anderies (Anderies, Janssen & Ostrom 2004; Ostrom 2007) to understand how policy instruments affect the condition of biophysical and social systems and their interactions. This paper is divided into four parts. The first two sections present background information relevant to the proposed new framework for understanding SESs and explains the new framework. The third section then discusses how it can be used to assess current governance systems. The conclusion discusses the implications of the proposed framework with respect to increased understanding of SES governance systems.

3.3 Policy Instruments as Rules of Interaction in Social-Ecological System Frameworks

In this article, SESs are conceived as dynamic systems involving interactions among resources (R), resource users (RU) and public infrastructure providers (PIP). The governance system through its policy instrument, represented by the interlinking arrows among components, aims to reconcile interactions within and between among R, RU, and PIP which are dynamic and

have different capacities to adapt to external factors (nature and social economic political settings). Thus, the governance system managing interactions between components within SESs can be deciphered by examining policy instruments.

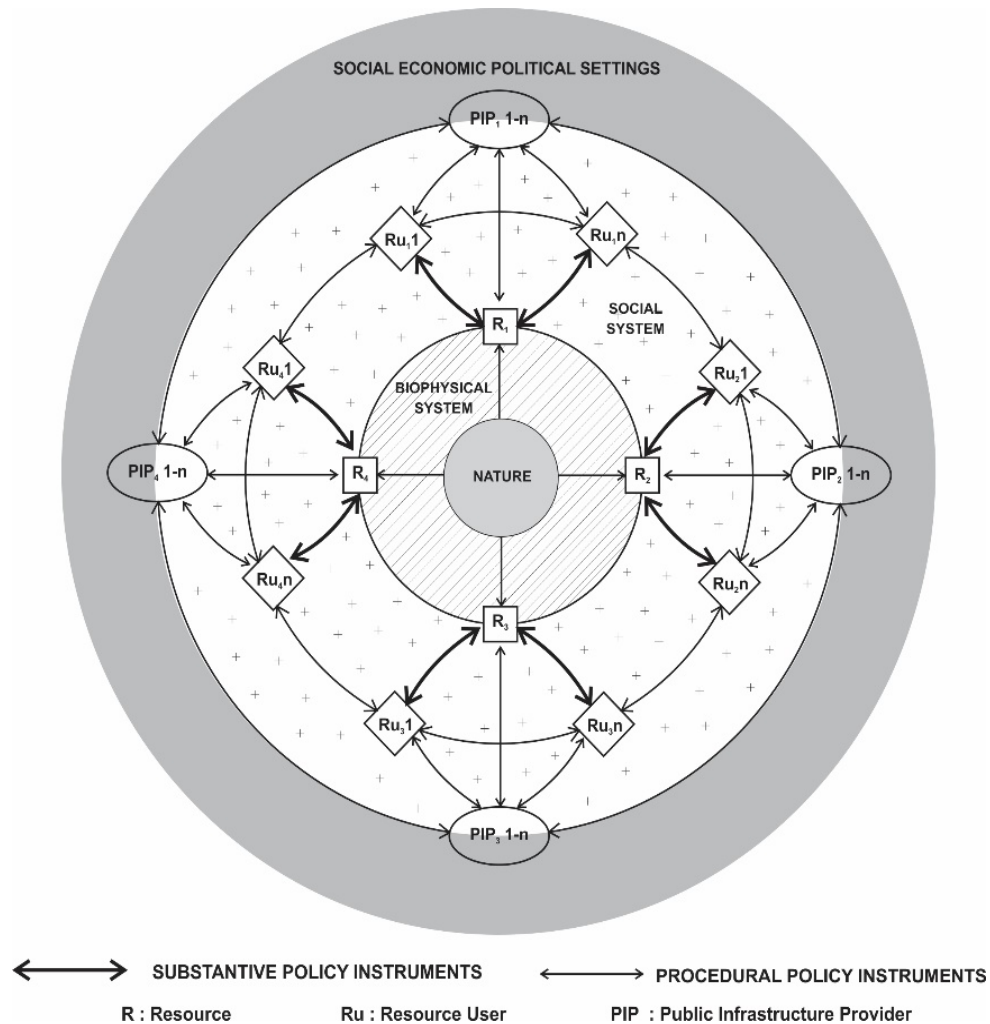


Figure 3. 1 Policy instrument as a rule of interaction in social-ecological system frameworks

As can be seen in Figure 3.1, we propose a four-tier system which is represented by four interlinked circles within the framework. The first tier (the inner circle) and the fourth tier (the outer circle) are the external factors: natural change, and social, economic, and political settings, respectively. Natural change affects the condition of the biophysical system (the second tier), while changes in social, economic and political conditions directly influence the social system (the third tier). The framework suggests that when there is a change in nature (e.g. climate change or a natural disaster) this impacts the biophysical system conditions (the second tier) and later its change impact the social system. Drought creates problem to the social system because it causes disturbances in water availability and other resources conditions. In the same way, changes in social, economic and political conditions may have significant, indirect impacts on the biophysical system through direct effects on the social system. The change in economic condition or political setting and population growth, for example, will influence social system conditions, in this case the condition resource users (RUs) and public infrastructure providers (PIPs). Subsequently, it will be responded by change in their manners in dealing with biophysical system.

In the framework (Figure 3.1), biophysical systems, represented in the second tier, are composed of resources and their interactions within the targeted resource system. Evidence shows that change in the condition of one resource is followed by change in condition of other related resources. For example, the relationship between vegetation cover and water balance in hydrological systems (Asmamaw, Mohammed & Lulseged 2011; Bieger, Hörmann & Fohrer 2013; Elmhagen, Eriksson & Lindborg 2015); and between water exploitation and ecosystem conditions (Davies et al., 2010). The way existing governance systems act through their policy instruments to ‘see and manage’ the resource system and the interactions between resources is represented by the interlinking arrows. Thus, the extent and manner in which the biophysical systems have been understood in governance system can be portrayed. This can be used as the information, for example in hydrological modelling, to reduce predictive uncertainty related to governance system exclusion. In this case, there will be different presentation (in arrows directions) in biophysical system between countries in which extractive actors are prevalent and countries where sustainable conditions become the objective.

The flexibility of the proposed framework facilitates real world representation of the multiple resources that require consideration when analysing or modelling a targeted SES’s governance. In practice, the detail with which the biophysical system is represented depends on the specific

question under investigation. A number of resources can be set up according to the issue under investigation (deductive) or all related resources can be considered in the resource governance structure (inductive). If a researcher wishes to examine government approaches in catchment management, for example, the related resources in the system would need to be further unpacked, in that case – land, water, and environment.

In the proposed framework (Figure 3.1), the social system consists of RUs and PIPs as the actors in resource governance, of which there can be a large number and variety, together with the complex interactions between them. Resource users (RUs) represent community, private or public sectors who utilize the resource (e.g: farmer, environmentalist in the case of water users). Meanwhile, public infrastructure providers (PIPs) represents both public or private sector who are given responsibility to manage the utilization of the resource which covers planning, implementation and monitoring. The condition of the social system is the result of interactions between and among RU_{1-n} and PIP_{1-n} . Thus, the dynamic conditions of actors - characteristics, number, scale and interconnectedness - need to be taken into account. Considering RUs and PIPs as entities obscures the significance of differences and unique characteristics of actors, their roles, interests and the power dynamic in their interactions in the SESs. Here, the framework takes into account the dynamic conditions of the actors involved in resource governance (RU_{1-n} , PIP_{1-n}) and their roles in the social systems. To what extent and how the interactions among and between RUs and PIPs in social system, which is significantly influenced by social, economic, political conditions, and have been directed in governance system can be portrayed through policy instruments (represented by the arrows) in reconciling their trade-offs.

As a governance tool designed to achieve targeted goals in certain conditions/problems (Hood 1983; Howlett 2005, 2010), policy instruments are context specific (Mukhtarov et al. 2015; Howlett 2005). There are myriad policy instruments used in policy formulation and policy implementation. Some of them are exemplified in Table 3.1.

Table 3. 1 Example of policy instruments

	<i>R</i>	<i>RU</i>	<i>PIP</i>
<i>R</i>	Catchment Management Area, Environment Protection Area, Conservation Area, etc	Licence/Permit, Incentives, Tax, User Rates, User Charges, Sanction, Penalties, etc	Boundaries, Report, Plans, etc
<i>RU</i>	Licence/Permit, Incentives, Tax, User Rates, User Charges, Sanction, Penalties, etc	Interest Group Creation, Public Enterprise, etc	Public Participation in Policy Process (Planning-Monitoring), Appeal Board, etc
<i>PIP</i>	Boundaries, Report, Plan, etc	Public Participation in Policy Process (Planning-Monitoring), Appeal Board, etc	Institutional Framework, Institutional Creation, Referral Authority in policy process, etc

In the policy formulation phase, policy instruments are designed to alter and affect the policy deliberations and the consideration and assessment of policy alternatives (Turnpenny et al. 2009) – later discussed as ‘procedural policy instruments’. Procedural policy instruments structure the way in which various actors are involved in policy making (without determining the outcome) (Klijn, Koppenjan & Termeer 1995). They affect and alter aspects of policy-making behaviour (Knoke 1990). Hence, they direct the behaviour within the biophysical system (R-R), between PIPs and Rs, and between resource users and public infrastructure providers (RU-RU, RU-PIP, PIP-PIP) in the social system. A management boundary is a good illustration of how a PIP deals with a R. A boundary is created by the PIP to support its performance in resource governance. In Australia water governance is a notable example of where a past management boundary was applied in a waterwork district. Another example is the institutional framework set up for resource governance. An institutional framework sets out how a PIP interacts with other PIPs in resource governance. Polycentric or centralistic types in resource governance, for example, can be differentiated by elaborating both instruments, so do top down or bottom up approaches in the interaction between RUs and PIPs.

While in the implementation phase, policy instruments are set to alter or affect the delivery of goods and services (Salamon & Elliott 2002) – later discussed as ‘substantive policy instruments’. Substantive policy instruments are government tools used to manage the behaviour of users in dealing with resources by affecting the nature, variety, quantity and delivery of resources. They are used to directly affect the actual substance of the kinds of day-

to-day production, distribution and consumption activities carried out in society (Howlett, Michael 2005; Kaufmann, Majone & Ostrom 1986). They are techniques or mechanisms which are designed to alter the behaviour of actors involved in those activities (Anne & Helen 1990). An example of substantive policy instruments is the implementation of licences in resource utilisation. A licence is a governance tool, which manages how resource users deal with a resource. Given that their function is to control how resources are utilised by users, substantive policy instruments play a major role in linking biophysical and social systems. The effectiveness of substantive policy instruments is a significant determinant to create pareto improvement in trade-offs between biophysical and social systems.

In the framework, substantive and procedural policy instruments are used to describe ‘the dialogue’ among and between Rs, RUs and PIPs (as in Figure 1). How the governance system directs the dialogue varies in accordance with different condition of Rs, Rs, and PIPs. At the same time, the SES conditions are also different as they are influenced by the cumulative outcomes of numerous policy instruments that influence the intricate interplay of multi-scale dynamic components within the biophysical and social systems. Both substantive and procedural policy instruments are sensitive to the dynamic changes of the system components to which they linked. Changes in Rs, RUs, and/or PIPs would therefore be followed by changes in their policy instruments and vice versa. Further, changes in resource conditions or resource systems will be followed by RU and PIP adaptations within the social system. Here, the effects of policy instruments are not limited to changes in the conditions of directly managed components. Changes in policy instruments creates a disturbance that propagates through the SES. Therefore, we argue that policy instrument is an emergent property of the SES as it reconciles trade-offs among Resources (R), Resource Users (RU), and Public Infrastructure Providers (PIP) in SES. Dynamic interactions in SES can be represented by policy instruments.

By clarifying the structure of the components of the SES and the policy instruments used to manage their interactions, the framework presented a template to examine their resource governance systems and gain greater knowledge of these complex systems with the aim of improving existing governance based on empirically supported answers to several questions including:

1. To what extent and how has the biophysical system been understood and how has the social system been set up for resource governance?

2. Has every related or influenced resource, resource user and public infrastructure provider been considered in resource governance?
3. To what extent and how has the trade-off among and between related resources, resource users and public infrastructure providers been accommodated by policy instruments?
4. To what extent and how does the change of the policy instrument direction in one component affect the condition of other components and indirectly the robustness of the SES? How do external conditions affect the condition of the biophysical and social systems and the robustness of the SES?
5. To what extent and how has a policy instrument considered the interaction among components in SES? For example, what kind of interactions between PIPs responsible for land and water governance have been built into the policy instruments? Are they reciprocal? Or does one component outweigh other components?
6. To what extent and how robust and sustainable is a particular configuration of policy instruments in directing dynamic biophysical and social conditions in resource governance?

3.4 Applying the proposed framework to examine SES governance

In this section, we will demonstrate the applicability of this proposed framework in improving SES governance by examining how biophysical systems have been understood in social systems, how social systems respond to resource interdependencies in biophysical systems, and how resource governance understands the conditions of the biophysical and social systems within the targeted SES.

3.4.1 Resource interdependency manifestation in SES governance

A system is composed of interrelated resources, and each resource influences the condition of other resources in the biophysical system. Relationships between resources can be classified as strong to weak, and as mutualism or predation (Ostrom, 1990). Depending on the nature and strength of the relationships with other resources, some resources can be managed without consideration of their impact on other resources. This may be the case with natural gas or oil. In contrast, land, vegetation and water are strongly connected, such that changes in vegetation cover affect the hydrological cycle (Bieger, Hörmann & Fohrer 2013; Farley, Jobbágy &

Jackson 2005; Zhang, Dawes & Walker 2001). This is an example of a situation in which neglecting resource interdependence in SES governance can lead to complications.

The interdependence among resources expressed in policy instruments can be investigated using the proposed framework. Because of its flexibility in considering a number of resources, the proposed framework can be used as a tool to examine how interactions between different resources in a biophysical system have been understood and reflected in policy instruments. For example, how policy instruments used in governing land (R_1) consider the condition of water (R_2) and the environment (R_3), and vice versa. The interactions among resources in policy instruments can be further examined with respect to whether they have no linkages, reciprocal (two-way linkages), or where one dominates the other (one-way linkages). When there are no linkages, policy instruments are not designed to take other resource policy instruments into account (Figure 3.2a, 3.2b). In contrast, as land and water are interdependent resources, policy instruments should aim to achieve sustainable conditions for both resources simultaneously (Figure 3.2c). Further, parasitic interactions can occur when one resource outweighs the governance of other resources. For example, when water governance is used to provide or support land governance, but land governance does not influence water governance (Figure 3.2d). Governance systems need to reflect the structure, properties and processes of the natural resource systems within their ambit (Ekstrom & Young 2009). How policy instruments take into account resource interdependency can be examined through the existence of the linkages and arrows between them.

3.4.2 Conflicts of interest among involved actors in resource governance

One of the most challenging issues in resource governance is the increasing scale and interconnectedness of the various actors involved (RUs, PIPs) in the social system and managing the trade-offs between them in managing the resources. Coordinating public policy providers is not an easy task as every PIP is nested within a system of rules, beliefs, values, and interests which limits their ability and incentive to accept other PIPs (Howlett, Michael 2009). Policy instruments need to be arranged so that the values and interests of different PIPs are accommodated, while ensuring that policy instruments are not contradictory. Success is dependent on how effectively existing policy instruments manage these trade-offs, so that all actors involved can benefit or pareto optimum can be achieved.

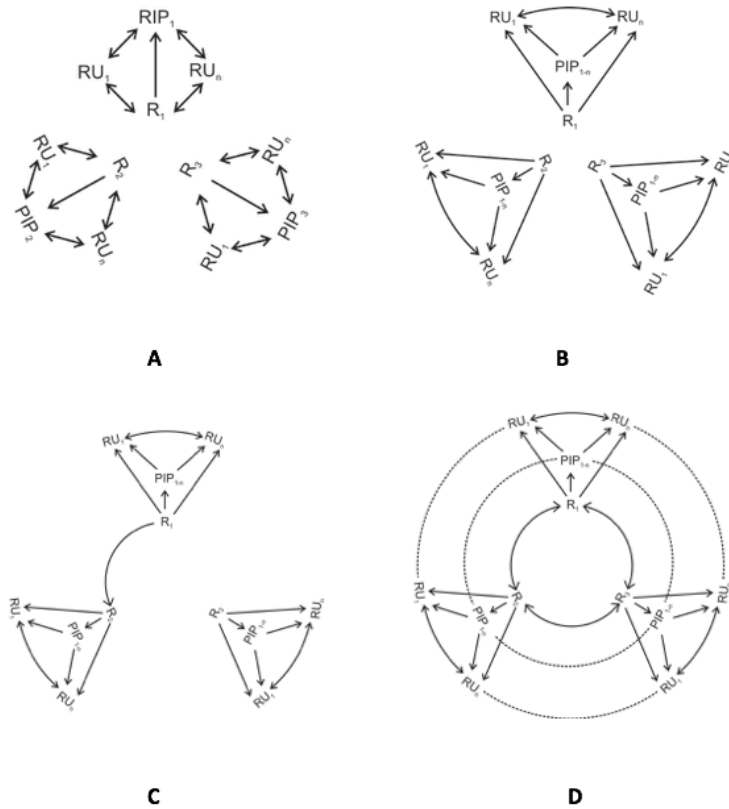


Figure 3. 2 Resource interdependency manifestation in SES governance

The collaboration or conflict among RUs and among PIPs can be examined with the proposed framework in which they are represented by the policy instruments. Continuing the previous example, we assume at least three different PIPs are involved, being the PIP responsible for land (PIP_1), PIP responsible for water governance (PIP_2), and PIP responsible for environmental governance (PIP_3). Several types of institutional frameworks could be generated from the interactions between these three PIPs. Public infrastructure providers responsible for those three resources may exist under different authorities or within the same authority. This means that different resources (e.g. land, water, and environment) may be governed by the same PIP (Figure 3.3a), while under another framework a resource may be managed by several different PIPs (Figure 3.3b). By examining procedural policy instruments, how land, water, and environment interdependencies structure the way in which these three different PIPs are involved in policy making in the social system can be identified (Figure 3.3). To what extent is the policy process of the PIP_2 responsible for water intervened with by PIP_1 and PIP_3 ? Is this a reciprocal relation (Figure 3.3c) or does one outweigh/dominate the other (Figure 3.3d), or are there no interactions among them (Figure 3.3b)? By describing the linkages among PIPs in the social system, the proposed framework can be used to diagnose the efficacy of the

institutional framework of resource governance. The proposed framework allows for examination of the behaviours of resource users (RUs) and public infrastructure providers (PIPs) in the social system (the third tier in Figure 1) which differ depending on their context (Bressers & O'Toole 1998), as influenced by the social, economic and policy settings (the fourth tier) (Howlett, Michael 1991). As the trade-offs occurring among involved actors in social system is sensitive to their conditions when adapting to social economic and political setting, a preferable optimum condition varies among different social system.

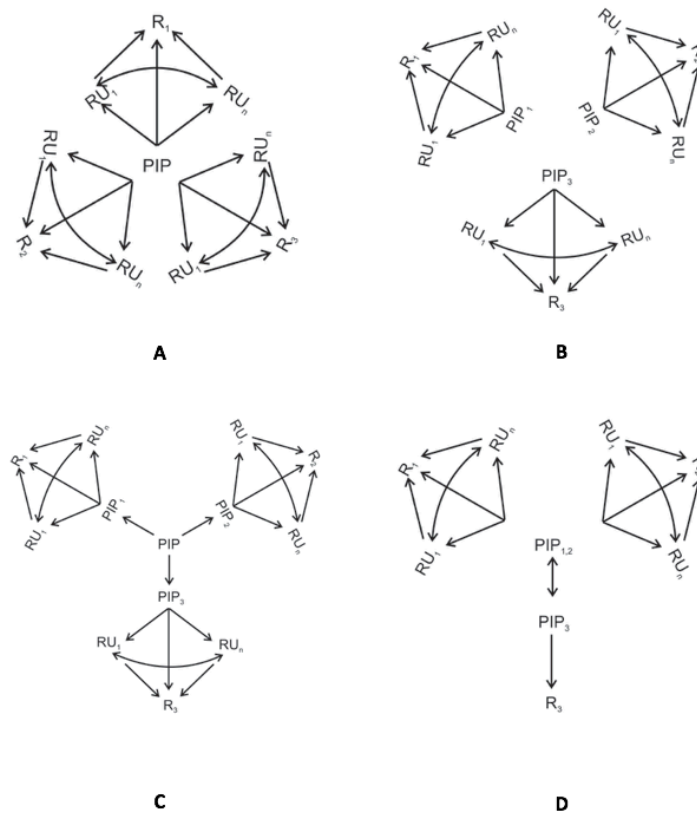


Figure 3. 3 Institutional framework variations in SES governance

3.4.3 Trade-offs and synergies between the biophysical and social system

Resource sustainability is a function of resource supply (biophysical system) and demand (social system). A resource can be sustained whenever the trade-off does not exceed the tipping point (Scalr, Volavka-Close & Brown 2013), while maintaining mutual benefits between the biophysical and social systems (Agarwal et al. 2000). In the past, when biophysical systems were not exposed to excessive human intervention, the SES's resilience toward natural

perturbations (the first tier in Figure 3.1) was managed by natural processes affecting the interrelated resources within the resource system (the second tier Figure 3.1). Resource sustainability results from the interactions among resources (the second tier) adapting to changes in the first tier. Over time, the increasing population and number of actors involved, and the interactions among them represented in the social system (the third tier Figure 3.1) have dramatically increased the impacts of social system change on the biophysical system conditions. The more actors involved the greater the number of interactions. Currently, the condition of the social-ecological systems is not only the product of natural change but also of the accumulative impact of past human activity (Acar 2017; Broderick 2005; Dovers 2000; Goudie 1981; Young, OR 2002). These increasingly intense interactions between the second and third tiers are directed by substantive policy instruments which rule the actual substance of the kinds of day-to-day production, distribution and consumption activities carried out in society. Substantive policy instruments, therefore, play a significant role in maintaining sustainability through the creation of trade-off mechanisms balancing supply (biophysical system) and demand (social system). Thus, the resource condition is dependent on how the social system has been framed to deal with the biophysical system, and vice versa. The preferable pareto optimum in trade-offs will differ depending on the unique condition of the biophysical and social systems.

Different conditions of biophysical and social systems result in different interactions among them. This can be exemplified by different configurations which are represented by different conditions in the governance system (Figure 3.4). In resource governance – when the focus is on the production function – policy instruments are directed by the social system (PIP interests) rather than the condition of the biophysical system (Figure 3.4a). On the other hand – when conservation is the focus of resource governance – balancing resources is the main consideration in creating policy instruments (Figure 3.4b). Therefore, how the biophysical system is framed manifests in the interaction between components of the social system, in particular the interactions between and among RUs and PIPs. Further, resource sustainability depends on the function of the interactions within and between resource supply in the biophysical system and demand from the social system. Thus, the configuration of policy instruments can inform the roles of Rs, RUs, and PIPs in SES governance, as represented through the lines and arrows in Figure 3.4.

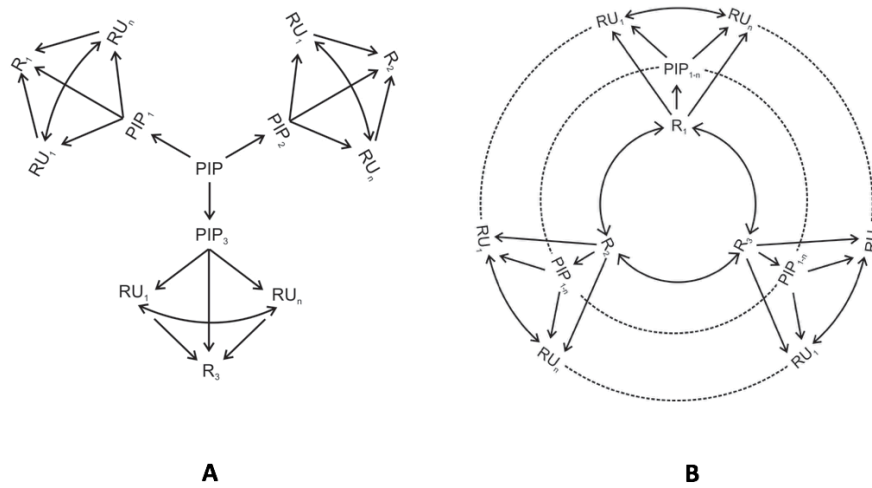


Figure 3. 4 Governance functions and the configuration of policy instruments in SES

Thus, different policy instruments are often required to manage the demand and supply of a resource depending on the context of the particular biophysical and social systems in which they are implemented. For example, the variation in policy instruments used in water governance across different biophysical systems as water resource conditions vary across regions. In regions where water is scarce, policy instruments focus more on water security and water efficiency in order to address sustainability, such as by applying water caps or user charges. In this context, the focus for the formation of policy instruments is to minimise impacts on the biophysical system conditions (the second tier in Figure 3.1), rather than social system conditions (the third tier in Figure 3.1). In contrast, in regions where water scarcity is not a concern, the main focus of policy instruments is more likely to be on social system conditions (the third tier in Figure 1), rather than biophysical system conditions (the second tier in Figure 3.1). In this context, substantive policy instruments may focus more on the promotion of effective and efficient water utilisation and distribution, such as water entitlements and water licences/permits. The absence or failure of substantive instruments in the latter situation can result in asymmetric water availability and accessibility (Kobayashi 2014), which can endanger social system sustainability and lead to detrimental consequences for the biophysical system (e.g. illegal groundwater exploitation if current surface water allocation is inequitable). The same policy instrument can therefore produce different outcomes when applied in a different social system (Kobayashi 2014), which can endanger social system sustainability. For example, the implementation of water meters as a policy instruments in water governance. Even though water meters have been used successfully to manage

interactions between resources and resource users (substantive policy instrument) in some countries, this instrument may not be appropriate in other countries with poorly implemented monitoring systems.

Expanding the analysis to two or more interdependent resources, the framework can also help to examine how the configuration of the chosen policy instruments can accommodate unique interactions between resources interdependencies in the social system, or how the social system (including existing policy instruments) interacts with the biophysical system.

3.5 Conclusion

It is vital to understand the different types of governance system failures and how they lead to the loss of robustness in SESs. Further, we need a better understanding of the role of policy instruments and their configuration in governance systems in leading to different SES conditions. By including policy instruments into the SES framework, the proposed framework can help visualise: (1) how the biophysical system has been understood in resource governance; (2) how the social system has been set up in resource governance; and (3) how the trade-off between dynamic biophysical and social systems has been managed in the governance of SESs. The proposed framework helps in analysing not only how well interactions within components of the biophysical and social systems are accommodated by policy instruments in supporting a sustainable condition, but also for identifying any absence, overlapping or contradictory policy instruments in the governance of the SES. Drawing pareto sets, through deciphering the interactions of SES components, can support the development of more robust human environment modelling.

Chapter 4

The Evolution of Policy Instruments Used in Water, Land and Environmental Governance in Victoria, Australia from 1860–2016

This chapter has been submitted as the following article:

Ratri Werdingtyas, Yongping Wei, Andrew W. Western, 2019. The Evolution of Policy Instruments Used in Water, Land, and Environmental Governance, *Environmental Science and Policy* (under review)

4.1 Abstract

Debate continues regarding which policy instrument should be used to ensure land, water, and environmental governance that promotes the sustainability of social-ecological systems (SESs). Studies on policy instruments and SES frameworks have played important roles in the theoretical development of natural resource governance systems. They, however, have been considered in isolation from one another. This study aims to bridge between the two by interpreting policy instruments as rules of interaction in a social-ecological system. Specifically, a longitudinal study of Victorian Acts was conducted to understand how policy instruments for land, water, and environmental governance adopted from 1860 to 2016 worked in the governing SESs. Through a content analysis of the Acts, we constructed a simple typology of the ways in which policy instruments manage components of SESs. This typology includes the reserve regime, authority regime, information regime and integration regime. The study shows the circumstances under which interactions among components of biophysical and social systems deserve attention as partial shapers of policy instruments. The present work can be used to understand, examine and reflect on policy instruments currently used for resource governance and to make strategic improvements that account for current conditions rather than adopting new policies without understanding the existing context.

4.2 Introduction

Water, land and the environment are key natural resources of a catchment social-ecological system (SES). Globally, over two thirds of catchment systems have been degraded due to human intervention. Urgent action is needed to enhance human capacities to govern these natural resources now and, in a future, dominated by socio-economic and climatic change. Resource governance is likely to continue to transform as it is influenced by changing biophysical condition (such as drought, salinity) and the evolving social political environment. For example, some important socio-political influences in Victoria, Australia (where our case study is conducted) have been the strengthening environmental movement, the Paterson reforms separating water policy from supply functions, and more recent COAG reform in Australia (Connell, 2011; Robin, 2013; Tisdell, Ward, & Grudzinski, 2002). The ongoing transformation is reflected in changes in legislation, policies and institutional arrangements. The history of the establishment of government agencies, such as Land Conservation Authority, Catchment Management Authorities and the change in the concepts of ‘natural’ water rights demonstrates that organizations and policies have changed considerably with time (Connell, 2011; Holley & Sinclair, 2018; Powell, 1989). Debate continues on which interventions for land, water, and environmental governance better promote the sustainability of catchment SESs (Ekstrom & Young, 2009; Folke, Pritchard, Berkes, Colding, & Svedin, 2007; Mitchell, 2005).

The presence of governance to mediate interactions between biophysical and social systems is represented in policy instruments. The over-consumption of water resources, pollution of waterways, declines in aquatic ecosystems and many social issues such as conflicts of interest among resource users, imbalances or disparities in water allocation, and political tensions among regions are the consequences of policy instrument failures in shaping the behaviors of complex and dynamic human-environment interactions (Cooper & Crase, 2016; Dovers, 2000; Robison et al., 2014; van der Brugge, Rotmans, & Loorbach, 2005; Wallis, Ison, & Samson, 2013). The degradation of catchment ecological systems is the result of a failure of policy instruments to govern interactions between and among components of biophysical and social systems adequately (Dovers,

2000; Horne, 2012, 2013; Sewell, Handmer, & Smith, 1985; van der Brugge et al., 2005; Young, 2000). Previously, several attempts to classify and design policy instruments have been made which did not consider the contexts where they are implemented (Gunningham, Sinclair, & Grabosky, 1998; Hood, 1983; Ripley, 1966). However, the choice of available policy instrument is constrained by the context. The same policy instrument, if used in one context, would not necessarily produce the same outcomes in a different context (Bressers & O'Toole, 1998; Linder & Peters, 1989). Thus, these classifications do not help in understanding what enables successful resource governance – in particular, the way in which institutions modify existing policy instruments or create new policy instruments.

There have been increasing studies on policy instrument design to cope with these complex, dynamic and cross-cutting social-environmental issues. It is agreed that specific policy instruments are often targeted to particular problems and objectives (Hood 1983; Howlett, Michael 2005, 2010). Thus, there tend to be multiple policy instruments in play and, in practice, the accumulated instruments may be either compatible, complementary or counterproductive with one another, in terms of the objectives and targets of the whole system. It is also found that policy instruments are the product of government learning processes in coping with specific problems that have arisen over time and in adapting to changing conditions (Borrás & Edquist, 2013; Bressers & O'Toole, 1998; Howlett, 2010; Landry & Varone, 2005; Linder & Peters, 1989). Policy instruments can gradually evolve with changing conditions and problems in an environment in which stability and change are bound together (Hill, 2013; Mahoney & Rueschemeyer, 2003). Depending on its genesis, each policy instrument has its own development pathway (Mahoney & Thelen, 2010). Thus, policy instruments are context specific. Policy instrument selection is dependent and driven by the situation involving multiple actors (Mukhtarov et al. 2015), and the precedence of past problem definition and past interventions by previous actors (Junginger, 2014). Understanding the effectiveness of these combined policy instruments requires a systemic and long-term investigation of the pathways through which current policy instrument have been developed from previous ones (Dovers, 2000; Ellis, Cripps, Russ, & Broom, 2016; Kallis, 2010; Ross & Connell, 2016; Underdal, 2012; van der Brugge et al., 2005; Xia & Pahl-Wostl, 2012). Finally, it has recently been argued that

policy instruments do not work in isolation in SESs where they are applied, rather they interact together. The effectiveness of policy instruments depends on their acceptance and appropriateness to the surroundings: the biophysical and social systems (Blomquist, Dinar, & Kemper, 2005; Flanagan, Uyarra, & Laranja, 2011; Howlett, 2009; Landry & Varone, 2005; Nickson & Vargas, 2002).

Meanwhile, a large and growing body of literature has investigated the governance of SESs in reference to adaptive governance (Folke, Hahn, Olsson, & Norberg, 2005; Koontz, Gupta, Mudliar, & Ranjan, 2015; Pahl-Wostl, 2007; Scholz & Stiftel, 2005), polycentric governance (Ostrom, 1990), collaborative governance (Fish, Ioris, & Watson, 2010), integrated management (Mitchell, 2005; Nathan, Owen, Maria Carmen, & Donald, 2011), and policy integration (Briassoulis, 2004; Jordan & Lenschow, 2010). Nevertheless, there is still a lack of knowledge on how a policy instrument can be most effectively improved in the context of its relationships with other previous and existing policy instruments, and on the capacity of policy instruments to engage with, and respond to, dynamic problems and conditions in SES governances.

In this article, we aim to address this knowledge gap by using policy instruments as a rule of interaction in a social-ecological system for improving the sustainability of SESs. Specifically, a longitudinal study of policy instrument development for land, water and environmental governances in Victoria, Australia for 1860-2016 was conducted. Understanding the Victorian journey to manage the interaction among components of SES in land, water, and environmental governance has potential to provide useful lessons for other regions globally that are undergoing similar concerns in synergizing and optimizing their natural resources use.

4.3 Methods

4.3.1 Theoretical framework

A theoretical framework relating policy instruments to components of SESs for water, land, and environmental governances is given in Figure 4.1. The framework is proposed

to provide template in examining the actual state of governance system in managing dynamic SES components and their interaction. In the framework, the governance of SESs is represented by the configuration of policy instruments used to rule interactions occurring within and between bio-physical systems and social systems and in this case between and among resources (R_{1-n}), resource users ($Ru_{11} - Ru_{nn}$) and public infrastructure providers (PIP_{11} - PIP_{nn}). Here, public infrastructure providers represent government agencies/authorities who responsible for managing utilization of the resource at national, state to local levels. We focus on policy instruments that have been used to govern resource utilization (substantive policy instruments) and behaviors throughout the policy process in terms of resource governance (procedural policy instruments). Substantive policy instruments directly affect the activities conducted in society regarding day-to-day production, distribution and consumption related to the resource, such as licensing, limits or encouragement, subsidies, quotas, standards, rules, rates and taxes (Howlett, Michael 2005; Kaufmann, Majone & Ostrom 1986). Procedural policy instruments affect the content or process of policy implementation and the way policy making is undertaken; including procedures for influencing network formation, changing actors' interactions and adding actors to policy networks (Klijn, Koppenjan & Termeer 1995). We regard policy instruments as the result of choices made based on governments' learning processes from managing dynamic human-nature interactions in resource governance. Thus, an investigation of policy instruments can offer insight into how the interconnections between components of biophysical and social systems have been accommodated.

The integration of policy instruments for land, water, and environmental governance should be considered, as these resources are interdependent within catchment social-ecological systems (Mitchell, 2005; Raini, 2009). Furthermore, even though their interdependence has been acknowledged, the policy instruments targeting them are dependent on government learning processes in understanding these human-nature interactions. Therefore, to understand how policy instruments have been improved for land, water and environmental governance, it is necessary to understand how the interactions among components of biophysical and social system have been set in their governance.—.

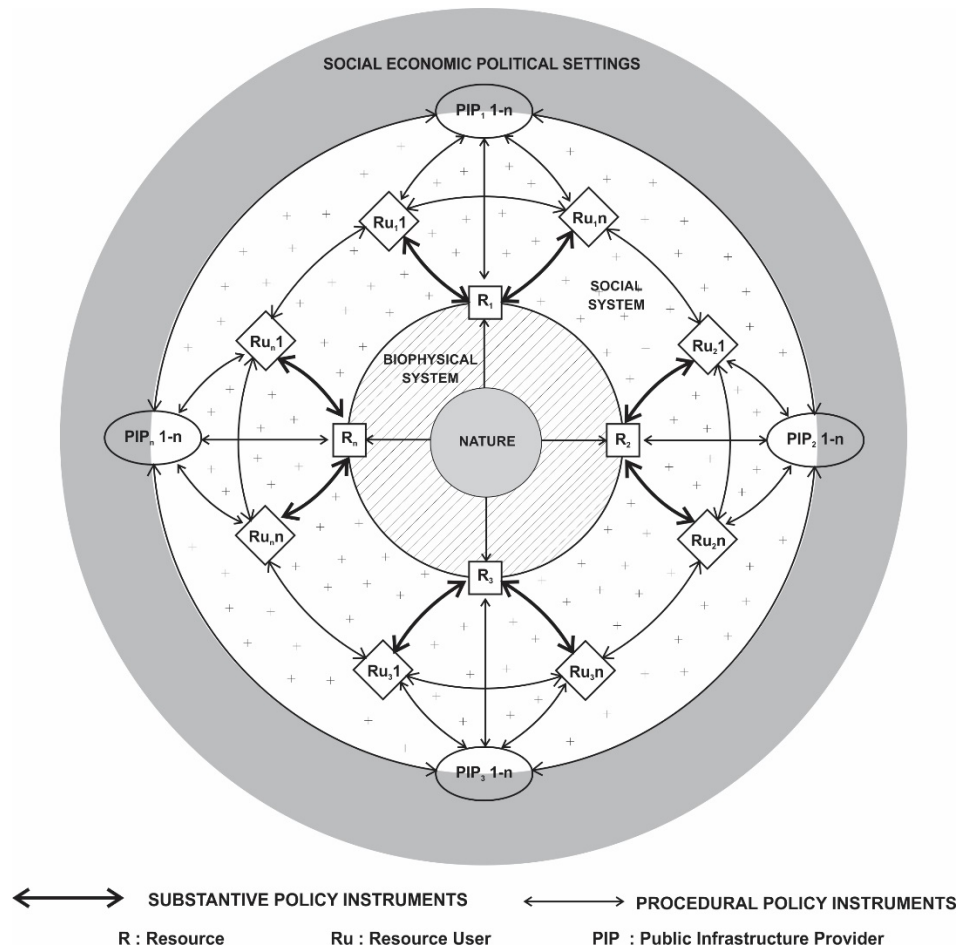


Figure 4. 1 Policy instruments as a rule of interaction in a social-ecological system

4.3.2 Water, land and environmental governance in Victoria, Australia

Australia has been recognized worldwide as a pacesetter in water reform and land and environmental governance. Environmental consequences resulting from extensive land clearing and major development of water resources and irrigation have led to changed approaches to resource governance. The history of the past century has shown that Australia has shifted emphasis in resource governance from a focus on maximizing resource use to the better management of available supplies (Pigram, 2006; Powell, 1989), in which water, land, and environmental governance are a major part.

Different forms of governance inform different learning process involving changing conditions and problems in SESs. In terms of biophysical and social changes, Victoria has experienced the most significant changes among all states in Australia. Deforestation

in Victoria has resulted in the destruction of half of all forests in the state over the past century (Sinclair, White, Medley, Smith, & Newell, 2012). The extensive construction of water reservoirs and other water resources developments to cope with drought and flood from 1866 to 1983 has also strongly influenced water flows (Department of Water Resource Victoria, 1989). These interventions have resulted in the formation of a vastly modified river system, and in far-reaching environmental consequences. At the same time, Victoria's growing population has placed pressure on resource governance. Victoria's recorded population was only 1,264 in 1837 and reached nearly 6 million in 2016 (the indigenous population was not acknowledged or counted). Therefore, investigating regime shifts in the evolution of Victoria's policy instruments for water, land, and environmental governance can offer clear insights on how such policy instruments have been developed over time to cope with complex, dynamic and cross-cutting social and environmental problems.

4.3.3 Study period

As policies are transformed and reconfigured through a gradual process, a long-term period spanning the 1860s to 2016 was adopted as our study period. The 1860s was selected as a starting point as the Land and Waterworks Acts of 1862 were enacted in Victoria to regulate land and water utilization..

4.3.4 Data sources and data retrieval

We used acts as the data sources in this study as acts serve as the main statutory instruments that govern land, water and environmental governances in Victoria. The Acts is the foundation in the formulation of subordinate legislation or (technical) regulations that should be followed by every resource user (RU) and related public infrastructure providers (PIP) including private sector in their actions. We focused on the substantive and procedural policy instruments used by the government to govern the interactions among and between components of social-ecological systems (resources, resource users, and public infrastructure providers) for adapting to changes in biophysical systems and to socio-economic settings. For example, for seeking license permit approval, the private sector (RU) should seek approval from PIP, they need to follow policy instruments used

to rule their interaction (RU – PIP). It applies also how the user interact with other users (RU-RU) or the interaction among PIPs (PIP-PIP).

All Acts enacted since the first European settlement in Australia are published online and are freely accessible from www.austlii.edu.au. Thus, we used this resource as our primary data source to identify policy instruments for land, water, and environment governances. The data retrieval process is shown in Figure 4.2. A total of 489 Victorian Acts enacted from 1860 – 2016 were selected based on their title containing at least one of the keywords used (Table 4.1). The keywords “land”, “water”, and “environment” were applied to conduct our first search, from which we identified 366 Acts. We then applied a second list of keywords that were identified from the first search related to land, water, and environmental governance: “crown”, “forest”, “drainage”, “irrigation”, “river”, “catchment”, and “flood”. To ensure that the policy instruments identified focused on Victoria, we excluded Acts concerned with cross-boundary or local issues (e.g., the River Murray Act, Loddon–Campapse Regional Planning, and the Murray Darling Basin Act). It should be noted that the amendments of the selected Acts were not counted when determining the number of Acts (489), but the amendments were coded. While the enactment of the Acts may lead to subordinate legislation (for example regulation formulated as a follow-up action after the enactment of an Act), our analysis was confined to the Acts as the foundations in the formulation of (technical) regulations.

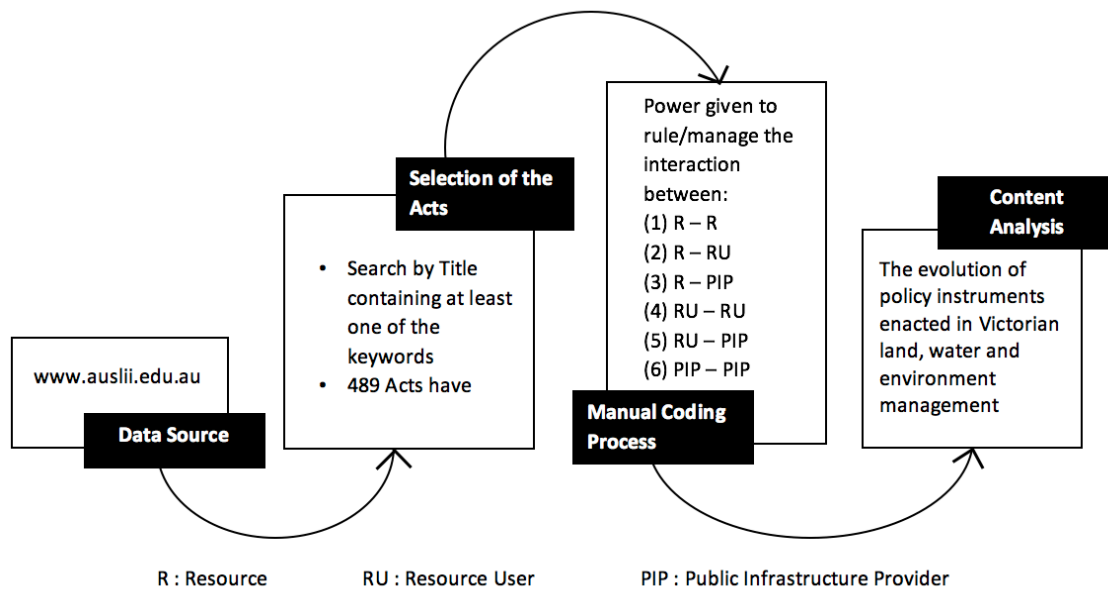


Figure 4. 2 Data retrieval and coding process

Table 4.1 The search results

First Search Keywords	Number of Acts	Second Search Keywords	Number of Acts
Land	188	Crown	10
Water	168	Forest	82
Environment	10	Drainage	19
		Irrigation	1
		River	7
		Catchment	1
		Flood	3

4.3.5 Content analysis

Acts related to land, water and environment governance were examined through a content analysis to identify policy instruments and to classify them. As noted in Section 2.1, SES governance in the framework is represented by the accumulated policy instruments implemented to rule the interactions between components of SESs: resources (R), resource users (RU), and public infrastructure providers (PIP). In this study, we used an inductive approach, instead of a deductive approach which is based on the categorization of policy instruments in the literature (Gunningham et al., 1998; Hood, 1983; Ripley, 1966), to categorize the policy instruments. Following grounded theory, all extracted Acts were manually read to identify government interventions and were classified based on interactions between SES components. Our first coding task was to identify terms included in the content of the Acts corresponding to government interventions governing interactions among: (1) resources and other resources (R-R); (2) resources and resource users (R-RU); (3) resources and public infrastructure providers (R-PIP); (4) resource users and other resource users (RU-RU); (5) resource users and public infrastructure providers (RU-PIP); and (6) public infrastructure providers and other public infrastructure providers (PIP-PIP). Six government policy instruments were identified from the examined Acts. The substantive policy instruments included licenses/permits, user charges, rules, reports and plans and procedural policy instruments included institutional frameworks and boundaries. Then we examined the policy instruments in land, water, and environmental governances separately to understand their changes over time. For the specific coding procedures used, please see Figure 4.2.

4.4. Results

4.4.1 Policy instruments used for Victorian water governance

The Water Act, enacted over the period 1860s to 2016, is Victoria's main statutory policy for water governance. This Act covered policy instruments that ruled interactions among water resources, water users and public infrastructure providers responsible for supply, distribution and conservation (see the supplementary material for the list of Acts). Over the past century these Acts have emphasized the use of six policy instruments for water governances. Four policy instruments are identified as substantive policy instruments, as they have played a role in determining daily practices. They include (1) grants, easements and licenses, (2) user charges, (3) rules, and (4) reports and plans. The other two are procedural policy instruments used to alter the behavior of social and biophysical systems of decision-making and include (1) institutional frameworks including mechanisms of information distribution among stakeholders and (2) boundaries.

The evolution of Victorian policy instruments enacted in water governance took several forms (see Table 2). First, no significant differences between instruments used over the last century were identified, with the same policy instruments used from the early settlement period to the 2010s as the means to manage users' actions in dealing to resources (substantive policy instruments). The amalgamation and merging of public infrastructure providers and the creation of new authorities and management boundaries has been undertaken in attempts to improve Victoria's water governing processes (procedural policy instruments). Second, four different regimes were identified: (1) policy instruments determined by resource conditions (1860s – 1900s); (2) policy instruments shaped mainly by authorities or from public infrastructure providers' perspective (1900s – 1970s); (3) the importance of information for operating policy instruments (1970 – 1980s); and (4) the importance of the coordination or integration of biophysical and social systems in operating policy instruments (1980s-2016). Third, all policy instruments of Victorian water governance covered similar periods of time in their respective evolution (see Table 4.2).

Table 4. 2 Evolution of policy instruments of Victorian water governance

Regime shift	Reserve	Authority	Information	Coordination and Integration
	1860 – 1900s	1900s – 1970s	1970s – 1980s	1980s – 2016
Licences, permits, grants, and easement	Authorisation to utilise resources through licences, permits, grants, and easement is granted as long as extractable water resources are available. No considerations are made except regarding the complementarity of demand (plans proposed by users) and supply (water-resource availability).	Both the availability of water resources and the flow of water and its use are directed by a public-infrastructure provider – the State Rivers and Water Supply Commission (SRWSC) under the Governor in Council approval.. The amount and timing of water access by water users is determined by public infrastructure providers (e.g., water entitlements and the duration of water licences are fixed by the SRWSC). In addition, areas to be granted more water are determined (during water shortages).	Allowable water extraction by water users through licences, permits, easements, and grants is determined from water-assessment results. From 1975, the Minister of Water Resources and Water Supply as the primary authority (PIP) responsible for allocating water. In allocating water, the Minister conducts water assessments throughout the state (information for water governance).	Licences, permits, grants and easements for managing resource users’ resource utilisation are granted based on comprehensive information gathered from related involved stakeholders, related resource conditions and the perspectives of public infrastructure providers involved in water management.
User rates	The user rate is determined according to the costs and expenses of waterworks. The costs or expenses of waterworks are divided equally among users.	Rates are differentiated into several divisions, in terms of benefits derived from works constructed for services of the district as determined by public-infrastructure providers.	Rates are applied based on information on resource conditions and circumstances gathered by responsible authority, in this case water authority (PIP) and the Minister for Water.	Rates are applied based on information on resource conditions and circumstances in coordination with other related authority/PIP (for example, water rates are influenced with land rates). Water rates serve as property rates (the value and size of property), and as times or rates at which water can be used. Service rates are implied (tariffs on serviced properties, a development tariff on unserved district properties, a tariff for drainage or

				salinity mitigation for district properties, and a tariff on properties supporting a management plan for a groundwater-supply protection area) and fixed by providers according to the value or size of property or by an amount fixed according to the extent of use based on benefits gleaned from the service or revenues determined by public-infrastructure providers.
Rules	Limitations on water diversion are applied based on natural flows.	Rules on water apportionment are determined based on the public-infrastructure provider's perspectives or concerns (e.g., how much water is distributed and water entitlements to the licence holder are fixed based on the authority/PIP's concerns). In 1928 providers established that no less than one-half and no more than three-fourths of available resources could be apportioned as water rights pro rata. In 1946 this was changed to no less than one-third and no more than three-fourths of available resources with the remainder apportioned as water rights pro rata. In addition, authorities can assign water resources (e.g., the provider can allocate additional water resources to areas with salinity issues).	Water apportionments are allocated by the Minister based on information gathered by the Water Resource Council, which advises the Minister on matters pertaining to state water resources, water supply drainage, and state sewerage.	Water management schemes and water entitlement and licences are decided based on assessment result of: • Current and future water resources • Environment and conservation considerations • Water quality considerations • Any other relevant report or statement prepared under any Acts, such as the catchment strategy under the Catchment and Land Protection Act 1994 • Political concern (the preferred allocation of water resources or anything else that the Minister decides is appropriate)
Plans and reports	Plans as requirements represent users' views on resource conditions (e.g., individual maps and waterworks plans – proposed	Plans are used by authorities to allocate water among users. Content and requirements are fixed by authorities (e.g., the River Improvement District Plan and Irrigation and Water Supply District Plan).	Plans acted as authoritative tools (in this case the Minister for Water Supply) to manage and improve water resources in Victoria (e.g., water-management schemes).	Plans are used to form sustainable socio-ecological systems (e.g., the Regional, Catchment Management Plan). Reports are periodically created to support authorities' decision-making

	by the Trust or involved individual).	Reports are drafted when required by the authority/PIP to meet its objectives (e.g., land registration and the SRWS report).	Reports are used to gather information to support water assessment processes.	(e.g., the catchment and land protection board, catchment management authorities).
Boundaries	Boundaries for management are established based on resource conditions (e.g., the formation of Irrigation and Water Supply Districts – proposed by the involved individual/trust).	Management boundaries are established by authorities (e.g., the Minister of the Crown’s formation of the Irrigation and Water Supply Districts Trust).	The establishment of boundaries is based on information to manage and improve water resources in Victoria (e.g., water catchment areas and land for conservation purposes).	Boundaries for management are created to form sustainable socio-ecological systems (e.g., Water Supply Districts, Waterway Management Districts, Water Sewerage Districts, Irrigation District Areas of Interest, Environment and Recreational Areas, Ground Water Supply Protection Areas and Regional Catchment and Land Protection Regions).
Institutional frameworks (including the role of information in decision-making processes)	Institutions for water management are established based on resources (e.g., the establishment of a waterworks trust proposed by the relevant individual or council as a means to access water). As institutions were incrementally established based on demand, only water-resource availability is considered.	Institutions for management purposes are established by the government (e.g., the establishment of the SRWSC for consolidating land and water-use practices). Information was collected by the SRWSC as required for its functions.	Institutions are held responsible for gathering information needed to support decision-making. The Minister of Water Resources and Water Supply supported by water resource councils is established to assess water resources and the environment in connection with waterways and to form water-management schemes. Information gathered by authorities is central to the internal decision-making process.	Institutions perform three different decision-making functions: planning authority, responsible authority and referral authority. The Minister for Water acts as a responsible authority/PIP of water-resource management and can manage resources (water) and related resources (water and the environment). For example, the Minister may purchase or compulsorily acquire any land that may be needed in connection with or as incidental to the performance of its functions or the achievement of its goals. However, every decision or action executed by responsible authorities must be approved by referral authorities and must align with what has been

established from planning and provisions.

The information among these three types of institutions plays a vital role in the decision-making process.

From 1860 to 1900s, all policy instruments were set up by the Victorian Legislative Council which governed the British Crown Colony of Victoria. This was done based on water resource availability. Authorities and boundaries were established based on water resource conditions. Waterworks Trusts and their boundaries were created based on the supply of and demand for resources. Individuals, groups of individuals, councils and groups of councils could propose the formation of a district and Trust when the required amount of water proposed was available. At the same time, licences, easements and permits would be granted provided water was available. After receiving authorisation, the user could temporarily or permanently alter the course of any river, creek, watercourse or embankment and widen or deepen environmental features to access water, with no limitations. The application of user charges followed licensing. Whereas a licence refers to the approval of individual operations or waterworks trust proposals, user charges refer to charges applied according to the actual service. Through this regime, costs of waterworks were divided equally among users. Plans and reports were a requirement when water licences or water easements (water apportionments) were proposed. Their content only focused on proposed drains or drain improvements, on the identification of areas covered by a plan, and on the estimated costs, which were based on resource supply and demand. Both were developed when required by authorities (ad hoc), which in this case was by the Governor in Council. The information gathered in plans and reports was used by the Governor in Council to grant or approve a license or permit. The demand-supply mechanism was also applied in policy instruments designed to manage floods (e.g. flood protection districts, trusts, plans, and reports).

After becoming a State in the Commonwealth of Australia in 1901, the responsibility for the legislative and administrative frameworks within which natural resources are managed moved to the Victoria governments, who in turn have traditionally devolved some responsibilities for natural resource management. The State River and Water Supply Commission established in 1905 under the Water Act 1905 was given the power to manage all water works conducted in Victoria State. Consequently, the policy instruments used differed from those used previously in a number of important ways. The establishment of boundaries and authorities such as irrigation water districts and trusts, and waterworks districts and trusts, were based on the authority/PIP's interests, which in this case were the State River and Water Supply Commission (SRWSC), under the acknowledgment of the Governor in Council. The establishment of the SRWSC was designed to bring together all Victorian water trust and irrigation schemes to consolidate water rights, authorizations and rules governing diversion of

or access to water. The authority (PIP) held the power to determine the amount of water that would be made available (water entitlements), and to hold or distribute water through licenses and grants based on demand-supply information gathered from proposed plans and reports. User charges were fixed annually by the authority (PIP) based on the relative extent of benefits derived by works constructed by the authority (PIP). Unlike the previous regime, the more access or benefits users could secure, the higher user charges became. This was determined by the authority (PIP). For example, from 1928 to 1944, land was divided into three divisions based on the relative extent of benefits derived from such lands through works constructed for a given district. Land was then divided into four divisions in 1944 and five division in 1949. The purpose of plans and reports under this regime was to reflect the authority/PIP's concerns. Reports and plans were used to monitor water resource conditions and distribution rather than as a requirement to divert water.

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Land and environmental consideration in the implementation of policy instruments in water governance was formalized by the Water Act 1989. Under this Act, policy instruments were established to support coordination among the three interdependent resources. In granting licenses and determining water apportionment, the act required consideration of other resources or sectors simultaneously: existing and future water balances, the environment and conservation, water quality, economic impacts and any other relevant report or statement prepared under any Act. In this case, licenses would only be granted if they did not negatively affect resource and related resource conditions (biophysical systems) and when they were approved by other related authorities (referral and planning authorities).

In addition, boundaries and an institutional framework were established to support the mechanisms described above. These boundaries were determined according to underlying natural processes and government concerns. Boundaries included water supply districts, water sewerage districts, waterway management districts, irrigation districts, groundwater supply protection areas, areas of interest, environmental and recreational areas, and catchment management areas. Each district was held responsible for identifying and reporting on water resource supply and demand. The institutional framework made each district/area management connected or nested each other to make sure the district performance to ensure that the district's performance corresponded with the broader system, including the establishment of Catchment Management Authorities under the Catchment and Land Protection Act 1994. In addition, with the further coordination with other resources in water governance, the role of plans and reports changed. Based on demands and created incrementally as required by authorities, plans started to be developed comprehensively and regularly. Plans aimed to achieve sustainable water management rather than of merely coping with incremental problems or with water access requirements (accidental actions by demand). Examples include water management schemes, and regional catchment strategies. Similar changes were made to the role of reports, which were produced annually rather than by demand. Both plans and reports became tools from which to understand the broader integrated system over the long term.

4.4.2 Policy instruments employed in Victorian Land Governance

In general, policy instruments for land governance addressing land use practices and related policy processes, were similar to those adopted for water practices (Table 4.3). Licenses/permits, user charges (land rates), rules, reports and plans were used to manage and monitor land use practices (substantive policy instruments), while changing institutional frameworks and boundaries were used to alter the policy process in land governance (procedural policy instruments). The development of policy instruments for land governance echoed that of water governance over most of its history but differed in the initial stages (Table 3). The key difference was that policy instruments in land governance were initially set up based on the authority/PIP's views while policy instruments in water governance were established based on water availability levels. That is, while water governance had a "Reserve" oriented stage followed by an "Authority" stage, land governance began with "Authority" oriented policy instruments.

From the start, the authority/PIP's perspectives on land were the main consideration in setting up rules and boundaries and in granting licenses and permits for land use. The boundaries and their functions were established by authorities (PIPs). Land was classified as agricultural land, grazing land, pastoral land, auriferous land, swamp land, state forests, timber reserves, water reserves, and land that may be sold by auction. The Governor in Council was granted the power to determine land uses (e.g., expanding or diminishing the area of land of any class, selling or granting licenses to use crown land for cultivation or grazing, or placing sanctions on clearcutting). In this stage, all policy instruments in land governance, including licenses, user charges, plans and reports, and the boundaries and institutional frameworks were decided by the Governor in Council. The authority/PIP's interests thus dominated land governance and related policy processes..

Unlike the initial Authority stage (1860-1970) when land was classified based on the authority/PIP's concerns over productivity or functions (eg. good agricultural or grazing land, pastoral lands, timber reserves, etc), from 1970 land that was not privately held was classified as public land including crown lands. Public land was managed by different authorities based on the lands purpose. The land was governed by the Minister and/or a authority (PIP), which could purchase or compulsorily acquire land required by the authority (PIP) in connection with

the performance of its functions or the achievement of its goals. As every authority (PIP) uses its own policy instruments for achieving its targeted goals, the authority (PIP) would determine policy instruments by which the land vested under its authority (PIP) could be conserved, developed or utilized to achieve its objectives. Boundaries and institutional frameworks aimed to support the authority/PIP's performance. As different authorities (PIPs) had their respective functions and visions (e.g., the Minister of Water Supply, Minister for Planning, Minister for Conservation, and Environment Protection Authority), different policy instruments were applied. There was no coordination in granting licenses/permits, user charges or rules for land use practices among authorities. Consequently, overlapping actions (policy instruments) for the same jurisdictional area started to appear. In this period, there was minimal coordination among authorities. Various overlapping policy instruments were recognized. There was no formal coordination in policy instrument implementation led by different authorities. Plans and reports were governed by the authority (PIP) and developed based on the authority/PIP's objectives with no coordination with other authorities (PIPs). Each authority (PIP) executed its own investigations and plans based on its own data. Authorities (PIPs) communicated only to discuss compulsory rules/requirements in not breaching previous policies in their decision-making processes. Otherwise it was optional rather than the compulsory to take other authorities/PIP's recommendations into account, including opinions of the Environment Protection Authority.

From the 1980s onwards, a new stage in land governance emerged where coordination and integration received more emphasis. Several attempts to further coordinate resources, authorities, and information used for land governance were made. The first attempt involved the consolidation of authority (PIP), which can be seen via the consolidation of the Minister of Crown Land and the Minister for Forests into the Minister for Conservation, Land and Forest in 1983 and via the consolidation of the Minister for Conservation Forests and Lands, the Minister for Water Resources and the Minister for Planning and Environment in 1996. A second attempt involved the enactment of the Planning and Environment Act 1987, which significantly changed decision-making on land governance. Through the Act, the Minister for Planning and Environment was designated as the single authority (PIP) to issue permits, govern land use development and coordinate related or impacted authorities in granting land use licenses. For example, coordination between the Minister for Planning and Environment and the Minister for Water Resources permitted any activity or change in the use of land that could affect the existing drainage regime. In brief, the Act differentiated authorities into three roles:

planning authorities (the Minister for Planning and Environment), responsible authorities (authorities responsible for planning implementation), and referral authorities (authorities involved in decision-making processes). With this change in institutional frameworks for the decision-making process, policy instruments used by authorities also changed. Every policy instrument enacted needed to be approved or acknowledged by other authorities and vice versa. A third attempt involved the integration of execution. The establishment of the Department of Environment, Water, Land and Planning in 2014 integrated authorities and policy instruments. Authorities used the same plan, data, information, rules and boundaries and in turn acknowledged one another.

Table 4. 3 Development of Policy Instruments of Victorian Land Governance

	Authority	Information	Coordination/Integration
	1860 – 1970s	1970s – 1980s	1980s – 2016
• Licences, permit • User rates • Rules	From the provisions with which licences or permits for land use were granted, rules and land rates enacted for land governance were set up based on the authority/PIP's perspective.	Granted licences and permits and rules and rates applied to land governance were enacted based on information gathered by authorities such as the Soil Conservation Authority, the Land Conservation Authority and the Environment Protection Authority.	Land-use licences, permits and rules and land rates applied to land governance were determined in coordination with other related authorities, reflecting their interests and information on conditions of the resource system.
Plans and reports	Plans and reports were created by the authorities according to their concerns.	Every authority/PIP could gather information based on its concerns. Every authority (PIP) followed its own plans and reports despite referring to the same area. Examples: ▪ Reports created from investigations conducted by the Land Conservation Council for the Minister for the Crown and the Minister for Conservation. ▪ Reports created from investigations conducted by the Water Resource Council for the Minister for Water Supply. ▪ Preliminary Environment Reports submitted by the Minister with respect to the use of public land/conducting public work. ▪ Environment Effect Statements submitted by relevant Ministers when acquired by the Minister for Conservation.	Reports and plans were used to monitor socio-ecological system conditions (e.g., regional and catchment management plans). Reports were periodically created to support decision-making processes of related authorities (e.g., catchment and land protection board reports).
Boundaries	Land management boundaries were established based on the authority/PIP's concerns (e.g., land that could be sold by auction, pastoral land, state forest reserves, timber reserves, good agricultural or grazing land, land classified as inferior grazing land (as proclaimed by the	Every authority/PIP could purchase or compulsorily acquire any land to support its functions, including to gather information to support land use decisions. Land was differentiated based on the information that authorities gathered (e.g., environment protection areas, water supply and catchment areas, public land	Every boundary set up by responsible authorities formed part of a larger resource system (e.g., land governed by the Minister for Water Supply is classified into several types: water sewerage districts, irrigation districts, areas of interest, environment and recreation areas, groundwater

	Minister for the Crown), irrigation water supply districts, and drainage districts (as proclaimed by the SRWS). The provisions of its proclamation were also set up based on authorities' concerns	for conservation purposes, and areas applying planning schemes).	supply protection areas, special areas and regional catchments and land protection regions). Representing different functions, combined they create a single entity (a resource system). Besides coordinating and integrating boundaries of the same responsible authorities, coordination between responsible authorities in their use of land (boundary creation) was established through the formation of the Planning and Environment Act of 1987.
Institutional frameworks	Authorities responsible for land governance were formed by the Governor in Council). Examples include the establishment of the SRWSC, Soil Conservation Authority	Institutions were created to gather information needed to support decisions (e.g., land conservation councils and environment protection councils).	An institutional framework was established to integrate three authorities involved in decision-making processes: planning authorities, responsible authorities and referral authorities. However, many attempts were made by Victorian government to realise synergies among these three forms of. The first attempt involved the consolidation of institutions among responsible authorities of land governance and of other related resources. The second attempt involved planning authorities acting as facilitators of responsible and referral authorities regarding land use. The third attempt involved integrating execution under the Department of Environment, Water, Land and Planning for all land utilisation.

4.4.3 Policy instruments used in Victorian Environmental Governance

We turn now to the evolution of policy instruments of Victorian environmental governance. Attempts made by the Victorian government to protect the environment date to the 19th century. However, no Acts were enacted specifically for environmental purposes prior to 1970 (Table 4). Government interventions in terms of environmental conditions were blended with Acts on water and land governances (e.g., the Victorian Water Conservation Act 1881, 1883, 1884, 1885 and 1886; the Water Conservation Act 1887 and 1889; the Soil Conservation and Land Utilization Act 1949, 1958, 1962, and 1966; the Land Conservation Act 1970; the Flood Protection Act 1911 and 1912, and the River Improvement Act 1948 and 1958). The environmental provisions in both Acts was blended in land and water policy instruments and their purposes. Before 1970 environmental concerns were raised when there were environmental problems (ad hoc) or government concerns, as exemplified in Flood Protection Act 1911 and 1912. Meanwhile, government concerns regarding the environment have been recorded for the provision of areas of environmental protection under the Planning Scheme regulated by the Town and Country Planning Act 1958. The establishment of the Land Conservation Authority in 1940 (which became the Soil Conservation Authority in 1958) and the River Improvement Trusts in 1948 serve as more evidence of government concerns over environmental conditions. Following this trend, policy instruments used by authorities were based on the authorities' interests or perspectives.

The Environment Protection Act 1970, the Minister for Conservation 1972 and the Planning and Environment Act 1987 focused on environmental governance (Table 4.4). The types of government interventions identified by these three Acts are similar to those of land and water governance. The Environment Protection Act 1970 required that license/permit approval and rules applied to monitor and alter people's behaviors toward the environment be based on comprehensive information on the resource system in the present and future. Reports and plans served as references on which other policy instrument provisions should be based, not only on government concerns. In terms of altering the nature of the policy process, the Environment Protection Act 1970 established the Environment Protection Authority (EPA) and provisions with respect to the power, duties, and functions of the EPA in relation to other authorities (PIPs). The EPA was supported by representatives of various Ministers and authorities in Victoria addressing issues related to land, water, and biodiversity, including the Minister for Water Supply, the SRWS Commission, the Melbourne and Metropolitan Board of Works, the

Minister of Agriculture, the Soil Conservation Authority, and the Minister of Local Government. In running its functions to control and improve environmental quality, the EPA classified any area, segment or element of the environment for its purposes. The Minister for Conservation established in 1972, via the Minister for Conservation Act 1972, made a consequential attempt to account for environmental purposes. The Minister was responsible for the protection and preservation of the environment and for the proper management and utilization of resources in Victoria. The Minister considered recommending both the Soil Conservation Authority and Environment Protection Authority, showing that information (reports) supporting decision-making (licenses, charges, rules, and plans) and its processes (institutional frameworks) was becoming an important input to environmental governance. The Planning and Environment Act 1987 created a platform for synergizing environmental protection efforts executed by several stakeholders. The provision of policy instruments under the Act was an attempt to link or coordinate environmental concerns with other forms of resource utilization (land and water) during the decision-making process through planning mechanisms. The act notes that all land, water, and environmental practices must be aligned with the State Environment Protection Policy to ensure their sustainability. In addition, for every decision, every responsible authority (PIA) must identify other authorities that might be directly affected by the decision as a referral authority (PIA). Extending beyond the institutional framework, the Act and its amendments aimed to ensure that all government interventions in resource governance were coordinated and integrated.

Table 4. 4 Development of Policy Instruments practiced in Victorian Environmental Governance

Regime shift	Before the Enactment of the Environment Protection Act of 1970	Information	Coordination/Integration
	< 1970s	1970s – 1980s	1980s – 2016
Licences/Permits	Government intervention in environmental conditions was embedded in land and water governance.	Licences and permits were granted depending on information gathered by the authority/PIP based on its goals and perspectives.	Licences were created by responsible authorities with the approval of referral authorities (PIPs).
User Rates		Rates were determined based on information on resource conditions.	Rates were charged based on environmental conditions. Such conditions depended on not only authorities’ interests but also on system functions or resources (where the rate is applied) and other resources and their sustainability.
Rules		Environmental consideration was recommended (not compulsory) during decision-making.	Environmental factors must be considered in the valuation of assets and services of resource governance.
Plans and Reports		Plans were used by the Environmental Protection Authority to improve environmental conditions in Victoria (e.g., state environmental protection policies).	Plans were used by the responsible authority (PIP) to develop sustainable social-ecological systems based on other authorities’ plans, reports and concerns. This process was coordinated by the Minister for Planning.
		Reports were used to gather information of concern to the Environmental Protection Authority.	Reports were periodically created to support the decision-making processes of related authorities.
Boundaries	Boundaries were established based on information gathered by the responsible authority (PIP) to perform its functions.	Environmental boundaries were created based on functions of the responsible authority and aligned with the boundaries of other authorities (e.g., the establishment of environmental and recreational areas and groundwater supply protection areas under	

		the Minister for Water Resource based on related governance system to support a whole governance system).
Institutional Frameworks	Institutional frameworks were created to gather information needed to support decisions (e.g., the Land Environmental Protection Authority consists of representatives from several authorities related to environmental conditions).	Environmental Protection Authorities worked to synergise the three different functions of the decision-making process: planning authority (the State Environmental Protection Policy); responsible authority (for environment management); and referral authority (the EPA became a referral authority for other responsible authorities of the decision-making process).

4.4.4 Synthesis of the evolution of Victoria's water, land and environmental policy instruments

In-depth investigation was conducted on six policy instruments adopted in Victoria over the past century both to monitor and alter daily practices in resource utilization (substantive policy instruments) and to modify political and other behavior during policy instrument operationalization in resource governance (procedural policy instruments). We identified four regimes based on the interaction among components of SESs of natural resource governances.

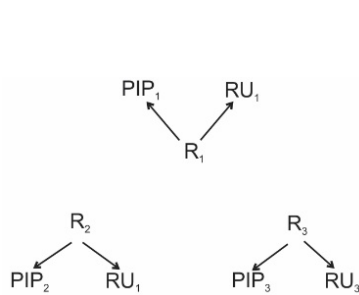


Figure a. Reserve Regime

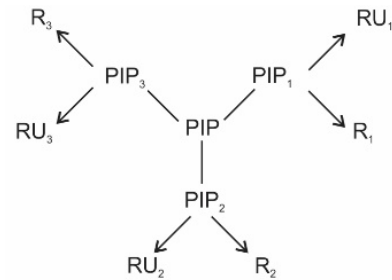


Figure b. Authority Regime

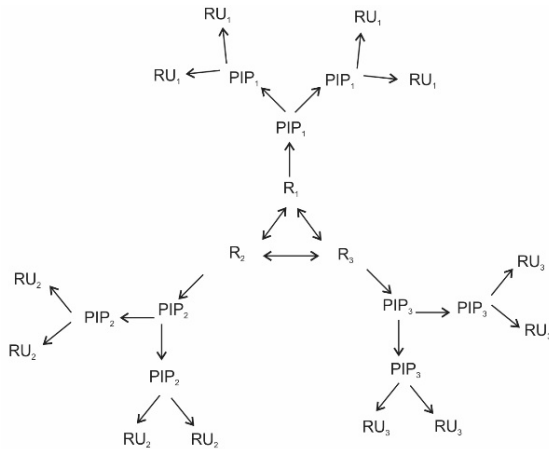


Figure c. Authority Regime

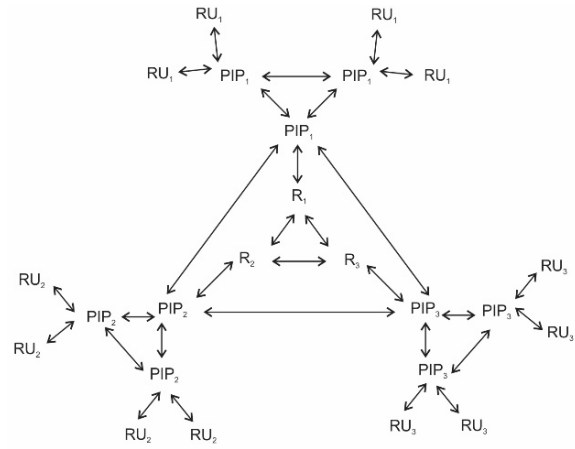


Figure d. Integration Regime

Figure 4. 3 Interactions between SES components of natural resource governances

The first regime is the reserve regime. In this regime, policy instruments used to manage interactions with the resource were directed by the resource condition (Figure 3a). The second regime is the authority regime. Under this regime, the concerns and interests of public infrastructure providers became the focus in formulating policy instruments (Figure 3b). The third regime is the information regime. For the information regime, the function of the biophysical system became the center of policy instrument formulation in resource governance (Figure 3c). The importance of understanding the biophysical system as an entity was recognized as an important facet of resource governance. While significant information was assembled, the choice of type of information was driven by different backgrounds, goals, and perspectives of the authority/PIP in shaping decision-making processes. This meant that in dealing with interdependent resources, outcomes were still compromised by inconsistencies. Improving consistency then became a focus addressed in the fourth regime (Figure 3d). The regime of integration was characterized by policy instruments that are not only designed to consider the resource as a part of the biophysical system but also the integration of the resource with components in the social system. The four different governance regimes reflect the evolution of interactions among Rs, RUs and PIPs in land, water, and environmental governance in Victoria.

Land, water, and environmental governance in Victoria experienced different starting points before entering the integration regime at approximately the same time (Figure 4). Policy instruments in water governance experienced four regimes (Figure 4a), whereas, land governance experienced three stages (Figure 4b) and there were two regimes in environmental governance (see Figure 4c). The different conditions of the resources and the governance perspective regarding each resource was the likely cause for this different in starting points. In Victoria, land is an abundant resource while water is a limited resource. As a scarce resource, water resource condition was likely to be the focus in formulating policy instruments. In contrast, as an abundant resource, the government had more influence in the creation of the policy instrument in land governance. In the case of environmental governance, environmental condition was initially considered to be the result of land and water practices rather than as a separate resource in its own right. Thus, policy instruments were initially set up by considering the information regarding the conditions of the other resources.

Taken together our results suggest that the types of policy instruments governing the interactions among and between Rs, RUs, and PIPs in land, water, and environmental governance from 1860–2016 did not vary but that there were differences in the circumstances in which they were implemented, in this case, differing interactions among components of the biophysical and social systems. Under each regime, policy instruments held a particular focus in managing components of the SES.

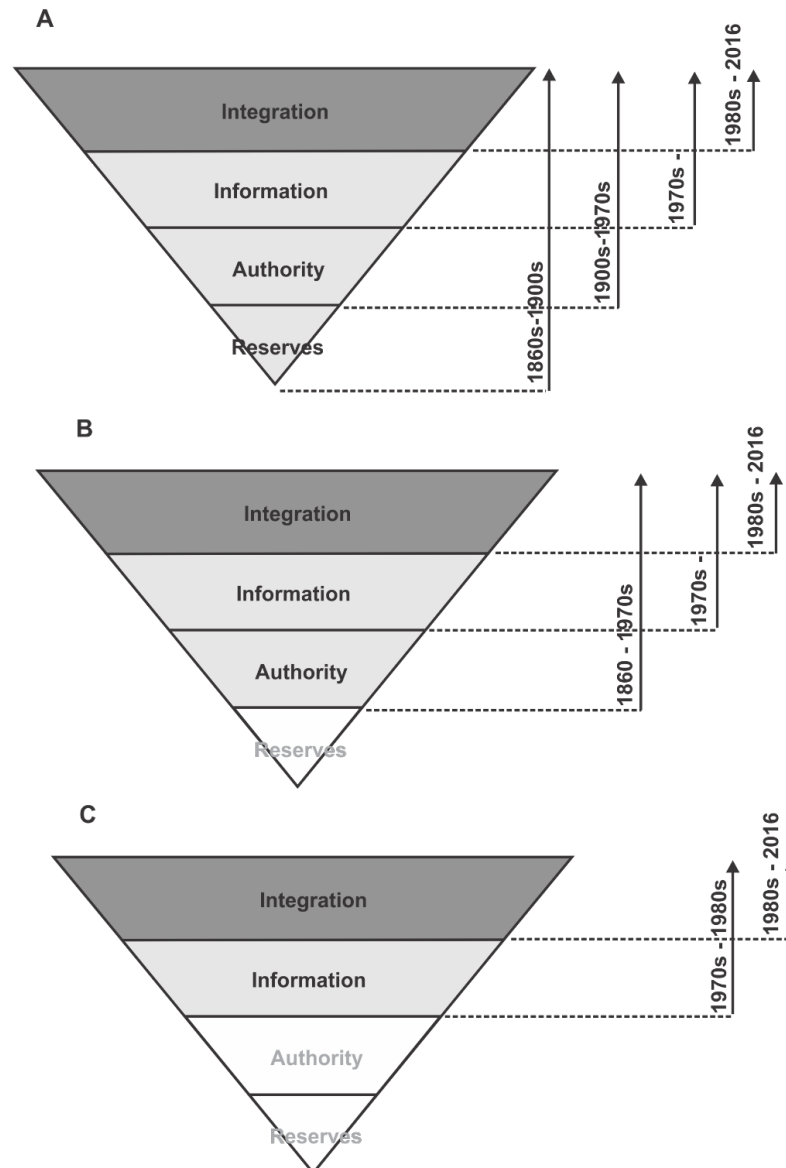


Figure 4. 4 Regime shifts of policy instruments on land, water and environmental governance adopted in Victoria 1860–2016. A. Policy instrument regime shift in Victorian water governance; B. Policy instrument regime shift in Victorian land governance; C. Policy instrument regime shift in Victorian environmental governance.

4.5 Discussion and conclusion

Coordinated, non-conflicting, and complementary policy instruments are required to address different problems in SESs. Policy instruments vary and have their own pathways (historically situated) aligned with the social learning process recognizing how a problem is related to a resource. In addition, change in policy instruments is more visible than change in the whole governance system. Therefore, policy instruments are used here to represent rules of interaction in the social-ecological system and to track how these have evolved over time in the contexts of land, water and environmental governance in Victoria, Australia.

The evolution of Victorian policy instruments in managing the interactions among components of biophysical and social system was reflected by changes in the interactions among resources (Rs), resource users (RUs), and public infrastructure providers (PIPs) in land, water, and environmental governance (Figure 4.1). Four policy regimes were identified (Figure 4.4). In the first three regimes, policy instruments did not fully accommodate the interactions as seen from existing linkages among resources, resource users, and public infrastructure providers (Figure 4.3 a, b, and c). Only in the fourth regime (integration regime– Figure 4.3d), have these linkages have been accommodated in the implementation of policy instruments. The four different governance regimes reflect how the interactions among Rs, RUs and PIPs evolved in land, water, and environmental governance in Victoria. Our results show the changing capacities of policy instruments in accommodating the interactions among SES components, as proposed in Figure 1. Thus, we demonstrate that policy instruments can be used as a tool help understand the interactions within the SES. In addition, such analysis may help to provide clear pathways to steer the governance changes in desirable ways instead of adopting new policy instruments without understanding the past and current situations.

The conditions of SESs result from how the linkages between social and biophysical systems are managed. Sustainable resource governance requires that all components in the SES should be considered. By examining the governance of interdependent land, water and environmental resources in Victoria, this study makes several noteworthy contributions to the realm of policy instrument development. First, the interdependencies among multiple resources in a biophysical

system need to be acknowledged and considered in policy instrument design. Second, interactions between interdependent resources in biophysical systems should be reflected in interactions between components of social systems, which can spur further synergies among multiple policy instruments implemented in the SES. Thirdly, interactions between biophysical and social systems deserve attention as one of the important influences on policy instrument development.

This article connects two different but potentially related theoretical developments on resource governance: policy instrument and biophysical and social interconnectedness in SESs. We argue that these two developments can be integrated to address knowledge gaps in sustainable SES governance. We performed a content analysis on the evolution of policy instruments governing three different resources: land, water and environment in Victoria from 1860-2016. We found almost no difference in the types of policy instruments used in governing those three resources over the last century. However, differences occurred in how policy instruments have been used to manage interactions among components of SESs. These findings provide a template to examine and improve the relevant policy instruments in a theoretically meaningful way; promoting more sustainable resource governance.

Several limitations of this study should be noted. Firstly, the data source used to analyse the evolution of policy instruments was confined to Victorian Acts, thus the influence of changes in international and national policies were not taken into account. Secondly, more specifically, the data source was confined to Victorian Acts as the foundations for formulation of regulations. Follow-up actions after the enactment of an Act were not covered in our analysis. Finally, the key findings from this study was drawn only based on what stated in the acts, not on their real impacts on biophysical systems. Therefore, further research which integrates these normative conclusions with the changes in SES is needed to enlighten the linkage between governance and SES.

Chapter 5

Governance Integration Across Multiple Resources in a Social Ecological System

This chapter will be submitted as the following article:

Ratri Werdiningtyas, Yongping Wei, Andrew W. Western, Governance Integration Across Multiple Resource in a Social Ecological System. Environmental Policy and Governance (to be submitted)

5.1 Abstract

Problems in social-ecological system are rarely attributable to a single cause. Moreover, single policy instruments are insufficient to cope with interconnected problems. However, the integration of mixed policy instruments presents a major challenge in SES governance. This article aims to analyse the development of policy integration during the co-evolution of land, water and environmental governance and then to compare the co-evolution with biophysical responses in Victoria, Australia during 1860-2016. It reveals that there is a strong association between this co-evolution and the SES condition. The findings provide empirical evidence that the change in each component of a biophysical system (land, water, and environment conditions) and the related governance of land, water, and environmental governance) follow their own pathways, yet they are interlinked. This interlinkage or interaction is difficult to track over a short-frame but becomes clearer with the long-term view of this study. Over time the Victorian government has learned to adapt and to accommodate dynamic condition of land, water, and environmental systems, and thereby limit the negative impacts of interventions. This has resulted in the inclusion of dynamic interactions within SES governance through the implementation of integrated policy instruments. Improving the relationships between objects, goals, actors, procedures, data and analyses in different policy instrument can create synergy and integration in land, water, and environmental governa

5.2 Introduction

In the Anthropocene, the main driver of change in biophysical systems has been human intervention through soft and hard infrastructure implemented in resource governance (Acar 2017; Goudie 1981; Link et al. 2017). The role of governance in resource management interventions is clear (Blomquist, W, Dinar & Kemper 2005; Ostrom 1990; Prishchepov et al. 2012; Sewell, Handmer & Smith 1985). However, the inherent complexity of governance presents a major challenge when measuring its impact on social-ecological systems (Carpenter et al. 2001; Ekstrom & Young 2009; Martinez-Harms et al. 2015).

The condition of a social-ecological system (SES) is the result of cumulatively dynamic interactions between biophysical and social systems adapting to external perturbations (Anderies, John. M 2015; Anderies, John. M, Janssen & Ostrom 2004; Ostrom 2007; Ostrom & Cox 2010). Policy instruments direct both resource user behaviour and policy processes regulating resource usage (Howlett, Michael 2005, 2010). Thus, SES conditions are a function of the configuration of multiple policy instruments designed to manage resources, resource users and public infrastructure providers. Consequently, each policy instrument should be viewed as a co-determinant of other policy instruments within a given SES.

The urgent need for integration in land, water, and environmental governance has frequently been invoked in resource governance literature (Briassoulis 2005; Carlsson & Sandström 2008; Jordan, A & Lenschow 2010; Macleod, Scholefield & Haygarth 2007b; Mitchell 2005; Rouillard et al. 2013; Varis, Enckell & Keskinen 2014). Hydrological and ecological understanding recognises that the conditions of land, water, and the environment are not isolated from one another (Agarwal et al. 2000; Dovers 2000; Macleod, Scholefield & Haygarth 2007b; Walker, J, Dowling & Veitch 2006). Stream flow is not only correlated with the efficacy in implemented policy instruments on water (e.g. water licences, water management schemes), but is also influenced by policy instruments implemented in land governance (e.g., land use permits, land use plans) (Farley, Jobbágy & Jackson 2005; Mati et al. 2008; Raini 2009). Land degradation and biodiversity loss are related to stream-flow conditions which are affected by water policy (Allan & Watts 2018; Blackman 2015; Sandstrom et al. 2017). In other words, human interventions directed by multiple policy instruments in land, water, and environmental governance not only change the condition of

targeted resources, but also create “downstream” impacts on other resources and on the whole system. Therefore, resource problems, such as floods, drought, land degradation and the loss of natural vegetation and biodiversity, are complex, cross-cutting and interconnected (Briassoulis 2005; Cohen, March & Olsen 1972; Duit et al. 2010). The problems are rarely attributable to a single cause (Axelrod & Cohen 2000). Thus, policy instruments implemented in the governance of land, water, and the environment are nested phenomena requiring systemic rather than partial analysis in order to understand their impacts on SES. Consequently, integrated land, water, and environmental governance has been proposed as a panacea in recent decades (Briassoulis 2005; Jordan, A & Lenschow 2010; Macleod, Varis, Enckell & Keskinen 2014). However, the efficacy of attempts at integration is dependent on how policy instruments work and fit together within a system (Borrás & Edquist 2013; Cohen, March & Olsen 1972; Linder, S, H. & Peters 1989). Integration between the configuration of multiple policy instruments is a fundamental property of catchment SES. However, from an empirical perspective, little is known about the form of integration and its impacts on SES conditions (Flanagan, Uyarra & Laranja 2011; Jordan, A & Lenschow 2010; Medema, McIntosh Brian & Jeffrey Paul 2008; Rouillard et al. 2013).

This paper aims to uncover the form of integration in the co-evolution of land, water, and environmental governance and its biophysical responses. In particular, it will elaborate how policy instruments implemented in land, water, and environmental governance have framed dynamic interactions among components of biophysical and social systems in their responses to external perturbations in Victoria, Australia, during 1890–2016. Tracking the history of land, water and environmental governance integration in Victoria can provide useful lessons for other regions experiencing similar tensions in natural resource governance.

5.3 Methods

5.3.1 A framework for analysing integration of land, water, and environmental governance within SES

A framework for analysing the integration of interdependent resource governance through a web of relationships among SES components was proposed (Figure 5.1). This framework uses the

methodology suggested by Brissaoulis (2005) and the framework in this thesis. In his methodology, Brissaoulis argues that the integration of two or more policies can be analysed by examining relationships among policy elements (objects, goals, actors, procedures and instruments), and/or by examining the dimensions of policy integration (substantive, analytical, procedural and practical). Ideal integration (a rare achievement) requires that all elements of policy are fully integrated so that all dimensions of integration are well satisfied. However, not all policy elements are amenable to redesign or change simultaneously (Howlett, Michael 2009), making it difficult to address all dimensions of integration. Most changes in policy elements are conducted separately (partial) to improve the current system, rather than to systemically change the ‘whole system’. In reality, a policy integration process is conducted based on human favour, which starts from components of policy objects that are handy, convenient and easy to manipulate while trying to build reasonable linkages with the other components (Brissaoulis 2005).

In the framework proposed in this thesis policy instruments manage the interactions within SES (Figure 5.1A). It argues that policy instruments are emergent properties of SES. Policy instruments regulate interactions among SES components (resources – Rs), resource users (RUs) and public infrastructure providers (PIPs), and they are sensitive to the dynamic changes of each component adapting to external perturbations. Policy instruments applied together within SES represent the capacity of governance to regulate the behaviour of biophysical (Rs) and social systems (RUs and PIPs), so that targeted goals are addressed in an interactive manner. Change in policy instruments reflect the change in a government’s understanding, defining and framing of interrelated problems, goals, actors, structures, procedures and data used in governing multiple resources. In this framework, policy instruments are considered as useful tools for exploring the integration of land, water, and environment in governance systems. Thus, in understanding the integration across multiple resource governance, policy instruments were used to understand the framing of objects, goals, actors, procedures, data and analyses in multiple policy instruments implemented in resource governance (see Figure 5.1).

Combining SES framework on policy integration with Brissaoulis’s methodology (Figure 5.1B) allows the integration to be classified into three types. The first type, substantive integration, is characterised by the existence of a common frame regarding both the objects being regulated and

the goals or interests operationalised in policy instruments. This type of integration concerns the extent to which interactions among resources (R_1 - R_n) are reflected in the implementation of policy instruments of targeted SES governances. The integration of policy objects and goals or objectives is the easiest, most commonly attempted. The other type of integration occurs as the need of cooperation in order to share roles and responsibilities among involved actors. For this reason, the second type of integration involves is procedural integration, which is integration among involved actors, structures and procedures (RU_1 - RU_n ; PIP_1 - PIP_n ; RU - PIP and R - PIP) that are implemented within social systems in dealing with biophysical systems. However, procedural integration – having clearly defined roles for every actor working towards the common goal – does not guarantee coherence or synergy in the outcome of actions if individuals refer to and apply different data and methodologies for decision-making and analysis. In the end, working together in SES governance, multiple PIPs require the integration of spatial and temporal data and methodology in their analyses. This data integration underpins the third type of integration, referred to as practical/analytical. In our proposed framework, substantive, procedural, and analytical practical integration are represented by the capacities of policy instruments to manage trade-offs among SES components.

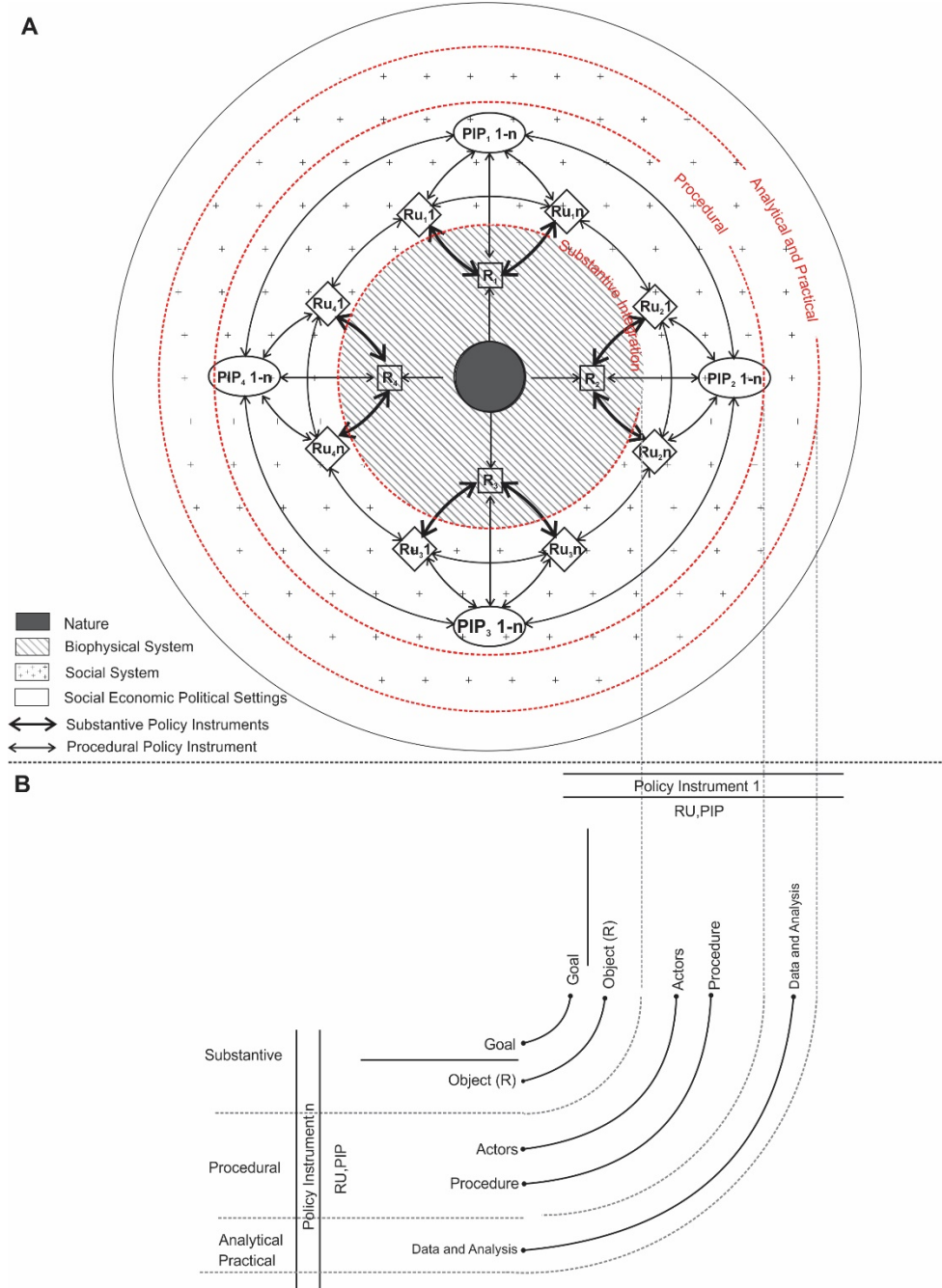


Figure 5. 1 A framework for analysing policy integration in SES governance. Figure 5.1A. Policy instrument as rules of interaction in SES; Figure 5.1B. Relationships among policies (Briassoulis 2005)

5.3.2 Land, water, and environment in Victoria

Located in south-eastern Australia, Victoria has a land area of 227,436 km² (95.7%) and a water area of 10,213 km² (4.3%). Victoria is the second-smallest state in Australia and the second-most

populous. By value, Victoria produces about one-quarter of Australia's agricultural production (Agriculture Victoria 2016) and accounts for nearly 40% of its agricultural output (Department of Environment 2013-2015). The expansion of agricultural activities has led to substantial reductions in forest and native vegetation areas and has significantly changed Victoria's land cover (Figure 5.2). Large-scale introduction of irrigation has occurred in some agricultural regions. Irrigation is the largest consumptive use of water in Victoria and an important component of the state's agriculture. Irrigation depends mostly on surface water resources. Historical efforts of greening the desert is a direct contributor to Victoria's success at boosting agriculture productivity to support population growth. As a consequence, the conditions of Victoria's land, water, and environment have been highly impacted by human intervention involving both physical and soft infrastructure (Dovers 2000; Lines 1991; Powell 1989; Young, A 2000). Over the past 120 years, since the first European irrigation developments, river flows have been impacted by the introduction of human-built infrastructure (e.g. dams) to regulate water flow. The main aim of water resource development was economic benefit. Not only has the evapotranspiration rate changed because of significant changes in vegetation cover, but the expansion of agricultural activities has led to massive water diversions from the river network for targeted agriculture areas. This has reduced the amount of water available for inundating precious wetland and riparian areas and has caused several second-order problems for the Victorian environment.

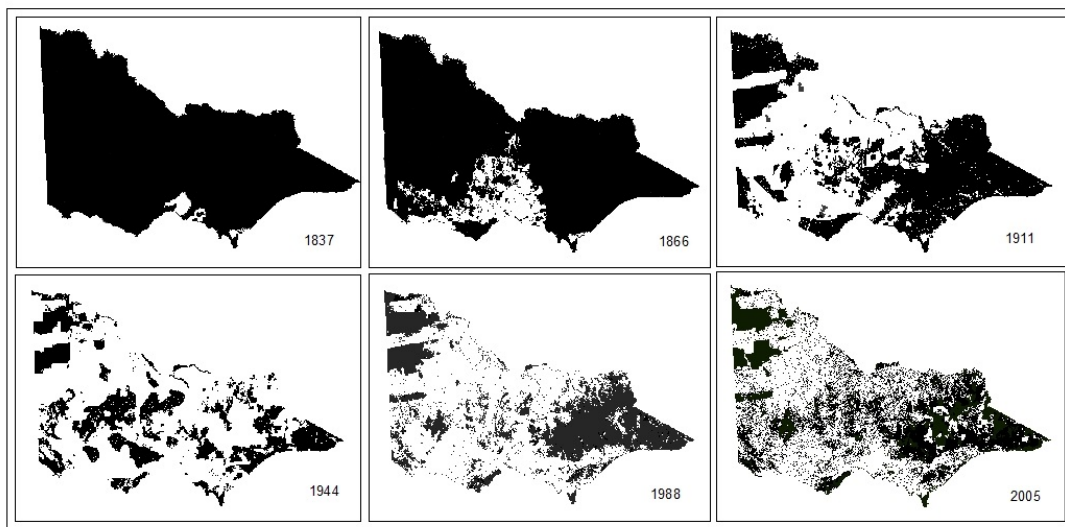


Figure 5. 2 Change of Victorian land cover. Black areas show native vegetation plus plantation forests and other planted trees. White areas show areas cleared of forest (data source from (Sinclair et al. 2012))

5.3.3 Understanding dynamic interactions between land, water, and environmental governance and associated changes to biophysical systems in Victoria

To trace how the integration of land, water, and environmental governance have developed and co-evolved with biophysical systems in Victoria, we undertook three analyses: 1) analysing the co-evolution of land, water, and environmental governance through the integration among its policy instruments; 2) collating and analysing data on biophysical changes in Victoria; 3) analysing the association between 1) and 2). We identified different types of integration through the content analysis of six policy instruments governing Victoria's land, water, and environment between 1860–2016). This was done by elaborating the relationships among objects, goals, actors, procedures, data and analyses in the implementation of policy instruments. For each phase of integration, trend analysis was used to examine biophysical and social variables, in this case land cover, runoff, water storage, environmental water, population and drought.

The content analyses in this paper were carried out on 489 Victorian Acts related to land, water, and environmental practices enacted between 1860–2016. To identify appropriate Acts, 'land', 'water' and 'environment' were used as the keywords for the first search on www.austlii.edu.au. For the second search, 'crown', 'forest', 'drainage', 'irrigation', 'river', 'catchment' and 'flood' were used; the first search had revealed that these terms were correlated with land, water, and environmental practices. We omitted Acts limited to specific locations (e.g., the River Murray Act, Loddon–Campapse Regional Planning, and the Murray-Darling Basin Act) to ensure a broader statewide scope for our study. Six policy instruments identified in Chapter 4 were coded to identify its object (scope of area), its goals, actors involved, procedure and data and analysis used in their implementations (see Table 5.1). Then, the governance integration for land, water, and environment was analysed through the relationship among objects, goals, actor, procedure and data analysis of policy instruments used in land, water, and environmental governance using Brissaoulis methods for analysing policy integration (see Figure 5.1B)

Table 5. 1. Coding policy instrument

Policy Instrument	Quotation in the Act enacted during 1860-2016	OBJECT of policy instrument	GOALS of policy instrument	ACTORS involved in the implementation of policy instrument	PROCEDURE in the implementation of policy instrument	DATA-ANALYSIS used in the implementation of policy instrument
License/ Permit	Quotation 1 (Ex. Waterworks Acts 1865)					
	Quotation 2 (Ex. Land Act 1862)					
	Quotation 3 (Rx. Environment Protection Act 1970)					
	Quotation n					
User Rates	Quotation 1 Quotation 2 Quotation n					
Rule	Quotation 1 Quotation 2 Quotation n					
Plan and Report	Quotation 1 Quotation 2 Quotation n					
Boundary	Quotation 1 Quotation 2 Quotation n					
Institutional Framework	Quotation 1 Quotation 2 Quotation n					

The biophysical data underpinning hydrology dynamics as human responses were depicted schematically in Figure 5.3. In the figure, human responses to the governance of land, water, and environment were represented by changes in land cover and water diversion. Land cover condition was described by the ratio of forest/conservation area to non-forest area, and the ratio of Crown

land area to the area of land sold to the public for economic purposes within the study period. It was essential that data representing change in Victoria's land cover was consistent with land-use classification. In order to ensure this, we used only one data set (Sinclair et al. 2012), which extends from 1837 to 2005. In this paper, data before 1860 was used to describe conditions pre-European settlement. This is an appropriate demarcation as the first Act related to land, water, and environmental practices in Victoria was the Land and Waterworks Act enacted in 1862.

To characterise biophysical changes, runoff was estimated using Zhang curve (Zhang et al., 2001), together with forest-cover data, average rainfall for 1961–1990 (Australian Government Bureau of Meteorology 1961-1990) and annual potential evapotranspiration (Australian Government Bureau of Meteorology). This was achieved by first calculating the proportion of forest cover using land-use data with a resolution of 25m x 25m (Sinclair et al. 2012) and then calculating an area weighted runoff for each 0.05° pixel in the climate layers. Finally, runoff was averaged across the state. Dryland agriculture, pasture, irrigated land and urbanised land were treated as non-forested. Both irrigated and urbanised land would differ in runoff production from the non-forest categories (Zhang et al., 2001); however, irrigated and urbanised land accounted for only a small percentage of total land area so this would have only a minor impact on state-wide estimates. All calculations were performed in ArcGIS and were repeated for each year land use data were available in the Sinclair et al. data set (Sinclair et al. 2012).

Government interventions to develop water resources were represented by water storage capacity data sourced from Department of Water Resource Victoria (Department of Water Resource Victoria 1989). Government interventions to protect aquatic environments from water harvesting before 2011 were estimated based on what was regulated in the Acts. Post 2011, these were represented by the volume of water entitlements (Victorian Environmental Water Holder 2011-2016). Meanwhile, climate conditions and population growth (Australian Bureau of Statistics 1860-2016) were considered as external conditions influencing hydrologic dynamics and the formulation of policy instruments. Climate conditions were represented by drought occurrences in Victoria based on annual rainfall anomalies (Australian Government Bureau of Meteorology 1900-2018) with major droughts being the Federation Drought (1895–1902), the World War II Drought (1936-1945), and the Millennium Drought (1997–2009).

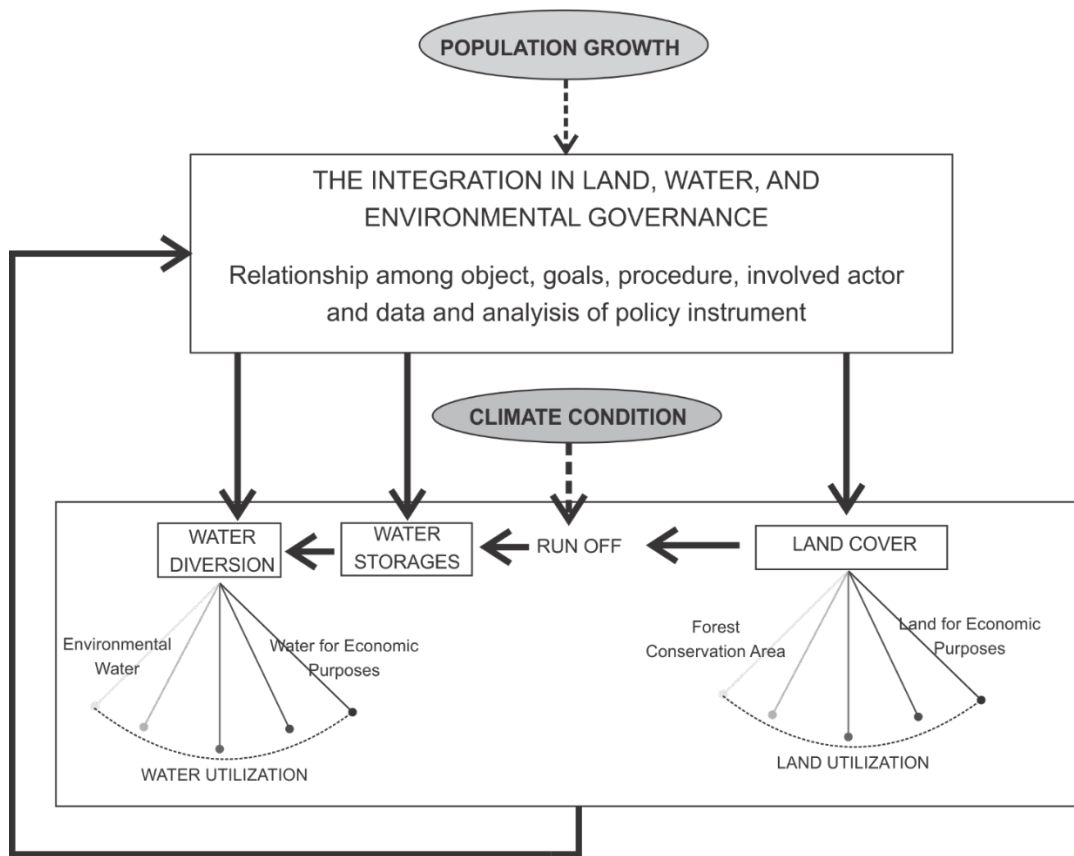


Figure 5.3 Framework for coupled government interventions through policy instruments and biophysical system responses

5.4 Results

5.4.1 Integration of land, water, and environmental governances

With a manual review of six policy instruments from 489 identified Acts, that are (1) licences/permits, (2) user rates, (3) rules, (4) plans and reports, (5) boundaries and (6) institutional frameworks, the history of land, water, and environmental governance in Victoria was divided into four distinct phases described below.

Phase 1 (1860s–1900s): no integration in land, water, and environmental governance

During the period of colonial government in Victoria, the government began to use licences, user rates, rules, plans and reports as the main tools to manage its utilisation of land and water. The

government implemented these instruments in water governance to manage demand on water resources. Meanwhile, policy instruments related to land governance focused on the sale and occupation of Crown land. There were no enacted policy instruments specific to environmental condition during this phase. Environmental problems were considered part of land and water governance and were handled on a case-by-case basis. Although the overall objectives stated in the Acts related to land and water practices had similar preferences to resource utilisation, there were no linkages or relationships among licences, user rates, rules, plans and reports implemented in land and water governance to manage the behaviour of land and water utilisations. Substantive policy instruments implemented in land and water governance were different in objects, goals, actors, procedure and data used in their implementation. Instruments were set up based on sectoral concerns and were applied incrementally without accommodating one another (Figure 5.4a).

Without giving consideration to other resources, goals, actors, procedures, and data, there was no coordination in spatial and temporal operational expression of policy instruments in practice. The establishment of management boundaries in water governance had no relation to land management boundaries. Land was in state ownership and classified based on the recommendation of the Land Classification Board; for example, these classifications included agriculture land, pastoral lands, grazing land, auriferous land, timber forest, and state forest reserve lands. The land within each class could be sold by auction or leased under the authority determination, in this case the Governor in Council. Once the land had been sold or leased, the owner or licence holder was responsible for land utilisation. Groups or individuals who wanted to divert water to cultivate the land proposed Waterworks Trusts and waterworks districts, which mushroomed in areas surrounding water resources. Water-related Acts gave local authorities (the Trusts) the power to control and manage their waterworks, including undertaking physical interventions by diverting water or constructing weirs and dams for the specific water resource they managed (e.g. rivers, creeks, watercourses, lakes, lagoons, swamps and marshes). In this regime, objects of consideration, goals, actors, procedures, data and analyses used for decision-making varied as they were based on local needs and perspectives. Thus, although land and water governance operated under Governor in Council circumstances, there was no coordination or formal interactions among policy instruments in their objects, goals, actors, procedures and data (Figure 5.4a). Coordination among actions in land and water practice depended on the Governor in Council as the holder of power in policy instrument

formulation. There was no common set of rules, and if there were inconsistencies or conflicts of interest between Acts applying to the same area, provisions of earlier active Acts prevailed.

Phase 2 (1900s–1980s): substantive integration in land, water, and environmental governance (creating equilibrium in the interaction among resources in biophysical systems)

This phase witnessed gradual changes in the approach guiding the framing of land, water, and environment in the governance of biophysical systems. At the beginning of this phase, the main objective of land and water governance was to serve human demand without considering environmental impacts. Human demand was the primary motivator for land clearing, massive waterworks constructions and water diversions for land and water utilisation. In contrast to the previous phase, during this phase, land and water started to be treated as an interdependent and more coordinated development. The coordination was established via the State Rivers and Water Supply Commission (SRWS) during 1900s–1940s, the Land Conservation Authority (LCA), the Environment Protection Authority (EPA) and the State Environment Protection Policy (SEPP) during 1940s–1980s. (Figure 5.4b).

- 1900s–1940s

According to the Water Act 1905, the State Rivers and Water Supply Commission (SRWSC) had the power to coordinate human interventions on land and water by formulating licences, user rates and rules applied to irrigation and water supply districts. Land registration was conducted every 5–20 years to identify the current conditions of water resources and the demand on them within relevant areas. Information gathered from registration was used by the SRWSC when granting future licences/water allocations and setting user rates, rules and formulating plans and management boundaries. There was no relationship among water users or land users, in this case Trusts and landowners under SRWSC circumstances. Continuing from the previous situation (1860s – 1900s), early in the second phase, the implementation of policy instruments in land and water governance still failed to consider impacts on the environment.

- 1940s–1980s

Consideration of environmental conditions was initiated in the 1940s by the establishment of the Land Conservation Authority (1940), which was responsible for managing the balanced use of

land in Victoria (Figure 4b). The responsibility of the LCA included the preservation of areas of ecological significance, including the establishment of water supply catchment areas. This was the onset of substantive integration in Victorian land, water and environmental governance, which was followed by a vision for integration among various actors related to land, water, and environmental practices regulated in the Environment Protection Act 1970. The Act established the State Environment Protection Policy (SEPP), the guide for balanced resource utilisation in Victoria, and the Environment Protection Authority (EPA). The enacting of the SEPP meant that subsequent policy instruments were required to use SEPP as their guidelines. The existence of SEPP and EPA raised the importance of environmental considerations in land and water governance, creating equilibrium in biophysical systems. The balanced condition of land, water, and environment stated in SEPP became the goal of all policy instruments implemented in land, water, and environmental governance.

In contrast to the substantive integration in goals and objects, authority over land, water, and environmental governance was divided across multiple authorities in 1970s. It is not possible to pinpoint the precise year in which the technocratic approach began to shift. The state-centric approach in land and water governance was replaced by multi-authority governance (polycentric governance), where decision-making and influence in land, water, and environmental governance were shared across multiple authorities. The reduced power of the Governor in Council was reflected in the strengthened powers of the Ministers of Conservation and Water Resources which were the authorities responsible for land and water, and of the Environmental Protection Authority (EPA) which was the authority responsible for environment. The Ministers and EPA were given powers to purchase or compulsorily acquire any land required for the performance of their functions. Their roles included regulating the behaviour of resource users dealing with resources. Licences, user rates, rules, plans, and reports were formulated and enacted in the context of highly interdependent polycentric governance.

In terms of behaviour in policy processes, every authority responsible for land, water, and environment had their own values, perspectives and interests that shaped the framing and implementation of their policy instruments. They had their own management boundaries and procedures for realising their function in the area within their scope under the SEPP. In practice,

they used their own data to support their decisions. The Minister of Water Resources and Water Supply was given power to determine which water resources should be conserved, developed or utilised to the best advantage of Victoria. The Minister was advised by the Water Resources Council, which consisted of members with multiple perspectives who conducted investigations related to water resources and supply throughout the state. In the same vein, the Land Conservation Council had been granted the power to propose investigations for land conservation purposes. Based on these investigations, the council made recommendations to the Minister with respect to the use of public land in order to provide balanced use of land with regard to present and future needs.

Although the interdependencies among land, water and environmental conditions had become a core feature in governance, actors involved were still largely independent when determining their actions. Every authority had their own values and data, and there were no organisational arrangements or requirements for communication, joint decision-making, collaboration or conflict resolution within and between the multiple responsible authorities. In short, at the end of this phase, Victoria had an unmet challenge to increase collaboration between the multiple responsible authorities involved in land, water, and environmental governance.

Phase 3 (1980s–2014): procedural integration in land, water, and environmental governance (creating equilibrium in the interactions among actors in the social system)

There have been several attempts at consolidating and simplifying the tangled web of interactions among actors in land, water, environmental governance (Figure 4c). The first attempt was institutional amalgamation. Lack of efficiency created a sense of urgency to work together, which led to coalitions among authorities. Some of these attempted coalitions during this period include: the amalgamation of the Minister of the Crown and the Minister for Forest into the Minister for Conservation, Forests and Land from 1983 to 1992; the extension of power of the Minister for Planning and Environment from 1983 to 1992, during which their responsibility was not only land-use development but also environmental protection and Crown planning; the establishment of the Minister for Conservation and Land Management, which was the amalgamation of the Minister for Conservation, Forest and Land and the Minister for Water Resources. This ministry included

most of the responsibilities of the Minister for Planning and Environment during 1992–2002. However, the amalgamation into one minister in land, water, and environmental governance was not long lasting, and was divided into ministries in 2002.

The Ministry for Planning was chosen in this phase to integrate structure and procedure among responsible authorities for land, water, and environment in Victoria. The Planning and Environment Act 1987 established the Minister for Planning and Environment as a single authority with the power to issue permits for land-use development. The Minister held the authority to permit any activity or any change in the use of land that could significantly affect the biophysical system (e.g. drainage regimes). The Minister for Planning and Environment became a mediator between various ministers and their plans regarding land, water and environmental practices. The Act set out that every sectoral decision-making process, in this case the implementation of policy instruments, made by responsible authorities must be made available to, and approved by, other related authorities (referral authority) who were decided by the Minister. As this procedural arrangement required the consideration of the concerns of other related responsible authorities, the degree of interaction increased. In addition, the Act also required the consideration of other reports, plans, policies, and investigations. As a result, both statutory planning (planning schemes) and strategic planning produced by ministers and authorities (e.g., water management schemes, catchment management plans, regional catchment strategies) should reinforce one another. Minister amalgamation and the extension power of the Minister for Planning and Environment in this phase showed that there were attempts to create procedural integration in decision-making processes by making formal linkages between responsible authorities (resource managers) and referral authorities (the authorities from which responsible authorities needed to seek approval before implementing their policy instruments), which later influence the implementation of their policy instruments. The winners and losers in the process of land, water, and environmental governance were identifiable and accommodated through procedural integration.

Phase 4 (2014 –2016): analytical and practical integration in land, water, and environmental governance

Procedural integration was not followed by analytical and practical integration. Although goals, objects, and procedural arrangements in land, water and environmental governance had been

coordinated, the policy instruments of one authority did not have a direct influence on the function of other authorities. For example, Catchment Management Authorities (CMAs) and the EPA were working on the same geographic and policy areas simultaneously (focuses on land, water, and environment) under the SEPP and the Minister for Planning, but the implementation of their policy instruments (licences/permits, user rates, rules, plans and reports) was still under the control of each authority supported by their own data and analyses.

The establishment of the Department of Environment, Water, Land, and Planning in 2014, with which the Ministers for Resources, Water, Planning and Environment and Climate Change collaborated, was a further attempt at integration, extending it to analytical and practical integration. In this case, every decision-making process needed to consider or use the same data/information and analytical platform established under the DEWLP framework. It required that every decision/policy made by one minister would be known, understood and used by other ministers. Every minister and authority, including its policy instruments, were a part of the DEWLP system. In this period, several ministers had their own powers to set targets and instruments according to their objectives and concerns, but they were required to use common analytical and practical processes under the DEWLP framework.

Several attempts at the integration of land, water, and environmental governance can be distinguished based on relationships among objects, goals, actors, procedures and data used in the implementation of policy instruments (Figure 5.4). In summary, based on the framing of interactions among biophysical system and social system components, the history of integration in Victorian land, water, and environmental governance can be divided into four distinct phases:

- **Phase 1: circa 1860–1900s.** No integration between land, water, and environmental governance. There were no linkages among objects, goals, actors, procedures and data used among policy instruments implemented in land, water, and environmental governance (Figure 4a).
- **Phase 2: circa 1900s–1980s.** Substantive integration between land, water, and environmental governance through the recognition of relationships among objects and goals in the implementation of policy instruments designed to create equilibrium in the biophysical system (Figure 4b).

- **Phase 3: circa 1980s–2014.** Procedural integration between land, water, and environmental governance through the encouragement of interaction among actors and procedures in the implementation of their policy instruments (Figure 4c).
- **Phase 4: 2014–2016.** Analytical practical integration between land, water, and environmental governance through the encouragement of using integrated data in the implementation of their policy instruments (Figure 4d).

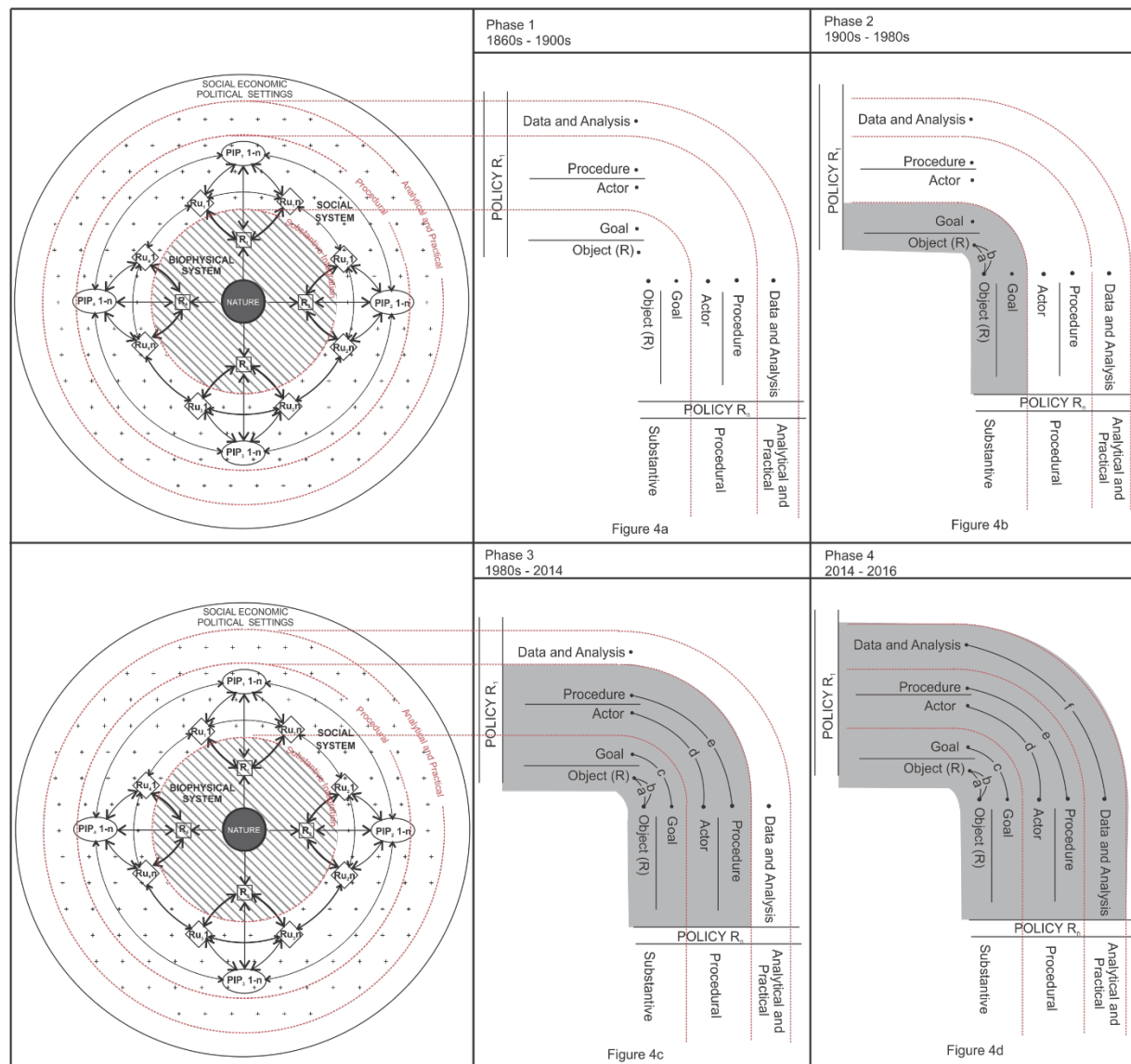


Figure 5. 4 Integration phases in land, water, and environmental governance in Victoria during 1860–2016

5.4.2 Co-evolution of land, water, and environmental governance within the biophysical system

The previous section elaborated how land, water, and environmental governance have been integrated in Victoria, moving from no integration in Phase 1 to cover four dimensions of integration by Phase 4 (Figure 5.4). In this section, how this gradual integration has been response to land, water, and environmental practices and influences the biophysical condition will be discussed. The co-evolution of land, water, and environmental governances and biophysical change in Victoria for the period 1860–2016 is shown in Figure 5.5.

Phase 1 (1860–1900s): no relationship among policy instruments implemented in land, water and environmental governances

The Australian landscape was in equilibrium before European settlement. Although European settlement started in 1837, the first Act in Victoria to regulate European settlement was enacted in 1862 and was followed by a series of Acts to regulate human behaviour when dealing with nature. Early European invaders took up large on Crown land, and there was in effect no governmental control. Without any specific regulation to control human behaviour in dealing with land, the first three decades of early settlement in Victoria led to the onset of environmental deterioration. From the 1860s onward, a series of Acts were formulated to reduce squatting runs, which were unregulated and took much of the productive Crown land (Powell 1989). Acts relating to water were also first introduced in 1865. Although pastoralism requires water availability, the implementation of policy instruments formulated under Acts for land selection and water utilisation did not represent their interdependencies (were not correlated). Government intervention in land and water management through policy instruments occurred incrementally as ad hoc decisions to cope with problems as they arose. Although attempts were made to control the direction and pace of expansion, policy instruments set out in Acts could not limit ‘free selection’ during this period. Over the period 1866–1901, forest cover decreased from approximately 90% to 50% of the state (Figure 5.5A). Almost all Victorian land was assigned as free-hold land (94%). However, following the enactment of a series of Acts, the trend differed between grazing and crop and pasture activities. Early settlement first involved the grazing of native vegetation, and this was followed by conversion to improved pastures, cropping and other agricultural activities, resulting

in a rapid increase in the native vegetation grazing area followed by a slow decline and a coincident increase in more intensive agriculture (Figure 5.5C). In terms of water resources, significant changes in land cover led to reduced evapotranspiration and increased runoff (Figure 5.5B). Over this period, there was only limited development of water resources and there was no consideration of environmental conditions in water governance. There is no documentation of environmental water allocations in this phase.

Phase 2 (1900s–1980s): creating equilibrium in the biophysical system through substantive integration in land, water and environmental governance

The Federation Drought (1895–1902) awakened the need to secure water availability for irrigated land. The drought was responded to by a long and extensive period of water storage construction and reorientation in land and water governance (Figure 5.5b). Land and water were treated as interlinked resources managed centrally by the SWRS Commission. The contribution of this consolidation is evident from the large increase in the area of the irrigation district, which more than doubled from 351,077 ha in 1906/07 to 812,223 ha in 1935 (Powell 1989).

Another extended drought in 1936–1945 and increased pressure resulting from population growth after World War II triggered another lesson for Victorian land and water governance. The State governments began to realise that emphasising engineering work alone was inadequate for survival from erratic, unpredictable and hazardous climatic and social pressures. Managing land and water required comprehensive and accurate knowledge of the biophysical system. It was actualised by the establishment of the Land Conservation Authority in 1940, which was responsible for conducting land assessments over the whole state in order to achieve a balanced use of Victorian land. An important milestone was the establishment of the first declared water supply catchment area. Land, water and environment were framed as separate entities in policy instruments implemented for land governance, with the aim of creating balanced use. During this phase there was a significant reduction in the rate of land clearing. In terms of water governance, not all policy instruments identified from the six-policy instrument framed land, water and environment as entities in their implementation.



Figure 5. 5 The co-evolution of hydrology and land, water, and environmental governance in Victoria. Figure A. Change in land utilisation was represented by the ratio between Crown land and free-hold land and the ration between forest and non-forest area. Figure B. Change in water resource condition was represented by water storage volume and runoff plotted against left axis. In addition, population representing demand on resource was plotted against the right axis. Figure C. Change in land use for economic purposes was represented by percentage of land allocated for grazing, native vegetation activities and agriculture activities.

The second drought and the growing population after World War II were responded to by changes in user rates and rules regarding water allocation. When a water right was first issued, the volume of water available under the right increased over four years such that one quarter, one half, three quarters and then the full volume were available in the first, second, third and fourth years of the water right respectively. User rates were determined based on benefits to users and took distance from water resources into account. Environmental condition was first considered in the 1940s with the enactment of a rule preventing the distribution of all available water and requiring the allocation of additional water for land affected by salinity.

In the 1970s, the need for comprehensive information regarding the condition of Victorian land, water, and environment became clear. The power of the Governor in Council in governing land, water, and environment was split into several different ministries and authorities. To ensure a common strategic direction with respect to environmental governance, a common goal, in this case the enactment of SEPP, was set up to be an umbrella for all actions conducted by the multiple authorities responsible for land, water, and environmental governance in Victoria. The enactment of the SEPP set out in the Environment Protection Act 1970 formalised the consideration of environment condition as an inseparable resource in land and water governance. With the SEPP providing a common goal, every policy instrument implemented in land and water governance needed to measure its environmental impacts in its implementation.

Phase 3 and 4 (1980s–2016): creating equilibrium in the social system through procedural, analytical and practical integration among policy instruments in land, water, and environmental governance.

Overall, since the 1980s, changes in the biophysical system – as measured by the indicators used here – have been much slower than in earlier periods (Figure 5.5), although the population has continued to grow and changes in climate have occurred. Beginning in the 1940s, the priority of land and water utilisation in favour of economic outcomes began changing gradually toward greater consideration of environmental health. The balance between Crown land and free-hold land reached its current status in the 1940s (Figure 5.5a). Meanwhile, forest and native vegetation areas were increasing (Figure 5.5a). Water governance was put under pressure by increasing demand and the lack of additional water-storage capacity after 1983. Victoria was entering a new phase in

its learning process in land, water, and environmental governance, where it was trying to find equilibrium in resource utilisations to avoid significant deleterious physical interventions in the biophysical system. From the 1980s onward, Victoria made several attempts to align interactions among components of the social system when implementing policy instruments impacting the biophysical system via land, water, and environmental governance. Evidence of attempts to balance rights in land, water and environmental governance are found in policy instruments encouraging greater integration among actors, procedure and data. These attempts were able to minimise the environmental footprint, although Victoria was increasingly challenged to meet the increased water demand for consumption and the environment. The allocation of environmental water was generally increasing (see Table 5.2).

Table 5.2 Environmental water availability and delivery across Victoria from 2011–12 to 2015–16

Year	2011–12	2012–13	2013–14	2014–15	2015–16
Total volume available (ML)	720716	765135	1105541	994545	1103766
Total volume delivered (ML and percentage of total volume available)	517229 (72%)	437241 (57%)	809678 (73%)	645767 (65%)	689532 (62%)

Source: VEWB Annual Report 2011–2015

5.5 Conclusion

This paper developed a framework for analysing integration of interdependent governance resources by examining the developing web of relationships among SES components (Figure 5.1). It was developed by combining the role of policy instruments in social-ecological systems and Briassoulis's method for policy integration. When reflecting on governance integration in SESs, it is informative to examine the relationships among objects, goals, actors, procedures and data of policy instruments used to govern the behaviour of biophysical and social system components. The relationships among multiple resources in the biophysical system (substantive integration) can be assessed by how objects and goals are framed in the implementation of policy instruments. Meanwhile, when dealing with the biophysical system, relationships among social system components can be elaborated by examining how interactions among actors, procedures have been set up. Finally, practical integration among policy instruments used in land, water, and

environmental governance can be assessed through the relationship among data and analyses used in the implementation of policy instruments.

In the Victorian journey, substantive, procedural and analytical practical integration were achieved in sequence. We can see that having common goals and perspectives (Phase 2) suggests a need for cooperation in order to share roles and responsibilities among involved actors. Analytical/practical integration is achieved only when substantive and procedural integration is well established. Procedural integration occurs when there is substantive integration among actors. In Victoria, substantive, procedural, and analytical practical integration would be achieved in sequence. In summary, integration in the governing of land, water, and environment will be synergised, congruent, coherent and compatible with one another when all policy instrument implementation connects and creates synergies among resources (Rs) in the biophysical system (substantive dimension), and actors (RUs, PIPs) in the social system. This is the full-dimensional integration.

This paper reports a detailed exploration of the history of land, water, and environmental governance integration in Victoria, Australia, and compares it with state-wide changes within the biophysical system. Our study time framework provides a complete history of the development of land, water, and environmental governance, as it extends over approximately 150 years, starting from early European settlement and extending to recent times when the focus of governance is on resource management rather than development. We found that integration during the co-evolution of land, water, and environmental governance involved a process of learning how to balance interactions among biophysical (resources) and social (actors involved in resource governance) system components. Poor understanding of the interdependencies of land, water and environment can lead to individual resources being undervalued compared to others. Before the 1940s, the environment was given little attention or value in Victorian governance of land and water. This is evident in the lack of linkages between the governance of different resources, as shown in Figure 5.4a. Over time, land, water, and environment began to be treated as inseparable resources. This was supported by substantive and procedural integration creating stronger relationships among objects, goals, actors, and procedures in the implementation of policy instruments. As a result, consistent bargaining positions for land water and the environment developed, creating a new trade-off in biophysical system conditions (see Figure 5.5, post 1980). This study provides

empirical evidence that there is an association between the Victorian government's understanding of dynamic and complex biophysical and social systems (represented in their policy instrument) and the condition of SES.

Above all, the Victorian case illustrates the development of governance mechanisms to promote resource utilisation while improving the capacities of policy instrument deployed in reconciling the trade-off among SES components. From the 1980s onward, Victorian land cover and water storage capacity has remained stable (Figure 5.5a, 5.5b). The challenge to meet increasing demand for water, for both consumption and to reverse environmental degradation (e.g. environmental water), was addressed by actively considering integration in the interventions on land, water, and environment to optimise the outcomes. Using state-wide data to trace the change in governance system and SES condition, it found that they have their own pathways but are interlinked over time. Through the strong association between the co-evolution of land, water, and environmental governance, the Victorian example shows that the capacity of resource governance to integrate their interventions in land, water, and environmental governance create differences in biophysical conditions (Figure 5.5). In examining each phase of integration identified in Victoria, it is notable that the onset of governance integration was through substantive integration, which was then followed by procedural, analytical, and practical integration in sequence.

Looking back at Victoria's journey, we may be persuaded that maintaining and strengthening integration among components of the biophysical and social systems in governance of land, water, and the environment is important for moving towards sustainability and for avoiding costly environmental degradation. Good outcomes in terms of wealth and environmental condition are not only the product of engineering work but also of governance innovations (Anadon Laura et al. 2016; Anadon et al. 2014). Although this case study describes Victoria in particular, the circumstances experienced over the past century are not unique. Given that integrating land, water, and environmental governance is a common agenda in many regions of the world, the Victorian lessons could be useful in other regions.

Chapter 6

Discussion and Conclusion

6.1 Summary

In the case of land, water, and environmental governance, challenges occur not only in accurately defining the intertwined problems, but also in how policy should be arranged to address the problems. Models, for example, socio-hydrological models are often used to assist in decision-making for effective resource governance. The interactions and feedbacks between humans and water are used in models to analyse systems. However, the lack of capacity to understand the ‘actual state of the system’, in most cases, has led to the resource governance being caught between the subjectivity and the arbitrariness approaches in viewing equitable allocations of resources (Popa, 2007). A common government perspective is that desired resource conditions need to be prescribed as part of governance, rather than a governance approach needing to be developed in order to fit the resource condition. In the last three decades, the social-ecological system framework (SESF) literature has provided a diagnostic approach to examining social-ecological system (SES) conditions by structuring issues that are significant from a problem-solving perspective and thereby reaching conclusions about SES conditions (Ostrom 2007). However, the potential of governance to create differences in SES conditions has not been the primary concern of SES frameworks (Armitage 2008; Travers et al. 2011). The current frameworks give no explanation of interactions among components in their extent and significance. This creates difficulties in guiding purposeful institutional change in order to steer SESs onto desirable pathways (Section 2.3).

Section 2.4 suggested that to improve social-ecological system (SES) governance requires understanding of how the complex interactions between components of biophysical and social systems have been regulated under previous and current governance arrangements, among other factors. There is still a lack of knowledge about how change in governance system needs to be made in order to steer SESs onto desirable pathways. Understanding how government interventions have been improved in the past, in terms of their capacities to accommodate dynamic interactions within the system requires understanding over a long timeframe is required as policy

change is a gradual process with change and stability bound together. Policy mixes and policy integration are common approaches used in SES governance since single interventions are not enough to cope with intertwined problems in the system. As discussed in Section 2.5, there are no clear prescriptions as to how they can be implemented or improved.

Attempting to give insight into the linkages between the governance system and an SES, this thesis aimed to understand the co-evolution of land, water, and environmental governance through integration of policy and social-ecological system frameworks. In this thesis, the state of Victoria is chosen as a case study through which to examine the development of land, water, and environment governance and its relationship with changes in the biophysical system. The evolution of land, water, and environmental governance is represented by the evolution of its policy instruments. Policy instruments include government tools which directly affect the way a resource is distributed (substantive policy instruments), as well as the behaviour in the policy process aimed at attaining the targeted condition (procedural policy instruments). Representing government interventions on land, water, and environment with policy instruments allows sensitivity to change in problems and conditions. The policy instruments, which act as primary data in this thesis, were extracted from Victorian Acts related to land, water, and environmental management enacted between 1860 and 2016. The policy instruments were coded and analysed to understand their role as “managers” of dynamic interactions, rather than as government solutions to solve problems. Finally, the development of policy instruments over time was associated with changes in biophysical and social system conditions.

In Chapter 3, a SES framework (‘the framework’) was developed by extending the SES frameworks proposed by Ostrom and Anderies (Anderies, Janssen & Ostrom 2004; Ostrom 2007) to include policy instruments as a key variable in SES framework. In past theoretical developments in resource management, policy instruments and SES, which have played important roles, have been considered in isolation from each other. In the framework, policy instruments have been positioned as explanators of the interaction between multiple interdependent resources (Rs), various resource users (RUs), and public infrastructure providers (PIPs) in SES. It argues that the role of policy instruments in managing the interactions between and among Rs, RUs, and PIP can help policy analysts explain the linkages between components of biophysical and social systems,

and that their configuration has a significant role in directing SES conditions. It assists the decision-maker examine systematically SES governance through the configuration of policy instruments by elucidating: (1) how the biophysical system has been understood in SES governance as represented by the relevant policy instruments; (2) how the social system has been set up in SES governance; and (3) how the synergies and trade-offs between biophysical and social systems have been managed in the governance of a SES. Using framework as a template helps examine how well interactions between the biophysical and social systems have been accommodated by policy instruments in supporting the sustainability of SESs, as well as helping to identify any absent, overlapping or contradictory policy instruments in the governance of the SES, and to identify policy integration.

In Chapter 4, by applying the conceptual framework developed in Chapter 3, a longitudinal study on Victorian Acts was conducted to understand the evolution of governance – through the configuration of policy instruments – for land, water, and environmental governances implemented from 1860 to 2016. Improvements in the capacity of governance to reflect the dynamic interaction within SES were evaluated. The investigation found that the types of policy instruments ruling the interactions among and between Rs, RUs, and PIPs in land, water, and environmental governances from 1860 to 2016 did not vary (those policy instruments being licences/permits, user rates, rules, plans and reports, boundaries, and institutional frameworks). However, changes have occurred in the circumstances in which they were implemented, in this case, differing interactions among components of the biophysical and social systems. From Victorian history, four typologies of policy instrument configuration were constructed: reserve regimes, authority regimes, information regimes, and integration regimes. From a theoretical perspective, this empirical study showed that the circumstances under which interactions between biophysical and social systems take place deserve attention as partial shapers of policy instruments.

Building on the findings in Chapter 4, Chapter 5 provides an exposition of the co-evolution of governance and SES condition. Unpacking the integration in policy instruments used in land, water, and environmental governance to understand their co-evolution, the study found that there is a strong association between the capacity of policy instruments to manage the interdependencies between components in an SES and changes in land, water, and environmental conditions. How

the capacity of policy instruments to manage the interactions between component SES can be assessed through integration in their objects, goals, actors, and data analysis in their implementations. The relationships between land, water, and environment in the biophysical system was assessed by how their interactions had been framed by policy instrument objects and goals. The relationship among actors involved in the social system can be assessed by examining how their interactions are framed in the procedure of the implementation of policy instruments. Finally, the practical integration in land, water, and environmental governance can be assessed through the integration of data and analysis used in the implementation of policy instruments. It was found that integration during the co-evolution of land, water, and environmental governance involved a process of leveraging the interaction that occurred within the system. In addition, the study found that there is a strong association between their integration with changes in land, water, and environmental conditions. Looking back at Victoria's journey in land, water, and environmental governance integration aiming to reverse degradation, it suggests that integration can be inferred from the way policy instruments have been implemented. Integration can be promoted by linking object (scope of objects covered), goals, actors, procedures and data in the implementation of policy instruments.

6.2 Implications

Government interventions aiming to promote the condition of land, water, and environment do not always result in positive outcomes. Mixtures of policy instruments are common phenomena when trying to cope with intertwined problems such as those related to land, water, and environment. However, there is still a lack of knowledge as to how policy instruments can be most effectively improved within the context of their relationships with other previous and existing policy instruments with the aim of steering the condition of an SES in desirable ways (purposeful institutional change). Considering policy instruments in SESs as rules of interaction among SES components, the framework provides a diagnostic method with which to examine the capacity of governance to manage the dynamic and complex interactions between biophysical and social system. The framework can be used to examine governance within SESs in three ways: (1) examining the capacity of a policy instrument as the manager of the dynamic interactions within the system; (2) individual governance of each of land, water, and environment; and (3) the integration of land, water, and environmental governance. Each policy instrument contains

information regarding its specific scope of objects covered, goals, actors, and procedures for implementation.

Unpacking that information enables analysis of how policy instruments manage the interaction between components of biophysical and social systems. In particular, it can describe the direction of causal interactions (trade-offs) among and between resources, resource users and public infrastructure providers. In the framework, substantive policy instruments set the rules for the interaction between resources and resource users. Unpacking a substantive policy instrument, for example a water licence, allows for the capacity of this policy instrument to accommodate dynamic complex interaction between elements of the biophysical and social systems to be examined. Specifically, how the linkage between water and other related resources (R-R), and how the interests of related and impacted actors (resource users and public infrastructure providers), have been considered in water licence implementation can be determined. In the same way, the framework can be used to examine procedural policy instruments which rule the behaviour of policy process. Specifically, it can be used to examine how the interaction between land, water, and environment (R-R) has been considered in the policy process, how the resource interactions (R-R) are reflected in the interaction/coordination among public infrastructure providers (PIP-PIP), and how the interaction has been used as the basis for public infrastructure providers managing resource users (PIP-RU), as well as interactions between resource users in dealing with resource (RU-R) and among resource users (RU-RU).

Reflecting how multiple policy instruments (policy instrument mix) work simultaneously in the governance of each of land, water, and environment, the framework can be used to identify any absence, overlap, or contradiction among policy instruments in managing complex and dynamic SESs. Moreover, the tone of governance for each of land, water, and environment can be identified. In Victoria's history (Chapter 4), the governance tone changes when the capacity of policy instruments to manage the interactions within SES is changing. In particular, it can be identified whether the governance has been weighted towards one component of the SES more than others, for example towards the resource condition or political will (PIP interest) or optimization of pareto set, by examining how the policy instruments steer the interaction/trade-off among components within the SES.

By reflecting policy instruments used in land, water, and environmental governance simultaneously within the framework, it is possible to identify the integration among these different sectors. As has been discussed earlier, every policy instrument contains information about the extent to which biophysical and social system conditions are considered in the implementation of the policy instrument, through the linkages identified within the framework. More linkages covered by the policy instrument means the policy instrument has more capacity to cope with the dynamic and complex interactions between SES components. Thus, reflecting policy instruments used in land, water, and environmental governance simultaneously within the framework, the integration between them can be identified. When the linkage between different resources (R-R) are covered by all policy instruments, the substantive dimension of integration is achieved. In the same way, when the linkage between social system components (resource users and public infrastructure provider) are well connected, the procedural dimension of integration is achieved. However, the findings from examining the Victorian journey show that policy instrument integration requires not only substantive and procedural integration, but also analysis and data integration during their implementation in order to improve the capacity of policy instruments to manage the interactions among components within SES.

Testing the framework on the Victorian journey in land, water, and environmental governance (Chapter 5), it is found that there is a strong association between the capacity of policy instrument as manager of interactions and the SES. The study provides empirical evidence that the change in each biophysical system (land, water, and environment) and its governance (land, water, environmental governance) have followed their own pathways, but that those pathways are interlinked, and the governance has coevolved. Without examining changes over the long term, this coevolution is likely to be overlooked (i.e. in short-term analyses). The government approach in their interventions in land, water, and environmental government have evolved over time as part of a government learning process to create pareto set in the interactions within SES that considers changes in land, water, and environment condition. Throughout Victorian history, in ways aligning with the psyche of Victorian settlement in the early 1830s, nature has been vastly altered to facilitate desired development. Economic perspectives were the main consideration in governance, and this resulted in limited recognition of natural systems in early land, water, and environmental

governance. It took more than a century for Victoria government to understand that resource governance needs to be developed to fit with natural systems, instead of prescribing nature as government rationale – which is still the common governance approach across the world. The Victorian government learning to adapt to and accommodate the natural system, and its desire to limit significant negative impacts of its intervention in land, water and environmental conditions, has resulted in the inclusion of dynamic interaction within the SES. As a consideration in formulating policy instruments for land, water and environmental governance, it is represented by the subtle changes in their policy instrument capacities.

Overall, the study shows a new way to promote integration in land, water, and environmental governance; that is, by improving the capacity of policy instruments to consider all the related components and their interaction within the SES during policy implementation. It is suggested from this study that policy instruments need to be viewed as managers of the interactions within the SES, instead of as problem solvers. Each policy instrument should consider and aim to leverage the interactions among component of biophysical and social system in which they operate. Policy instruments need to consider all related objectives, goals, and actors; to integrate procedures in their implementation; and to use integrated data and analysis to improve their capacities.

6.3 Limitations and future directions

In this study, the attempt to understand the associations between the co-evolution of land, water, and environmental governance and the conditions of the SES had several limitations, which could be the subject of future research. They include:

- The data source used to trace the co-evolution of land, water, and environmental governance was confined to Victorian Acts. The influence of international and national political conditions and local conditions on the evolution of land, water, and environmental governance was not directly included.
- The configuration of policy instruments implemented in land, water, and environmental practices extracted from the Acts were used to represent their governance. The investigation did not include the policy process leading to the enactment of an Act. This means that the motivation for the introduction or changes in the acts was not considered.

- Policy instruments were extracted manually from the Acts. There was no option to use qualitative data analysis software such as NVivo in the data analysis process as most of the Acts are in hardcopy documents. In addition, as the initial searching was limited keywords (“land”, “water”, “environment”, “crown”, “forest”, “drainage”, “irrigation”, “river”, “catchment”, and “flood”) in the title of Acts, there is possibility that some Acts related to land, water, and environmental practices were overlooked.
- The study used Victoria as a case study where the Acts serve as the main statutory apparatuses for land, water and environmental governances. This may not be the case in other regions.
- Due to lack of historical spatial data on land use change with high resolution and short records of other environmental data on run-off, water diversion, and environmental flow, the indicators used to describe the change in biophysical systems were very general. In addition, as the study covered a large and diverse area (the State of Victoria), time constraints led to the use long-term average annual rainfall to predict run-off, instead of adopting a yearly basis. Hence the impacts of climate variability on the biophysical system during the study period was not considered.
- The study used Victoria as a case study where there is strong dependency of land and environmental governance on water governance. In Victoria, water is the most important of all-natural resources; however, this would not be the case in many regions. An important area for further research is to investigate to what extent different resource conditions may influence their governance situations (e.g. water scarce compared with water rich).
- The study used the Victorian state (i.e. administrative) boundaries instead of catchment area in understanding the change of biophysical system. It also considered the state as a whole; however, the biophysical condition varies significantly across Victoria, meaning that the vulnerability or response to change in government intervention varies across the state. An important area for further research is to apply the governance regime shifts found in this study to specific catchment areas to understand their impacts on biophysical system.
- In this thesis, the linkage between changes in governance system and SES condition was examined using association analysis instead of causal relation analysis. This study provides empirical evidence that there is an association between the Victorian government’s understanding of dynamic and complex biophysical and social systems (represented in their policy instrument) and the condition of SES.

- The framework can assist decision-makers to examine their resource governance systems and gain greater knowledge of these complex systems with the aim of improving existing governance. Understanding the ‘actual state’ of a governance system in managing the dynamic conditions of SES components and their interaction will support development of more robust modelling, such as economic modeling, hydrological modeling, to steer the governance change for more sustainable SES.

6.4 Final words

Understanding the governance failures which led to degradation in land, water, and environment condition requires evidence of their mutual interactions. However, the complex intertwined problem related to land, water, and environment creates complexity in providing the solution. In this study, policy instruments were incorporated into the SESF by treating them as rules of interaction between SES components. Tracing the history of the co-evolution of policy instruments implemented in land, water, and environmental governance in Victoria during 1860–2016 with biophysical conditions, the findings demonstrated the association between the capacity of policy instruments to accommodate the dynamic interconnected components within the SES and the change in land, water, and environmental condition. Broader lessons from this study provide a new way to promote integration in land, water, and environmental governance, that is by improving the capacity of policy instruments to consider all the related components and their interaction in the SES during their implementation. It suggests that the policy maker should consider policy instruments as managers of the interactions within the SES, instead of as problem solvers, in their formulation. Applying the same considerations to each policy instrument regarding the SES conditions can create synergy and integration in land, water, and environmental governance.

Appendix

List of Acts

Keywords: Land

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|---|---|
| 1. The Land Act 1862 | 41. Land Tax Act 1918 |
| 2. The Land Act 1869 | 42. Transfer of Land Act 1918 |
| 3. The Land Act 1875 | 43. Land Tax Act 1919 |
| 4. The Land Act 1878 | 44. Land Tax Act 1920 |
| 5. The Land Act 1880 | 45. Land Tax Act 1921 |
| 6. The Land Act 1884 | 46. Land Compensation Act 1921 |
| 7. The Land Act 1889 | 47. Transfer of Land Act 1921 |
| 8. Land Act 1890 | 48. Land Tax Act 1922 |
| 9. Land Tax Act 1890 | 49. Land Tax Act 1923 |
| 10. Transfer of Land Act 1890 | 50. Land Tax Act 1926 |
| 11. Land Compensation Act 1890 | 51. Land Tax 1927 |
| 12. Land Act 1891 | 52. Land Tax Act 1928 |
| 13. Land Sales by Auction Fund Act 1891 | 53. Land Compensation Act 1928 |
| 14. Land Act 1893 | 54. Transfer of Land Act 1928 |
| 15. Settlement of Lands Act 1893 | 55. Land Tax Act 1929 |
| 16. Land Act 1896 | 56. Land Tax Act 1931 |
| 17. Land Act 1898 | 57. Land Act 1932 |
| 18. Land Act 1900 | 58. Land Tax Act 1932 |
| 19. Land Act 1901 | 59. Land Act 1933 |
| 20. Land Act 1903 | 60. Land Tax Act 1933 |
| 21. Transfer of Land Act 1903 | 61. Land Act 1934 |
| 22. Land Act 1904 | 62. Land Tax 1934 |
| 23. Transfer of Land Act 1904 | 63. Land Act 1935 |
| 24. Land Act 1905 | 64. Land Tax Act 1935 |
| 25. Land Draining Facilities Act 1907 | 65. Land Act 1936 |
| 26. Transfer of Land Act 1907 | 66. Land Tax Act 1936 |
| 27. Land Act 1909 | 67. Land Tax Act 1937 |
| 28. Land Settlement Loan and Application Act 1943 | 68. Land Tax Act 1938 |
| 29. Land Tax Act 1910 | 69. Land Act 1939 |
| 30. Land Tax Act 1911 | 70. Land Tax Act 1939 |
| 31. Land Tax Act 1912 | 71. Land Tax Act 1940 |
| 32. Land Tax Act 1913 | 72. Land Act 1941 |
| 33. Land Tax Act 1914 | 73. Land Tax Act 1941 |
| 34. Transfer of Land Act 1914 | 74. Transfer of Land Act 1941 |
| 35. Land Tax Act 1915 | 75. Land Tax 1942 |
| 36. Land Compensation Act 1915 | 76. Land Settlement Act 1943 |
| 37. Transfer of Land Act 1915 | 77. Land Settlement Loan and Application Act 1943 |
| 38. Land Tax Act 1916 | 78. Land Tax Act 1943 |
| 39. Transfer of Land Act 1916 | 79. Land Act 1944 |
| 40. Land Tax Act 1917 | 80. Land Tax Act 1944 |

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| 81. Land Tax Act 1945 | 124. Soil Conservation and Land Utilization Act 1962 |
| 82. Land Act 1946 | 125. Land Act 1963 |
| 83. Land Tax Act 1946 | 126. Land Tax 1963 |
| 84. Land Tax Act 1947 | 127. Sale of Land Act 1963 |
| 85. Soil Conservation and Land Utilization Act 1947 | 128. Land Act 1964 |
| 86. Land Act 1948 | 129. Land Tax 1964 |
| 87. Land Tax Act 1948 | 130. Public Lands and Works Act 1964 |
| 88. Transfer of Land Act 1948 | 131. Valuation of Land Act 1964 |
| 89. Land Act 1949 | 132. Land Settlement and Rural Finance Act 1965 |
| 90. Land Tax Act 1949 | 133. Land Tax 1965 |
| 91. Soil Conservation and Land Utilization Act 1949 | 134. Sale of Land Act 1965 |
| 92. Land Tax Act 1950 | 135. Valuation of Land Act 1965 |
| 93. Land Act 1951 | 136. Land Act 1966 |
| 94. Land Tax Act 1951 | 137. Land Tax 1966 |
| 95. Land Act 1952 | 138. Soil Conservation and Land Utilization Act 1966 |
| 96. Transfer of Land Act 1951 | 139. Land Tax 1967 |
| 97. Land Tax Act 1952 | 140. Land Act 1968 |
| 98. Land Tax 1953 | 141. Land Tax Act 1968 |
| 99. Land Tax Act 1954 | 142. Lands Compensation Act 1969 |
| 100. Transfer of Land Act 1954 | 143. Land Tax 1969 |
| 101. Land Tax 1955 | 144. Land Conservation Act 1970 |
| 102. Land Act 1956 | 145. Land Settlement Act 1970 |
| 103. Land Tax 1956 | 146. Land Tax Act 1970 |
| 104. Land Act 1957 | 147. Land Act 1971 |
| 105. Land Tax 1957 | 148. Land Tax Act 1971 |
| 106. Soil Conservation and Land Utilization Act 1957 | 149. Land Conservation 1972 |
| 107. Land Act 1958 | 150. Land Act 1972 |
| 108. Land Tax 1958 | 151. Land Tax Act 1972 |
| 109. Land Settlement Act 1958 | 152. Land Act 1973 |
| 110. Lands Compensation Act 1958 | 153. Land Tax Act 1973 |
| 111. Soil Conservation and Land Utilization Act 1958 | 154. Lands Compensation Act 1973 |
| 112. Land Settlement Act 1959 | 155. Valuation of Land Act 1973 |
| 113. Land Act 1959 | 156. Land Tax Act 1974 |
| 114. Transfer of Land Act 1959 | 157. Land Act 1975 |
| 115. Land Tax 1959 | 158. Land Tax Act 1975 |
| 116. Land Act 1960 | 159. Land Act 1976 |
| 117. Land Tax 1960 | 160. Land Act 1977 |
| 118. Valuation of Land Act 1960 | 161. Land Tax Act 1977 |
| 119. Land Act 1961 | 162. Land Tax Act 1978 |
| 120. Land Tax Act 1961 | 163. Valuation of Land Act 1978 |
| 121. Land Act 1962 | 164. Land Tax Act 1979 |
| 122. Land Tax Act 1962 | 165. Local Government (Land Liable to Flooding) Act 1979 |
| 123. Sale of Land 1962 | 166. Land Tax 1980 |

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| 167. Valuation of Land Act 1980 | 178. Land Act 1987 |
| 168. Sale of Land Act 1980 | 179. Land Act 1988 |
| 169. Sale of Land Act 1981 | 180. Land Act 1989 |
| 170. Public Lands and Works Act 1982 | 181. Land Act 1991 |
| 171. Land Tax 1983 | 182. Land Tax 1991 |
| 172. Land Act 1984 | 183. Land Act 1993 |
| 173. Land Act 1985 | 184. Land Titles Validation Act 1993 |
| 174. Sale of Land Act 1985 | 185. Land Act 1994 |
| 175. Soil Conservation and Land Utilization Act 1985 | 186. Land Titles Validation Act 1994 |
| 176. Land Act 1986 | 187. Land Act 1995 |
| 177. Land Acquisition and Compensation Act 1986 | 188. Land Revocation Act 1995 |

Keywords: Water

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|---|---|
| 1. Waterwork Act 1865 | 25. Water Supply Loan Application Act 1901 |
| 2. Waterworks Commissioners Act 1869 | 26. Water Supply Loan Application Act 1902 |
| 3. The Victorian Water Conservation Act 1881 | 27. Water Supply Loan Application Act 1903 |
| 4. The Victorian Water Conservation Act 1883 | 28. Water Act 1903 |
| 5. The Victorian Water Conservation Act 1884 | 29. Water Supply Special Funds Application Act 1904 |
| 6. The Victorian Water Conservation Act 1885 | 30. Water Act 1905 |
| 7. The Victorian Water Conservation Act 1886 | 31. Water Supply Loan Application Act 1905 |
| 8. The Water Conservation Act 1887 | 32. Waterworks Land Sales Act 1906 |
| 9. The Water Conservation Act 1889 | 33. Water Supply Loan Application Act 1906 |
| 10. Water Construction Encouragement Act 1890 | 34. Water Supply Loan Application Act 1907 |
| 11. Water Act 1890 | 35. Water Supply Loan Application Act 1909 |
| 12. Water Construction Encouragement Act 1891 | 36. Water Act 1909 |
| 13. Water Supply Loan Application Act 1891 | 37. Water Supply Loan Application Act 1910 |
| 14. Water Supply Loans 1890 | 38. Water Supply Loan Application Act 1911 |
| 15. Water Supply Advance Act 1893 | 39. Water Supply Loan Application Act 1912 |
| 16. Water Supply Loan Application Act 1893 | 40. Water Supply Loan Application Act 1914 |
| 17. Water Supply Loan Application Act 1895 | 41. Water Supply Loan Application Act 1915 |
| 18. Water Supply Loan Application Act 1896 | 42. Water Act 1915 |
| 19. Water Act 1896 | 43. Water Act 1916 |
| 20. Water Supply Loan Application Act 1897 | 44. Water Supply Loans 1916 |
| 21. Water Supply Loan Application Act 1898 | 45. Water Act 1918 |
| 22. Water Supply Advances Relief Act 1899 | 46. Water Supply Loan Application Act 1918 |
| 23. Water Supply Loan Application Act 1900 | 47. Water Supply Loan Application Act 1918 |
| 24. Water Act 1900 | 48. Water Supply Loan Act 1919 |
| | 49. Water Supply Loan Application Act 1919 |
| | 50. Water Supply Loan Application Act 1920 |
| | 51. Water Supply Loan Application Act 1921 |
| | 52. Water Supply Loan Application Act 1922 |
| | 53. Water Supply Loan Application Act 1923 |
| | 54. Water Supply Loan Application Act 1924 |

55. Water Supply Loan Application Act 1925
56. Water Supply Loan Application Act 1926
57. Water Supply Loan Application Act 1927
58. Water Supply Loan Application Act 1928
59. Water Act 1928
60. Water Supply Loan Application Act 1929
61. Water Supply Loan Application Act 1930
62. Water Supply Loan Application Act 1931
63. Water Supply Loan Application Act 1932
64. Water Supply Loan Application Act 1933
65. Water Supply Loan Application Act 1934
66. Water Supply Loan Application Act 1935
67. Water Supply Loan Application Act 1936
68. Water Act 1936
69. Water Act 1937
70. Water Supply Loan Application Act 1937
71. Water Supply Loan Application Act 1938
72. Water Act 1939
73. Water Supply Loan Application Act 1939
74. Water Act 1940
75. Water Supply Loan Application Act 1940
76. Water Act 1941
77. Water Supply Loan and Application Act 1941
78. Water Act 1942
79. Water Supply Loan Application Act 1942
80. Water Act 1943
81. Water Supply Loan Application Act 1943
82. Water Act 1944
83. Water Supply Loan Application Act 1944
84. Water Act 1945
85. Water Supply Loan Application Act 1945
86. Water Supply Loan and Application Act 1946
87. Water Act 1946
88. Water Act 1947
89. Water Supply Loan and Application Act 1947
90. Water Supply Loan Application Act 1948
91. Water Supply Loan and Application Act 1949
92. Water Supply Loan and Application Act 1950
93. Water Act 1950
94. Water Supply Loan Application Act 1951
95. Water Supply Loan Application Act 1952
96. Water Act 1952
97. Water Supply Loan Application Act 1953
98. Water Act 1954
99. Water Supply Loan Application Act 1954
100. Water Supply Loan Application Act 1955
101. Water Supply Loan Application Act 1956
102. Water Supply Loan Application Act 1957
103. Water Supply Loan Application Act 1958
104. Water Act 1958
105. Water Supply Loan Application Act 1959
106. Water Supply Loan Application Act 1960
107. Water Supply Loan Application Act 1961
108. Water Supply Loan Application Act 1962
109. Water Supply Loan Application Act 1963
110. Water Act 1963
111. Water Act 1964
112. Water Supply Loan Application Act 1964
113. Water Supply Loan Application Act 1965
114. Water Supply Loan Application Act 1966
115. Waterworks Trust Association of Victoria Act 1966
116. Water Supply Loan Application Act 1967
117. Water Supply Loan Application Act 1968
118. Water Act 1968
119. Water Supply Loan Application Act 1969
120. Water (Rates and Charges) Act 1940
121. Water (Leeve Banks) Act 1946
122. Water (Connection to Main) Act 1954
123. Water (Compensation) Act 1956
124. Water (valuation) Act 1958
125. Water (Contracts) Act 1959
126. Water (Irrigation Districts) Act 1959
127. Water (Irrigation) 1959)
128. Water (Land Reclamation) Act 1959
129. Water and Sewerage Authorities (Proceeding and Finances) Act 1981
130. Water (Recreational Areas) Act 1964
131. Water Authorities Accident Insurance Act 1965
132. Water License and Permits Act 1965
133. Water (rating by Area) Act 1966
134. Water Supply Works and Services Act 1970
135. Water Supply Works and Services Act 1971
136. Water Authorities Accident Insurance Act 1971

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| 137. Water Supply Works and Services Act 1972 | 152. Water and Sewerage Authorities (Financial) Act 1981 |
| 138. Water Supply Works and Services Act 1973 | 153. Water and Sewerage Authorities (Interest Payments) Act 1981 |
| 139. Water Supply Works and Services Act 1974 | 154. Water (Penalties and Borrowing Powers) Act 1982 |
| 140. Water Supply Works and Services Act 1975 | 155. Water (Borrowing Powers) Act 1983 |
| 141. Water Resources Act 1975 | 156. Water and Sewerage Authorities (Restructuring) Act 1983 |
| 142. Water and Sewerage Authorities Act 1976 | 157. Water (Delegation of Power) Act 1983 |
| 143. Water Supply Works and Services Act 1976 | 158. Water Charge Concession Act 1984 |
| 144. Water Supply Works and Services Act 1977 | 159. Water (Central Management Restructuring) Act 1984 |
| 145. Water Supply Works and Services Act 1978 | 160. Water and Sewerage Authorities (Further Restructuring) Act 1984 |
| 146. Water Drainage Act 1978 | 161. Water and Sewerage Authorities (Financial) Act 1985 |
| 147. Water Supply Works and Services Act 1979 | 162. Water (Advances) Act 1985 |
| 148. Water Authorities (Constitution and Powers) Act 1979 | 163. Water and Sewerage Authorities (Restructuring) Act 1988 |
| 149. Water Supply Works and Services Act 1980 | 164. Water Act 1989 |
| 150. Water (Valuation Equalization) Act 1980 | 165. Water (Waivers) Act 1991 |
| 151. Water Drainage Act 1981 | 166. Water (Election) 1992 |
| | 167. Water (Rural Water Corporation) Act 1992 |
| | 168. Water Industry Act 1994 |

Keywords: Environment

1. Environment Protection 1970
2. Environment Effects Act 1978
3. Environment Protection (License Fee) Act 1981
4. Environment Protection (penalties) Act 1982
5. Environment Protection (Review) Act 1984
6. Planning and Environment Act 1987
7. Environment Protection (Fees and Penalties) Act 1990
8. Environment Protection (Resource Recovery) Act 1992
9. National Environment Protection Council (Victoria) Act 1995
10. Planning and Environment (Development Contributions) Act 1995

Keywords: Crown (Land)

1. Act for Regulating the sale of Crown Lands and for other purposes 1860
2. Crown Land Reserves Act 1893
3. Crown Land Reserves Act 1910

4. Land (Crown Leases Adjustment) Act 1936
5. Land (Surrender to the Crown) Act 1971
6. Land (Crown Bailiffs) Act 1972
7. Crown Land (Reserves) Act 1978
8. Crown Land (Mineral Springs) Act 1980
9. Land (Crown Grants and Reserves) Act 1993
10. Act for Regulating the sale of Crown Lands and for other purposes

Keywords: Forest

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|--|---|
| 1. The State Forest Act 1876 | 26. Forest Act 1939 |
| 2. Forest Act 1907 | 27. State Forest and Loan Application Act 1939 |
| 3. Forest Act 1910 | 28. State Forest and Loan Application Act 1941 |
| 4. Forest Act 1915 | 29. Forest Act 1942 |
| 5. Forest Act 1918 | 30. Forest Act 1943 |
| 6. Victorian Loan (State Forest) Act 1924 | 31. Forest (Exchange of Lands) Act 1943 |
| 7. Victorian Loan (State Forest) Act 1930 | 32. State Forest and Loan Application Act 1944 |
| 8. Forest Act 1927 | 33. State Forest and Loan Application Act 1945 |
| 9. Forest Act 1928 | 34. State Forest and Loan Application Act 1946 |
| 10. Forest Act 1930 | 35. Forest (Exchange of Lands) Extension Act 1946 |
| 11. Forest Act 1932 | 36. State Forest and Loan Application Act 1947 |
| 12. State Forest and Loan Application Act 1932 | 37. State Forest and Loan Application Act 1948 |
| 13. State Forest and Loan Application Act 1933 | 38. Forest (Exchange of Lands) Extension Act 1949 |
| 14. State Forest and Loan Application Act 1934 | 39. State Forest and Loan Application Act 1949 |
| 15. State Forest and Loan Application Act 1935 | 40. Forest (Commissioners) Act 1947 |
| 16. State Forest and Loan Application Act 1936 | 41. Forest (Land acquisition) Act 1948 |
| 17. State Forest and Loan Application Act 1937 | 42. State Forest and Loan Application Act 1950 |
| 18. State Forest and Loan Application Act 1938 | 43. State Forest and Loan Application Act 1951 |
| 19. State Forest and Loan Application Act 1940 | 44. State Forest and Loan Application Act 1952 |
| 20. State Forest and Loan Application Act 1941 | 45. Forest (Exchange of Lands) Act 1952 |
| 21. State Forest and Loan Application Act 1942 | 46. State Forest and Loan Application Act 1953 |
| 22. State Forest and Loan Application Act 1943 | |
| 23. Forest Act 1933 | |
| 24. Forest (Exchange of Lands) Act 1936 | |
| 25. Forest (Exchange of Lands) Act 1939 | |

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| 47. State Forest and Loan Application Act 1954 | 64. Forest Act 1958 |
| 48. State Forest and Loan Application Act 1955 | 65. State Forest Works and Service Act 1970 |
| 49. State Forest and Loan Application Act 1956 | 66. State Forest Works and Service Act 1971 |
| 50. State Forest and Loan Application Act 1957 | 67. State Forest Works and Service Act 1972 |
| 51. State Forest and Loan Application Act 1958 | 68. State Forest Works and Service Act 1973 |
| 52. State Forest and Loan Application Act 1959 | 69. State Forest Works and Service Act 1974 |
| 53. State Forest and Loan Application Act 1960 | 70. State Forest Works and Service Act 1975 |
| 54. State Forest and Loan Application Act 1961 | 71. State Forest Works and Service Act 1976 |
| 55. State Forest and Loan Application Act 1962 | 72. State Forest Works and Service Act 1977 |
| 56. State Forest and Loan Application Act 1963 | 73. State Forest Works and Service Act 1978 |
| 57. State Forest and Loan Application Act 1964 | 74. State Forest Works and Service Act 1979 |
| 58. State Forest and Loan Application Act 1965 | 75. State Forest Works and Service Act 1980 |
| 59. State Forest and Loan Application Act 1966 | 76. Forest (Advances) Act 1976 |
| 60. State Forest and Loan Application Act 1967 | 77. Forest Act (Reserved Land) 1979 |
| 61. State Forest and Loan Application Act 1968 | 78. Forest (Penalties) Act 1980 |
| 62. State Forest and Loan Application Act 1969 | 79. Director-General of Conservation, Forests and Lands Act 1983 |
| 63. Forest Act 1957 | 80. Conservation, Forest and Lands Act 1987 |
| | 81. Forest (Victree Forests Agreement) Act 1989 |
| | 82. Forest (Timber Harvesting) Act 1990 |

Keywords: Drainage

- | | |
|---|-------------------------------------|
| 1. The Land Drainage Act 1864 | 12. Drainage of Land Act 1928 |
| 2. Drainage Areas Act 1898 | 13. Drainage Areas Act 1928 |
| 3. Drainage of Land Act 1890 | 14. Drainage Areas Act 1928 |
| 4. Drainage Areas Act 1905 | 15. Drainage Areas Act 1950 |
| 5. Drainage Areas Act 1906 | 16. Drainage Areas Act 1958 |
| 6. Drainage of Land Act 1907 | 17. Drainage of Land Act 1958 |
| 7. Drainage of Land Act 1915 | 18. Drainage Areas (Rates) Act 1963 |
| 8. Drainage Areas Act 1915 | 19. Drainage of Land Act 1975 |
| 9. Drainage Areas Act 1922 | |
| 10. Metropolitan Drainage and Rivers Act 1923 | |
| 11. Metropolitan Drainage and Rivers Act 1926 | |

Keywords: Irrigation

1. The Irrigation Act 1886

Keywords: River and/or Catchment

1. River Improvement Act 1948
2. River Improvement Act 1958
3. State River and Water Supply Commission (Special Project) Act 1969
4. State River and Water Supply Commission (Special Project) Act 1972
5. River Improvement (Minimum Rate) Act 1974
6. River Improvement (United District) Act 1976
7. River Improvement (Trust and Valuation) Act 1979
8. Catchment and land Protection Act 1994

Keywords: Flood

1. Flood Protection Act 1911
2. Flood Protection Act 1912
3. Flood Plain Management Act 1982

Content Analysis: An Example

Water Conservation Act 1887

3. When the council of any municipal district or the councils of any two or more municipal districts jointly desire to have waterworks constructed in or for such district or districts, such council or councils shall cause to be prepared a general plan and a description of such waterworks as may be proposed by such council or councils, and for such purpose may from time to time contract one with the other or others.

Municipal councils to prepare plans of proposed waterworks.
No. 716 s. 2.

4. Such general plan shall be prepared on a scale of not less than two miles to an inch and shall show the character and extent of the works proposed; and such description shall clearly set forth the object and purpose of the proposed waterworks and the mode in which it is desired to obtain funds for their construction, and shall contain an estimate of the cost thereof and a statement of the annual value of the rateable property to be benefited thereby. Both such general plan and such description shall be forwarded to the responsible Minister of the Crown for the time being administering this Act (hereinafter called "the Minister") with an application for submission to the Governor in Council for his authority to construct maintain and continue the proposed waterworks.

Plan and description to be sent to Minister with an application for constitution of Trust by Governor in Council.
Ib. s. 3.



Plan as a requirement to gain approval to utilize available water



RESERVE REGIME

Water Conservation Act 1928

77. (1) Where works to be constructed under this Act for the service of any area of lands consist entirely or for the most part of drainage works, the Governor in Council, if he thinks fit, instead of constituting such area a waterworks district under the last preceding section of this Act, may in manner hereinafter provided constitute the same a drainage district under the jurisdiction and control of the Commission.

Water Act 1915 s. 77.
Power to constitute drainage districts under the Commission.

(2) The Minister may by writing under his hand publish his declaration that the lands included in any area defined in such declaration ought to be constituted a drainage district under the jurisdiction and control of the Commission.

Declaration by Minister.

(3) Every such declaration shall state the particulars of the scheme of works proposed for such district and the estimated cost of such works.

Particulars to be stated in Minister's declaration

(4) Such declaration shall be published in the *Gazette* and in some newspaper circulating generally within such area and a copy thereof shall be laid before both Houses of Parliament; and not less than thirty days after the same has been so laid before Parliament the Governor in Council may if he thinks fit make an Order constituting such area a drainage district under the jurisdiction and control of the Commission.

Declaration to be published and laid before Parliament.
Order in Council.

(5) Every such Order in Council shall—

- (a) specify the boundaries of the district;
- (b) assign a name to the district;
- (c) state the particulars of the scheme of works for the service of the district;
- (d) state the estimated cost of such scheme; and
- (e) contain such provisions not inconsistent with this Act as according to the facts and circumstances of each case the Governor in Council thinks fit.

Contents of Order in Council.



The concerns and interest of public infrastructure providers became the focus in the formulation of plan



AUTHORITY REGIME

Water Conservation Act 1975

Role of Minister

22. (1) The Minister—
- (a) must make sure that a continuous program of assessment of the water resources of the State is undertaken; and
 - (b) subject to and in accordance with this Act, may allocate the available water resources.
- (2) The water resources assessment program must provide for the collection, collation, analysis and publication of information about—
- (a) the availability of water; and
 - (b) the disposal of wastewater (including trade waste, sewage and saline water); and
 - (c) the use and re-use of water resources; and
 - (d) floodwaters; and
 - (e) drainage and waterway management; and
 - (f) water quality (including salinity); and
 - (g) in-stream uses of water; and
 - (h) anything else that the Minister decides is appropriate.

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Information regarding the function of
biophysical system became the center in
formulating plan

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INFORMATION REGIME

Water Conservation Act 1989

214. (1) The Minister may, if he or she decides that an investigation in relation to water management should be carried out, publish in the *Government Gazette* and in a newspaper circulating generally in the affected area a notice which—

- (a) states the intention of the Minister to appoint a community-based committee to carry out the investigation; and
 - (b) briefly describes the proposal to be investigated; and
 - (c) describes the general area affected by the proposal.
- (2) The following provisions apply with respect to the membership of a committee appointed under this section:
- (a) More than one half of the membership must consist of persons who are owners or occupiers of land in the affected area;
 - (b) Any council whose municipal district is wholly or partly within the affected area must be represented on the committee;
 - (c) Any public statutory body which the Minister considers to be directly affected by the proposal must be represented on the committee;
 - (d) The Minister must make sure that, so far as possible, all relevant interests (including environmental interests) are fairly represented on the committee.
- (3) The Minister must give the committee sufficient resources to enable it to carry out the investigation.

Water management schemes

215. (1) When it has completed an investigation into a proposal the committee may prepare a water management scheme for the area affected by the proposal.

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Plan that are not only designed to
consider water as a part of biophysical
system but also its integration with
component in social system.

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COORDINATION REGIME

References

- Acar, S 2017, *The curse of natural resources : a developmental analysis in a comparative context*, Palgrave Macmillan.
- Adams, VM & Pressey, RL 2014, 'Uncertainties around the implementation of a clearing-control policy in a unique catchment in Northern Australia: Exploring equity issues and balancing competing objectives', *PLoS ONE*, vol. 9, no. 5, pp. 1-11.
- Agarwal, A, de los Angeles, MS, Bhatia, R, Chéret, I, Davila-Poblete, S, Falkenmark, M, Gonzalez-Villarreal, F, Jøneh-Clausen, T, Ait Kadi, M, Kindler, J, Rees, JA, Roberts, P, Rogers, P, Solanes, M & Wright, A 2000, *Integrated Water Resources Management*, <<http://hdl.handle.net/10535/4986>>.
- Agriculture 2016, *Supporting Victoria's Agriculture. Agriculture Victoria Strategy*, by Agriculture Victoria, Victoria Government, <http://agriculture.vic.gov.au/__data/assets/pdf_file/0011/385949>.
- Alkemade, F, Hekkert, MP & Negro, SO 2011, 'Transition policy and innovation policy: Friends or foes?', *Environmental Innovation and Societal Transitions*, vol. 1, no. 1, pp. 125-9.
- Allan, C & Watts, RJ 2018, 'Revealing adaptive management of environmental flows', *Environmental Management*, vol. 61, no. 3, pp. 520-33.
- Anadon Laura, D, Chan, G, Harley Alicia, G, Matus, K, Moon, S, Murthy Sharmila, L & Clark William, C 2016, 'Making technological innovation work for sustainable development', *Proceedings of the National Academy of Sciences of the United States of America*, vol. 113, no. 35, p. 9682.
- Anadon, LD, Matus, K, Moon, S, Chan, G, Harley, A, G, Murthy, S, Timmer, V, Latif, AA, Araujo, K, Booker, K, Choi, H, Dubrawski, K, Friedlander, L, Ingersoll, C, Kempster, E, Pereira, L, Stephens, J, Vinsel, L & Clark, WC 2014, *Innovation and Access to Technologies for Sustainable Development: Diagnosing Weakness and Identifying Interventions in the Transnational Arena*, Harvard Kennedy School of Government, Cambridge, <<https://www.hks.harvard.edu/centers/mrcbg/programs/sustsci/documents/papers/2014-01>>.
- Anderies, JM 2015, 'Understanding the dynamics of sustainable social-ecological systems: Human behavior, institutions and regulatory feedback', *Bulletin of Mathematical Biology*, vol. 77, no. 2, pp. 259-80.

Anderies, JM & Janssen, MA 2013, 'Robustness of social-ecological systems: Implication for public policy'.

Anderies, JM, Janssen, MA & Ostrom, E 2004, 'A Framework to analyze the robustness of social-ecological systems from an institutional perspective', *Ecology and Society*, vol. 9, no. 1.

Anderies, JM, Rodriguez, AA, Janssen, MA & Cifdaloz, O 2007, 'Panaceas, uncertainty, and the robust control framework in sustainability science', *Proc Natl Acad Sci U S A*, vol. 104, no. 39, pp. 15194-9.

Anne, S & Helen, I 1990, 'Behavioral assumptions of policy tools', *The Journal of Politics*, vol. 52, no. 2, p. 510.

Araral, E 2013, 'What makes socio-ecological systems robust? An institutional analysis of the 2,000 year-old Ifugao society', *Human Ecology: An Interdisciplinary Journal*, vol. 41, no. 6, pp. 859-70.

Armitage, D 2008, 'Governance and the commons in a multi-level world', *International Journal of the Commons*, vol. 2, no. 1, pp. 7-32.

Asmamaw, LB, Mohammed, AA & Lulseged, TD 2011, 'Land use/cover dynamics and their effects in the Gerado catchment, northeastern Ethiopia', *International Journal of Environmental Studies*, vol. 68, no. 6, pp. 883-900.

Australian Bureau of Statistics 1860-2016, *Victorian Year Book* 2016-2017, <<https://www.abs.gov.au/AUSSTATS>>.

Australian Government Bureau of Meteorology *Average Annual Evapotranspiration*, viewed February 2019, <http://www.bom.gov.au/jsp/ncc/climate_averages/evapotranspiration>.

—— 1900-2018, *Annual Rainfall Anomaly*, <<http://www.bom.gov.au/climate/change>>.

—— 1961-1990, *Average Annual Rainfall*, viewed February 2019, <http://www.bom.gov.au/jsp/ncc/climate_averages/rainfall/index.jsp>.

Axelrod, RM & Cohen, MD 2000, *Harnessing complexity : organizational implications of a scientific frontier*, Basic Books.

Baker, DM, Murray, G & Agyare, AK 2018, 'Governance and the making and breaking of social-ecological traps', *Ecology and Society*, vol. 23, no. 1.

- Baker, TJ, Cullen, B, Debevec, L, Abeye, Y 2015, 'A socio-hydrological approach for incorporating gender into biophysical models and implications for water resource research', *Applied Geography*, vol. 62, p.325-338
- Bärlund, I, Lehtonen, H & Tattari, S 2005, 'Assessment of environmental impacts following alternative agricultural policy scenarios', *Water Science & Technology*, vol. 51, no. 3/4, pp. 117-25.
- Barnett, P, Tenbenschel, T, Cumming, J, Clayden, C, Ashton, T, Pledger, M & Burnette, M 2009, 'Implementing new modes of governance in the New Zealand health system: An empirical study', *Health policy*, vol. 93, no. 2-3, pp. 118-27.
- Bason, C 2014, *Design for policy*, Design for Social Responsibility Series, Gower Publishing Limited.
- Basurto, X & Nenadovic, M 2012, 'A systematic approach to studying fisheries governance', *Global Policy*, vol. 3, no. 2, pp. 222-30.
- Bellu, LG & Pansini, RV 2009, *Quantitative Socio-Economic Policy Impact Analysis. A methodological Introduction*. FAO Policy Learning Programme, The United Nations.
- Berrouet, LM, Machado, J & Villegas-Palacio, C 2018, 'Vulnerability of socio—ecological systems: A conceptual Framework', *Ecological Indicators*, vol. 84, pp. 632-47.
- Bieger, K, Hörmann, G & Fohrer, N 2013, 'The impact of land use change in the Xiangxi Catchment (China) on water balance and sediment transport', *Regional Environmental Change*, vol. 15, no. 3, pp. 485-98.
- Bijker, WE, Hughes, TP & Pinch, T 1987, *The social construction of technological systems : new directions in the sociology and history of technology*, MIT Press.
- Bingeman, K, Berkes, F & Gardner, JS 2004, 'Institutional responses to development pressures: Resilience of socio-ecological systems in Himachal Pradesh, India', *International Journal of Sustainable Development & World Ecology*, vol. 11, no. 1, pp. 99-115.
- Bischoff-Mattson, Z & Lynch, A 2017, 'Integrative governance of environmental water in Australia's Murray-Darling Basin: Evolving challenges and emerging pathways', *Environmental Management*, vol. 60, no. 1, pp. 41-56.

Blackman, A 2015, 'Strict versus mixed-use protected areas: Guatemala's Maya biosphere reserve', *Ecological Economics*, vol. 112, pp. 14-24.

Blackmore, C 2007, 'What kinds of knowledge, knowing and learning are required for addressing resource dilemmas?: a theoretical overview', *Environmental Science & Policy*, vol. 10, no. 6, pp. 512-25.

Blackmore, C, Ison, R & Jiggins, J 2007, 'Social learning: an alternative policy instrument for managing in the context of Europe's water', *Environmental Science & Policy*, vol. 10, no. 6, pp. 493-8.

Blaikie, PM, Brookfield, HC & Allen, B 2015, *Land degradation and society*, Routledge Revivals, Routledge.

Blomquist, W, Dinar, A & Kemper, K 2005, *Comparison Of Institutional Arrangements For River Basin Management In Eight Basins / Comparison Of Institutional Arrangements For River Basin Management In Eight Basins*, Policy Research Working Papers, The World Bank.

Blomquist, W & Schlager, E 2005, 'Political pitfalls of integrated watershed management', *Society & Natural Resources*, vol. 18, no. 2, pp. 101-17.

Blomquist, WA & Calbick, KS 2005, *Institutional and policy analysis of river basin management. [electronic resource] : the Fraser River Basin, Canada*, Policy research working paper: 3525, [Washington, D.C. : World Bank, 2005].

Borrás, S & Edquist, C 2013, 'The choice of innovation policy instruments', *Technological Forecasting & Social Change*, vol. 80, pp. 1513-22.

Boelens, R 2014, 'Cultural politics and the hydrosocial cycle: water power and identity in the Andean highlands', *Geoforum*, vol.57, p.234-247.

Bourgeron, PS, Humphries, HC & Riboli-Sasco, L 2009, 'Regional analysis of social-ecological systems', *Natures Sciences Sociétés*, vol. 17, no. 2, pp. 185-93.

Bressers, HT, A. & O'Toole, LJ 1998, 'The selection of policy instruments: A network-based perspective', *Journal of Public Policy*, vol. 18, no. 3, p. 213.

Briassoulis, H 2005, *Policy Integration for Complex Environmental Problems: The Example of Mediterranean Desertification*, 3, Book News, Inc., 0887-3763, Book Review

- Broderick, K 2005, 'Communities in catchments: Implications for natural resource management', *Geographical Research*, vol. 43, no. 3, pp. 286-96.
- Brown, MD & Lubczenko, V 1990, *Groundwater and salinity in the Murray Basin : an educational resource kit*, [Murray-Darling Basin Commission].
- Buckman, G & Diesendorf, M 2010, 'Design limitations in Australian renewable electricity policies', *Energy Policy*, vol. 38, no. 7, pp. 3365-76.
- Carlsson, L & Sandström, A 2008, 'Network governance of the commons', *International Journal of the Commons*, vol. 2, no. 1, p. 33.
- Carpenter, S, Walker, B, Anderies, JM & Abel, N 2001, 'From metaphor to measurement: Resilience of what to what?', *Ecosystem*, vol. 4, no. 8, pp. 765-81.
- Christiansen, J & Bunt, L 2014, 'Innovating public policy: Allowing for social complexity and uncertainty in the design of public outcomes', in C Bason (ed.), *Design for policy*, Gower, England.
- Cohen, MD, March, JG & Olsen, JP 1972, 'A garbage can model of organizational choice', *Administrative Science Quarterly*, vol. 17, no. 1, pp. 1-25.
- Colin, L 1998, *Sustainable forest management Ian S. Ferguson*, "Irish Naturalists' Journal" Committee, 00211311, book-review.
- Collins, K & Ison, R 2009, 'Editorial: living with environmental change: adaptation as social learning', no. 6, p. 351.
- Connor, R & Dovers, S 2004, *Institutional change for sustainable development*, Edward Elgar.
- Cooper, B & Crase, L 2016, 'Governing water service provision: Lessons from Australia', *Utilities Policy*, vol. 43, pp. 42-7.
- Corbin, JM & Strauss, AL 2008, *Basics of qualitative research : techniques and procedures for developing grounded theory*, 3rd ed. edn, SAGE Publications.
- Cousins, SAO, Auffret, AG, Lindgren, J, Tr, xe & nk, L 2015, 'Regional-scale land-cover change during the 20th century and its consequences for biodiversity', *Ambio*, vol. 44, pp. S17-S27.

Cox, M 2011, 'Advancing the diagnostic analysis of environmental problems', *International Journal of the Commons*, vol. 5, no. 2, p. 346.

Cummins, T & Watson, A 2012, 'A hundred-year policy experiment: the Murray-Darling Basin in Australia', in J Quiggin, T Mallawaarachchi & S Chmabers (eds), *Water Policy Reform. Lesson in Sustainability from the Murray-Darling Basin*, Edward Elgar Publishing Limited, United Kingdom.

Department of Environment, W, Land and Planning, 2013-2015, *Sustainable Irrigation Program*, <https://www.water.vic.gov.au/__data/assets/>.

Department of Water Resource Victoria 1988, *Proceedings of the National Workshop on Integrated Catchment Management, Newman College, University of Melbourne, 17-19 May 1988*, Australian Water Resources Council conference series: no. 16.

DoWR Victoria 1989, *Water Victoria: A Resource Handbook*

Docker, B & Robinson, I 2013, 'Environmental water management in Australia: experience from the Murray-Darling Basin', *International Journal of Water Resources Development*, vol. 30, no. 1, pp. 164-77.

Dovers, S 2000, *Environmental history and policy : still settling Australia*, Oxford University Press.

—— 2001, *Institutions for sustainability*, Tela: 7, Australian Conservation Foundation.

Dovers, S & Wild River, S 2003, *Managing Australia's environment*, Federation Press.

Duit, A, Galaz, V, Eckerberg, K & Ebbesson, J 2010, 'Governance, complexity, and resilience', *Global Environmental Change*, vol. 20, no. 3, pp. 363-8.

Easton, D 1953, *The political system, an inquiry into the state of political science*, [1st ed.] edn, Knopf.

—— 1965, *A framework for political analysis*, Prentice-Hall contemporary political theory series, Prentice-Hall.

Ebbesson, J 2010, 'The rule of law in governance of complex socio-ecological changes', *Global Environmental Change*, vol. 20, no. 3, pp. 414-22.

- Ekbja, HR & Evans, TP 2009, 'Regimes of information: Land use, management, and policy', *Information Society*, vol. 25, no. 5, pp. 328-43.
- Ekstrom, JA & Young, OR 2009, 'Evaluating functional fit between a set of institutions and an ecosystem', *Ecology & Society*, vol. 14, no. 2: 16.
- Eliadis, FP, Hill, MM & Howlett, M 2005, *Designing government : from instruments to governance*, Books at JSTOR All Purchased, McGill-Queen's University Press.
- Ellis, C, Cripps, R, Russ, M & Broom, S 2016, 'Transforming water management in Llanelli, UK', *Proceeding of the Institution of Civil Engineers*, vol. 169, no. 1, pp. 25-33.
- Elmhagen, B, Eriksson, O & Lindborg, R 2015, 'Implications of climate and land-use change for landscape processes, biodiversity, ecosystem services, and governance', *Ambio*, vol. 44, pp. S1-S5.
- Elmore, RF 1983, *Forward and backward mapping : reversible logic in the analysis of public policy / Richard F. Elmore*, Seattle, Wash. : Graduate School of Public Affairs, University of Washington, 1983.
- Engle, NL & Lemos, MC 2010, 'Unpacking governance: Building adaptive capacity to climate change of river basins in Brazil', *Global Environmental Change*, vol. 20, pp. 4-13.
- Ertsen, M, Murphy, J, Purdue, L, Zhu, T 2013, 'A journey of thousand miles begins with one small step – human agency, hydrological processes and time in socio-hydrology', *Hydrology & Earth System Science Discussion*, vol. 10.
- Everard, M 2004, 'Investing in sustainable catchments', *Science of The Total Environment*, vol. 324, no. 1-3, p. 1.
- Evers, M 2016, 'Integrative river basin management: challenges and methodologies within the German planning system', *Environmental Earth Sciences*, no. 14, p. 1.
- Farley, KA, Jobbágy, EG & Jackson, RB 2005, 'Effects of afforestation on water yield: a global synthesis with implications for policy', *Global Change Biology*, vol. 11, no. 10, pp. 1565-76.
- Fay, J, Erickson, DL & Allan, JD 1997, 'The influence of catchment land use on stream integrity across multiple spatial scales', *Freshwater Biology*, vol. 37, no. 1, p. 149.

- Fish, RD, Ioris, AAR & Watson, NM 2010, 'Integrating water and agricultural management: Collaborative governance for a complex policy problem', *Science of The Total Environment*, vol. 408, no. 23, pp. 5623-30.
- Fisher, JA & Brown, K 2014, 'Ecosystem services concepts and approaches in conservation: Just a rhetorical tool?', *Ecological Economics*, vol. 108, pp. 257-65.
- Flanagan, K, Uyarra, E & Laranja, M 2011, 'Reconceptualising the 'policy mix' for innovation', *Research Policy*, vol. 40, pp. 702-13.
- Foerster, A 2011, 'Developing Purposeful and Adaptive Institutions for Effective Environmental Water Governance', no. 15, p. 4005-4018.
- Folke, C, Hahn, T, Olsson, P & Norberg, J 2005, 'Adaptive Governance of Social-Ecological Systems', p. 441-474.
- Folke, C, Pritchard, L, Jr., Berkes, F, Colding, J & Svedin, U 2007, 'The problem of fit between ecosystems and institutions: Ten years later', *Ecology and Society*, vol. 12, no. 1.
- François, M 2008, 'Nirvana concepts, narratives and policy models: Insights from the water Sector', *Water Alternatives, Vol 1, Iss 1, Pp 131-156 (2008)*, no. 1, p. 131.
- Frohock, FM 1979, *Public policy : scope and logic*, Prentice-Hall.
- Goktug, M 2007, *Handbook of decision making. [electronic resource]*, Public administration and public policy: 123, CRC/Taylor & Francis.
- Gómez-Baggethun, E, Reyes-García, V, Olsson, P & Montes, C 2012, 'Traditional ecological knowledge and community resilience to environmental extremes: A case study in Doñana, SW Spain', *Global Environmental Change*, vol. 22, no. 3, pp. 640-50.
- Goode, DJ 2013, *Groundwater-level trends and forecasts, and salinity trends, in the Azraq, Dead Sea, Hammad, Jordan Side Valleys, Yarmouk, and Zarqa groundwater basins, Jordan / by Daniel J. Goode [and three others], Hashemite Kingdom of Jordan, Ministry of Water and Irrigation ; prepared in cooperation with the U.S. Agency for International Development and the U.S. Army Corps of Engineers*, U.S. Geological Survey open-file report: 2013-1061.
- Goudie, A 1981, *Thr Human Impact. Man's Role in Environmental Change*, The MIT Press, Massachusetts.

- Grimble, R & Wellard, K 1997, 'Stakeholder Methodologies in Natural Resource Management: a Review of Principles, Contexts, Experiences and Opportunities', no. 2, p. 173-194.
- Gunningham, N & Sinclair, D 1999, 'Regulatory Pluralism: Designing Policy Mixes for Environmental Protection', *Law & Policy*, no. Issue 1, p. 49.
- Gunawardena, A, White, B, Hailu, A., Wijeratne, EMS & Pandit, R 2018, 'Policy choice and riverine water quality in developing countries: An integrated hydro-economic modelling approach', *Journal of Environmental Management*, vol. 227, p.44-54.
- Hardi, P & Zdan, TJ 1997, *Assessing sustainable development : principles in practice*, International Institute for Sustainable Development.
- Harris, G 2007, *Seeking sustainability in an age of complexity*, Cambridge University Press, The United Kingdom.
- Hatfield-Dodds, S 2006, 'The catchment care principle: A new equity principle for environmental policy, with advantages for efficiency and adaptive governance', *Ecological Economics*, vol. 56, no. 3, pp. 373-85.
- Head, BW, Ross, H & Bellamy, J 2016, 'Managing wicked natural resource problems: The collaborative challenge at regional scales in Australia', *Landscape and Urban Planning*, vol. 154, pp. 81-92.
- Heathcote, IW 2009, *Integrated watershed management : principles and practice*, 2nd ed. edn, John Wiley & Sons.
- Heinmiller, BT 2007, 'The politics of cap and trade policies', *Natural Resources Journal*, no. Issue 2, p. 445.
- Hill, MJ 2013, *The public policy process*, Abingdon, Oxon ; New York, New York : Routledge, 2013.
- Hogl, K, Kleinschmit, D & Rayner, J 2016, 'Achieving policy integration across fragmented policy domains: Forests, agriculture, climate and energy', *Environment & Planning C: Government & Policy*, vol. 34, no. 3, pp. 399-414.
- Hood, C 1983, *The tools of government*, Public policy and politics, Macmillan.

Hornberger, GM, Raffensperger, JP, Wiberg, PL & Eshleman, KN 1998, *Elements of Physical Hydrology*, The Johns Hopkins University Press, Baltimore and London.

Horne, J 2012, 'Australian water policy in a climate change context: some reflections', *International Journal of Water Resources Development*, vol. 29, no. 2, pp. 137-51.

—— 2013, 'The 2012 Murray-Darling Basin Plan – issues to watch', *International Journal of Water Resources Development*, vol. 30, no. 1, pp. 152-63.

Howlett, M 1991, 'Policy instruments, policy styles, and policy implementation: National approaches to theories of instrument choice', *Policy Studies Journal*, vol. 19, no. 2, pp. 1-21.

—— 2005, 'What Is a Policy Instrument?

Tools, Mixes, and Implementation Styles', in M Howlett, P Eliadis & MM Hill (eds), *Designing Government*, McGill-Queen's University Press, pp. 31-50.

—— 2009, 'Governance modes, policy regimes and operational plans: A multi-level nested model of policy instrument choice and policy Design', *Policy Sciences*, vol. 42, no. 1, p. 73.

—— 2010, *Designing public policies. [electronic resource] : principles and instruments*, Routledge textbooks in policy studies, New York : Routledge, 2010.

Howlett, M & Lejano, RP 2013, 'Tales From the Crypt: The Rise and Fall (and Rebirth?) of Policy Design', no. 3, p. 357-381.

Howlett, M, Ramesh, M & Perl, A 2009, *Studying public policy : policy cycles & policy subsystems*, 3rd ed. edn, Oxford University Press.

Huitema, D, Mostert, E, Egas, W, Moellenkamp, S, Pahl-Wostl, C & Yalcin, R 2009, 'Adaptive water governance : Assessing the institutional prescriptions of adaptive (co-)management from a governance perspective and defining a research agenda', *Ecology and Society*, vol. 14, no. 1, p. 26.

Ingold, K, Moser, A, Metz, F, Herzog, L, Bader, H-P, Scheidegger, R & Stamm, C 2018, 'Misfit between physical affectedness and regulatory embeddedness: The case of drinking water supply along the Rhine River', *Global Environmental Change*, vol. 48, pp. 136-50.

Ison, RL, Roling, N & Watson, D 2007, 'Challenges to science and society in the sustainable management and use of water: investigating the role of social learning', *Environmental Science and Policy*, vol. 10, no. 6, pp. 499-511.

Jakeman, AJ & Letcher, RA 2003, 'Integrated assessment and modelling: features, principles and examples for catchment management', *Environmental Modelling & Software*, vol. 18, no. 6, pp. 491-501.

Jonas, W 2007, 'Design Research and its Meaning to the Methodological Development of the Discipline', in R Michel (ed.), *Design Research Now: Essays and Selected Projects*, Birkhäuser Basel, Basel, pp. 187-206, DOI 10.1007/978-3-7643-8472-2_11.

Jordan, A & Lenschow, A 2010, 'Environmental policy integration: a state of the art review', *Environmental Policy & Governance*, vol. 20, no. 3, pp. 147-58.

Jordan, AJ & Turnpenny, JR 2015, *The tools of policy formulation. [electronic resource] : actors, capacities, venues and effects*, New horizons in public policy, Edward Elgar Pub. Ltd.

Juhola, S, Glaas, E, Linnér, B-O & Neset, T-S 2016, 'Redefining maladaptation', *Environmental Science & Policy*, vol. 55, pp. 135-40.

Junginger, S 2014, 'Towards Policymaking as Designing: Policy making Beyond Problem-solving and Decision-making', in C Bason (ed.), *Design for Policy*, Gower, England.

Kallis, G 2010, 'Coevolution in water resource development. The vicious cycle of water supply and demand in Athens, Greece', *Ecological Economics*, vol. 69, pp. 796-809.

Kandasamy, J, Sountharajah, D, Sivabalan, P, Chanan, A, Vigneswaran, S & Sivapalan, M 2014, 'Socio-hydrologic drivers of the pendulum swing between agricultural development and environmental health: a case study from Murrumbidgee River basin, Australia', *Hydrology and Earth System Sciences*, no. 3.

Kaufmann, F-X, Majone, G & Ostrom, V 1986, *Guidance, control, and evaluation in the public sector : the Bielefeld interdisciplinary project*, De Gruyter studies in organization: 4, W. de Gruyter.

Kay, A 2006, *The dynamics of public policy : theory and evidence*, New horizons in public policy, Edward Elgar.

Kiczko, A, Romanowicz, RJ & Osuch, M 2011, 'Impact of water management policy on flow conditions in wetland areas', *Physics & Chemistry of the Earth - Parts A/B/C*, vol. 36, no. 13, pp. 638-45.

- Kisser, L & Ostrom, E 1982, 'The Three Worlds of Action', in E Ostrom (ed.), *Strategies of Political Inquiry*, Sage, Beverly Hills.
- Klijn, E-H, Koppenjan, J & Termeer, K 1995, 'Managing networks in the public sector: A theoretical study of management strategies in policy networks', *Public Administration*, vol. 73, no. 3, pp. 437-54.
- Knieper, C, Holtz, G, Kastens, B & Pahl-Wostl, C 2010, 'Analysing water governance in heterogeneous case studies—Experiences with a database approach', *Environmental Science & Policy*, vol. 13, no. 7, pp. 592-603.
- Knill, C & Tosun, J 2012, *Public policy : a new introduction*, Palgrave Macmillan.
- Knoke, D 1990, *Political networks : the structural perspective*, Structural analysis in the social sciences: 4, Cambridge University Press.
- Kobayashi, K 2014, *Community based water management and social capital*, IWA Publishing.
- Koontz, TM, Gupta, D, Mudliar, P & Ranjan, P 2015, 'Adaptive institutions in social-ecological systems governance: A synthesis framework', *Environmental Science and Policy*, vol. 53, no. Part B, pp. 139-51.
- Krippendorff, K 2013, *Content analysis : an introduction to its methodology*, 3rd ed. edn, SAGE.
- Landry, R & Varone, F 2005, 'Designing Government: from instrument to governance', in P Eliadis, MM Hill & M Howlett (eds), *The Choice of Policy Instruments: Confronting the Deductive and the Interactive Approaches*, McGill-Queen's University Press.
- Linder, S, H. & Peters, BG 1989, 'Instruments of government: perceptions and contexts', *Journal of Public Policy*, vol. 9, no. 1, pp. 35-58.
- Linder, SH & Peters, BG 1988, 'The analysis of design of the design of analysis?', *Policy Studies Review*, vol. 7, no. 4, pp. 738-50.
- Lines, WJ 1991, *Taming the great south land : a history of the conquest of nature in Australia*, North Sydney : Allen & Unwin, 1991.
- Link, JS, Thébaud, O, Smith, DC, Smith, ADM, Schmidt, Jr, Rice, J, Jaap Poos, J, Pita, C, Lipton, D, Kraan, M, Frusher, S, Doyen, L, Cudennec, A, Criddle, K & Bailly, D 2017, 'Keeping humans

in the ecosystem', *ICES Journal of Marine Science / Journal du Conseil*, vol. 74, no. 7, pp. 1947-56.

Lu, Z, Wei, Y, Feng, Q, Xiao, H, Cheng, G 2016, 'Progress on sociohydrology', *Advanced Water Science*, vol. 27, p.772-783.

Macleod, CJA, Scholefield, D & Haygarth, PM 2007a, 'Integration for sustainable catchment management', *Science of The Total Environment*, 02/15/, pp. 591-602, DOI 10.1016/j.scitotenv.2006.12.029.

—— 2007b, 'Integration for sustainable catchment management', *Science of The Total Environment*, vol. 373, no. 2–3, pp. 591-602.

Mahoney, J & Rueschemeyer, D 2003, *Comparative historical analysis in the social sciences*, Cambridge University Press.

Mahoney, J & Thelen, KA 2010, *Explaining institutional change. [electronic resource] : ambiguity, agency, and power*, Cambridge ; New York : Cambridge University Press, 2010.

Majone, G 1989, *Evidence, argument, and persuasion in the policy process*, Yale University Press.

Margolin, V & Buchanan, R 1995, *Discovering design : explorations in design studies*, University of Chicago Press.

Marshall, GR & Alexandra, J 2016, Institutional Path Dependence and Environmental Water Recovery in Australia's Murray-Darling Basin, *Water-Alternatives-An Interdisciplinary Journal on Water Politics and Development*, vol 93, pp.679-703.

Martinez-Harms, MJ, Bryan, BA, Balvanera, P, Law, EA, Rhodes, JR, Possingham, HP & Wilson, KA 2015, 'Making decisions for managing ecosystem services', *Biological Conservation*, vol. 184, pp. 229-38.

Mati, BM, Mutie, S, Gadain, H, Home, P & Mtalo, F 2008, 'Impacts of land-use/cover changes on the hydrology of the transboundary Mara River, Kenya/Tanzania', *Lakes & Reservoirs: Research & Management*, vol. 13, no. 2, pp. 169-77.

McGinnis, MV 1999, 'Making the Watershed Connection', no. 3, p. 497-501.

- Medema, W, McIntosh Brian, S & Jeffrey Paul, J 2008, 'From premise to practice: a critical assessment of integrated water resources management and adaptive management approaches in the water sector', *Ecology and Society*, vol. 13, no. 2.
- Middelkoop, H, Daamen, K, Gellens, D, Grabs, W, Kwadijk, JCJ, Lang, H, Parmet, BWAH, Schadler, B, Schula, J & Wilke, K 2001, 'Impact on climate change on hydrological process regimes and water resources management in the Rhine Basin', *Climate Change*, vol. 49, no. 12, pp. 105-28.
- Mitchell, B 2005, 'Integrated water resource management, institutional arrangements, and land-use planning', *Environmental and Planning*, vol. 37, no. 8, p. 1335, DOI 10.1068%2Fa37224.
- Moore, S & Rockloff, S 2006, 'Organizing regionally for natural resource management in Australia: Reflections on agency and government' *Journal of Environmental Policy & Planning*, vol 8 (3). pp. 259-277.
- Mostert, E, Craps, M & Pahl-Wostl, C 2008, 'Social learning: the key to integrated water resources management?', *Journal Water International*, Vol. 3, p. 293, DOI 10.1080/02508060802275757.
- Mukhtarov, F, Fox, S, Mukhamedova, N & Wegerich, K 2015, 'Interactive institutional design and contextual relevance: Water user groups in Turkey, Azerbaijan and Uzbekistan', *Environmental Science and Policy*, vol. 53, no. Part B, pp. 206-14.
- Mwenge Kahinda, J, Meissner, R & Engelbrecht, FA 2016, 'Implementing integrated catchment management in the upper Limpopo River basin: A situational assessment', *Physics & Chemistry of the Earth - Parts A/B/C*, vol. 93, pp. 104-18.
- Nathan, LE, Owen, RJ, Maria Carmen, L & Donald, RN 2011, 'Integrated and adaptive management of water resources: Tensions, legacies, and the next best thing', *Ecology and Society*, Vol 16, Iss 1, p 19 (2011), no. 1, p. 19.
- Nickson, A & Vargas, C 2002, 'The limitations of water regulation: The failure of the Cochabamba Concession in Bolivia', *Bulletin of Latin American Research*, vol. 21, no. 1, p. 99.
- Nicolaisen, J, Andrew, D & Hoeller, P 1991, 'Economics and the environemnt: A survey of issues and policy options', *OECD Economic Studies*, vol. 16, p.7-43.
- Nigel, W, Gordon, W & Will, M 2007, 'Editorial: Critical perspectives on integrated water management', *The Geographical Journal*, vol. 173, no. 4, p. 297.

Nilsson, M & Persson, A 2003, 'Framework for Analysing Environmental Policy Integration' *Journal of Environmental Policy and Planning*, vol. 5, no.4, p. 333-360.

Nkhata, B & Breen, C 2016, 'Assessing and measuring adaptive capacity: the experiences of African countries in developing meaningful metrics for water management', *Current Opinion in Environmental Sustainability*, vol. 21, pp. 9-14.

Nyberg, L, Evers, M, Dahlström, M & Pettersson, A 2014, 'Sustainability aspects of water regulation and flood risk reduction in Lake Vänern', *Aquatic Ecosystem Health & Management*, vol. 17, no. 4, pp. 331-40.

O'Toole, LJ 2000, 'Research on policy implementation: Assessment and prospects', *Journal of Public Administration Research and Theory: J-PART*, vol. 10, no. 2, p. 263.

Olsson, P, Folke, C & Berkes, F 2004, 'Adaptive Comanagement for Building Resilience in Social-Ecological Systems', no. 1, p. 75-90.

Ostrom, E 1990, *Governing the commons : the evolution of institutions for collective action*, Political economy of institutions and decisions, Cambridge ; New York : Cambridge University Press, 1990.

—— 2005, *Understanding institutional diversity*, Princeton paperbacks, Princeton University Press, Princeton.

—— 2007, 'A diagnostic approach for going beyond panaceas', *Proceedings of the National Academy of Sciences*, vol. 104, no. 39, pp. 15181-7.

—— 2009, 'A general framework for analyzing sustainability of social-ecological systems', *Science*, vol. 325, no. 5939, pp. 419-22.

—— 2011, 'Background on the institutional analysis and development framework', *Policy Studies Journal*, vol. 39, no. 1, pp. 7-27.

Ostrom, E & Cox, M 2010, 'Moving beyond panaceas: a multi-tiered diagnostic approach for social-ecological analysis', *Environmental Conservation*, vol. 37, no. 4, pp. 451-63.

Osvaldo, ES, F. Stuart Chapin, I, Juan, JA, Eric, B, Janine, B, Rodolfo, D, Elisabeth, H-S, Laura, FH, Robert, BJ, Ann, K, Rik, L, David, ML, Harold, AM, Martín, O, Poff, NL, Martin, TS, Brian, HW, Marilyn, W & Diana, HW 2000, 'Global biodiversity scenarios for the year 2100', *Science*, vol. 287, no. 5459, p. 1770.

Pahl-Wostl, C 2007, 'Transitions towards adaptive management of water facing climate and global change', no. 1, p. 49, DOI 10.1007/s11269-006-9040-4.

Pahl-Wostl, C, Holtz, G, Kastens, B & Knieper, C 2010, 'Analyzing complex water governance regimes: the management and transition framework', *Environmental Science & Policy*, vol. 13, no. 7, pp. 571-81.

Parsons, DW 1995, *Public policy : an introduction to the theory and practice of policy analysis*, Edward Elgar.

Persson, A 2004, *Environmental Policy Integration: An Introduction*, Stockholm Environment Institute, Stockholm.

Peter, JM 1981, 'Hints for crafting alternative policies', *Policy Analysis*, vol. 7, no. 2, p. 227.

Petit, O 2016, 'Paradise lost? The difficulties in defining and monitoring integrated water resources management indicators', *Current Opinion in Environmental Sustainability*, vol. 21, pp. 58-64.

Pigram, JJ 2006, *Australia's Water Resources: From Use To Management*, CSIRO Publishing, Australia.

Pittock, J & Connell, D 2010, 'Australia demonstrates the planet's future: Water and climate in the Murray-Darling Basin', *International Journal of Water Resources Development*, vol. 26, no. 4, pp. 561-78.

Pollitt, C 2008, *Time, policy, management : governing with the past*, Oxford University Press.

Poppa, Florin 2007, "On Pareto efficiency and equitable allocations of resources", *Romanian journal of economic forecasting*, vol. 10, p.73-79

Powell, JM 1989, *Watering the garden state : water, land and community in Victoria, 1834-1988*, Allen & Unwin.

Prishchepov, AV, Radeloff, VC, Baumann, M, Kuemmerle, T & Müller, D 2012, 'Effects of institutional changes on land use: agricultural land abandonment during the transition from state-command to market-driven economies in post-Soviet Eastern Europe', *Environmental Research Letters*, vol. 7, no. 2, p. 024021.

Quiggin, J, Mallawaarachchi, T & Chambers, S 2012, *Water policy reform : lessons in sustainability from the Murray Darling Basin*, Edward Elgar.

Quinn, JD, Reed, PM & Keller, K 2017, 'Direct policy search for robust multi-objective management of deeply uncertain socio-ecological tipping points', *Environmental Modelling & Software*, vol. 92, pp. 125-41.

Raini, JA 2009, 'Impact of land use changes on water resources and biodiversity of Lake Nakuru catchment basin, Kenya', *African Journal of Ecology*, vol. 47, pp. 39-45.

Rammel, C, Stagl, S & Wilfing, H 2007, 'Managing complex adaptive systems -- A co-evolutionary perspective on natural resource management', *Ecological Economics*, no. 1, p. 9.

Richard, B 1992, 'Wicked problems in design thinking', *Design Issues*, vol. 8, no. 2, p. 5.

Ripley, RB 1966, *Public policies and their politics : an introduction to the techniques of Government control*, [1st ed.] edn, Problems of modern government, W. W. Norton.

Robison, J, Bratschovsky, K, Latcham, J, Morris, E, Palmer, V & Villanueva, A 2014, 'Challenge and response in the Colorado River Basin', *Water Policy*, vol. 16, no. 1, pp. 12-57.

Rodriguez, AA, Cifdaloz, O, Anderies, JM, Janssen, MA & Dickeson, J 2010, 'Confronting Management Challenges in Highly Uncertain Natural Resource Systems: A robustness–Vulnerability Trade-off Approach', *Environmental Modeling & Assessment*, vol. 16, no. 1, pp. 15-36.

Roobavannan, M, van Emmerik, THM, Elshafei, Y, Kandasamy, J, Sanderson M, Vigneswaran, S, Pande, S, Sivapalan, M 2017, 'Norms and Values in socio-hydrological models', *Hydrology & Earth System Science Discussion*, p. 1-27.

Ross, A & Connell, D 2016, 'The evolution and performance of river basin management in the Murray- Darling Basin', *Ecology & Society*, vol. 21, no. 3, pp. 366-77.

Rotmans, J, Kemp, R & Van Asselt, M 2001, 'More evolution than revolution: transition management in public policy', *Foresight*, vol. 3, no. 1, p. 015-032.

Rouillard, JJ, Heal, KV, Ball, T & Reeves, AD 2013, 'Policy integration for adaptive water governance: learning from Scotland's experience', *Environmental Science and Policy*, vol. 33, pp. 378-87.

- Sabatier, PA, Weible, CM & Baumgartner, FR 2014, *Theories of the policy process*, Boulder, Colorado : Westview Press
- Salamon, LM & Elliott, OV 2002, *The tools of government : a guide to the new governance*, Oxford University Press.
- Sandstrom, V, Kauppi, PE, Scherer, L & Kastner, T 2017, 'Linking country level food supply to global land and water use and biodiversity impacts: the case of Finland', *Science of The Total Environment*, vol. 575, pp. 33-40.
- Scalr, ED, Volavka-Close, N & Brown, P 2013, *The Urban Transformation: Health, Shelter and Climate Change*, Routledge, USA.
- Scheffer, M 2009, *Critical Transition in Nature and Society*, Princeton University Press, USA.
- Scheffer, M & Carpenter, SR 2003, 'Catastrophic regime shifts in ecosystems: linking theory to observation', *Trends in Ecology & Evolution*, vol. 18, no. 12, pp. 648-56.
- Schlüter, M, Hirsch, D & Pahl-Wostl, C 2010, 'Coping with change: responses of the Uzbek water management regime to socio-economic transition and global change', *Environmental Science and Policy*, vol. 13, no. 7, pp. 620-36.
- Schneider, AL & Ingram, HM 1997, *Policy design for democracy*, Studies in government and public policy, University Press of Kansas.
- Scholz, JT & Stiftel, B 2005, *Adaptive governance and water conflict : new institutions for collaborative planning / edited by John T. Scholz, Bruce Stiftel*, Washington, D.C. : Resources for the Future, c2005.
- Sclar, E, Volavka-Close, N & Brown, P 2013, *The urban transformation : health, shelter and climate change*, Routledge.
- Scott, C & Banister, J 2008, 'The Dilemma of Water Management 'Regionalization' in Mexico under Centralized Resource Allocation' *International Journal of Water Resources Development*, vol. 24, no. 1, p. 61-74, DOI 10.1080/07900620701723083.
- Sewell, WRD, Handmer, JW & Smith, DI 1985, *Water planning in Australia : from myths to reality*, Centre for Resource and Environmental Studies, Australian National University, Canberra.

- Sinclair, SJ, White, MD, Medley, J, Smith, E & Newell, GR 2012, 'Mapping the past: Constructing a digital land-use history map for Victoria, Australia', *Proceedings of the Royal Society of Victoria*, vol. 124(3), pp. 193-206.
- Sivapalan, M, Blöschl, G, Zhang, L, Vertessy, R 2003, 'Downward approach to hydrological prediction', *Hydrology Process*, vol. 17, p. 2101-2111.
- Smith, DI & Stopp, P 1978, *The river basin : an introduction to the study of hydrology*, Cambridge topics in geography series, Cambridge University Press.
- Steffen, WL 2009, *Australia's biodiversity and climate change. [electronic resource]*, CSIRO Pub.
- Sterner, T & Coria, J 2012, *Policy Instruments for Environmental and Natural Resource Management*, RFF Press, New York.
- Steyaert, P & Jiggins, J 2007, 'Governance of complex environmental situations through social learning: a synthesis of SLIM's lessons for research, policy and practice', *Environmental Science & Policy*, vol. 10, no. 6, pp. 575-86.
- Suhardiman, D, Bastakoti, RC, Karki, E & Bharati, L 2018, 'The politics of river basin planning and state transformation processes in Nepal', *Geoforum*, vol. 96, p. 70.
- Sydney, MS 2007, 'Policy formulation: design and tools', in F Fischer, GJ Miller & MS Sydney (eds), *Handbook of public policy analysis: theory, politics and methods*, CRC Press, London & New York.
- Thiel, A 2015, 'Crafting or designing? Science and politics for purposeful institutional change in Social-Ecological Systems', *Environmental Science & Policy*, p. 81.
- Thiel, A, Adamseged, ME & Baake, C 2015, 'Evaluating an instrument for institutional crafting: How Ostrom's social–ecological systems framework is applied', *Environmental Science & Policy*, vol. 53, pp. 152-64.
- Thomas, D, Elinor, O & Paul, CS 2003, 'The struggle to govern the commons', *Science*, vol. 302, no. 5652, p. 1907.
- Thompson, S, Sivapalan, M, Harman, C, Srinivasan, V, Hipsey, M, Reed, P, Montanari, A, Blöschl, G 2013, 'Developing predictive insight into changing water systems: use-inspired hydrologic science for the Anthropocene. *Hydrology Earth System Science*, vol 17, p 5013-5039.

Travers, H, Clements, T, Keane, A & Milner-Gulland, EJ 2011, 'Incentives for cooperation: The effects of institutional controls on common pool resource extraction in Cambodia', *Ecological Economics*, vol. 71, pp. 151-61.

Troy, TJ, Pavao-Zuckerman, M, Evans, TP 2015, "Debates-Perspectives on sociohydrology: sociohydrologic modeling-tradeoffs, hypothesis testing, and validation", *Water Resources Research*.

Turnpenny, J, Radaelli, C, Jordan, A & Jacob, K 2009, 'The policy and politics of policy appraisal: emerging trends and new directions', *Journal of European Public Policy*, vol. 16, no. 4, p. 640-653.

Underdal, A 2012, 'Meeting common environmental challenges: the co-evolution of policies and practices', *International Environmental Agreements: Politics, Law and Economics*, vol. 13, no. 1, pp. 15-30.

Uyarra, E 2010, 'What is evolutionary about 'regional systems of innovation'? Implications for regional policy', *Journal of Evolutionary Economics*, vol. 20, no. 1, pp. 115-37.

van der Brugge, R, Rotmans, J & Loorbach, D 2005, 'The transition in Dutch water management', *Regional Environmental Change*, vol. 5, no. 4, p. 164-176, DOI 10.1007/s10113-004-0086-7.

Varis, O, Enckell, K & Keskinen, M 2014, 'Integrated water resources management: horizontal and vertical explorations and the 'water in all policies' approach', *International Journal of Water Resources Development*, vol. 30, no. 3, pp. 433-44.

Victorian Environmental Water Holder 2011-2016, *Annual Report*, <<http://www.vewh.vic.gov.au/news-and-publications/publications>>.

Walker, BH, Abel, N, Anderies, JM & Ryan, P 2009, 'Resilience, adaptability, and transformability in the Goulburn-Broken Catchment, Australia', *Ecology & Society*, vol. 14, no. 1, pp. 1-24.

Walker, J, Dowling, T & Veitch, S 2006, 'An assessment of catchment condition in Australia', *Ecological Indicators*, vol. 6, no. 1, pp. 205-14.

Wallis, PJ & Ison, RL 2011, Appreciating institutional complexity in water governance dynamics: A case from the Murray-Darling Basin, Australia, *Water Resources Management*, vol. 25, no.15, p. 4081-4097.

- Wallis, PJ, Ison, RL & Samson, K 2013, 'Identifying the conditions for social learning in water governance in regional Australia', *Land Use Policy*, vol. 31, pp. 412-21.
- Wallis, RL & Robinson, SJ 1991, 'Integrated Catchment Management: The Western Australian Experience', *Environment*, vol. 33, no. 10, pp. 31-3.
- Wang, S & Fu, B 2013, 'Trade-offs between forest ecosystem services', *Forest Policy and Economics*, vol. 26, pp. 145-6.
- Weber de Morais, G, Schlüter, A & Verweij, M 2015, 'Can institutional change theories contribute to the understanding of marine protected areas?', *Global Environmental Change*, vol. 31, pp. 154-62.
- Wei, J, Wei, Y & Western, A 2017, 'Evolution of the societal value of water resources for economic development versus environmental sustainability in Australia from 1843 to 2011', *Global Environmental Change*, vol. 42, pp. 82-92.
- White, EK, Peterson, TJ, Costelloe, J, Western, AW & Carrara, E 2016, 'Can we manage groundwater? A method to determine the quantitative testability of groundwater management plans', *Water Resources Research*, vol. 52, no 6, p. 4863-4882.
- Wildavsky, AB & Peters, BG 2017, *The art and craft of policy analysis*, Springer Political Science and International Studies eBooks, Palgrave Macmillan.
- Will, S, Paul, JC & John, RM 2007, 'The Anthropocene: Are humans now overwhelming the great forces of nature?', *Ambio*, vol. 36, no. 8, p. 614.
- Witt, U 2003, 'Economic policy making in evolutionary perspective', *Journal of Evolutionary Economics*, vol. 13, no 2, p. 77-94.
- Wyborn, C & Bixler, RP 2013, 'Collaboration and nested environmental governance: Scale dependency, scale framing, and cross-scale interactions in collaborative conservation', *Journal of Environmental Management*, vol. 123, pp. 58-67.
- Xia, C & Pahl-Wostl, C 2012, 'The development of water allocation management in the Yellow River Basin', *Water Resource Management*, vol 26, no 12, p.3395-3414.
- Xun, W, Ramesh, M, Howlett, M & Fritzen, S 2010, *The Public Policy Primer: Managing Public Policy*, Routledge, London.

Young, A 2000, *Environmental Change in Australia Since 1788*, OXFORD University Press.

Young, OR 2002, 'The institutional dimensions of environmental change: fit, interplay, and scale', *Environmental Law*, no. 4, p. 943.

Zhang, L, Dawes, WR & Walker, GR 2001, 'Response of mean annual evapotranspiration to vegetation changes at catchment scale', *Water Resources Research*, vol. 37, no 3, p. 701-708.