UNIVERSITY OF NEW ENGLAND

A CRITIQUE OF WATER SECURITY IN AUSTRALIA, CHINA AND JAPAN

A Dissertation submitted by

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ABSTRACT

This thesis provides a critique of how Australia, China and Japan are addressing water security through their policies, programs, major projects and legal measures. An assessment framework assures consistency in analysis, facilitates comparisons and builds a comprehensive picture of water security in each country by examination of primary and secondary sources. Major river systems and other water sources have been greatly modified in each country to meet the needs of cities, industries and agriculture as well as opportunities for water-based economic development. This has often seriously diminished the health of these vital systems, their ability to continue to meet current and future water demands and to deliver water services. It is widely recognised that water security is critical for human and environmental health, food, industrial and energy production, but official documentation seldom explores these linkages in any of the states. While public statements and policy documents in all three countries refer to sustainable development and integrated water management, the analysis shows that there is little if any understanding in the current governing regimes that ecological and environmental health are critical ingredients of water security. In fact, this research has found situations where deterioration in national water security not only threatens human and environmental welfare but could if unchecked undermine future national prosperity and stability. This situation is most acute in large heavily populated regions of China and in the Murray-Darling Basin, food bowl of Australia.

Analysis of the contrasting ways the three nations are handling current water management problems reveals the ways that national financial, administrative, institutional and political factors have constrained and limited national approaches to water resources management and water security. A common theme is that each state lacks sufficient focus on those patterns of leadership, governance, management and reform needed to deliver water security in complex water-based, socio-economic systems. Political decision-making and influence shape water management and water security outcomes in unexpected or unwanted ways, often as a result of the failure to accept independent, expert advice. As well, financial and administrative arrangements are too complex, involving too many government actors, to focus on water security goals. The detailed country critiques and comparative assessments make distinct contributions to the literature by demonstrating the extent to which each nation is positioned to ensure present and future water security for human and environmental welfare and for critical users. National water security is in turn vital for the security of the state.

CERTIFICATION OF DISSERTATION

I certify that the ideas, results, analyses and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously published or submitted for any other award.

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PREFACE

After some years of retirement, I decided to follow my interests in politics and international relations, political theory and political science, often stirred by professional interactions with politicians. It led me initially to formal study and latterly to research. This thesis concerns the critical domain of water security in Australia, China and Japan. The research spans the fields of politics, political science, governance and public policy as well as environmental and water resource management, all of which influence national water security. In examining policies and programs and their influence on water security there are times when my commentary has built on the following knowledge base.

Much of the focus throughout my career was on water, its management, conservation and use. As a trained scientist, I had the early opportunity to become involved in environmental and water resource management. That later broadened into research into public policy, public sector leadership, governmental systems and change. Most of my positions were in the public sector, internationally at the OECD, and at state and national level in Australia, with several short periods in academe and business. I was fortunate in the later years to lead various agencies, authorities and commissions, including Sydney Water Corporation, the NSW Healthy Rivers Commission and the South Australian Premier's Department. Many of my roles allowed me to contribute through reports, papers and public inquiries and to write several books.

Peter J Crawford

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CHAPTER 2 A CRITIQUE OF WATER SECURITY IN AUSTRALIA

TABLES

ABBREVIATIONS

AAS	Australian Academy of Science
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABC	Australian Broadcasting Commission
ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
ADB	Asian Development Bank
ANAO	Australian National Audit Office
APC	Australian Productivity Commission
ARRN	Asian River Restoration Network
ASEM	ASEM Scientific Research Institute
AST	Australian, State and Territory Governments
ATSE	Academy of Technological Sciences and Engineering (Australia)
AWA	Australian Water Association
AWP	Australian Water Partnership
BOD	Biochemical Oxygen Demand
BRI	Building Research Institute (Japan)
CAT	Climate Action Tracker
CCICED	China Council for International Cooperation on Environment and Development
CCP	Chinese Communist Party
CMA	Catchment Management Authority
CNBS	China National Bureau of Statistics

COAG	Council of Australian Governments
CSIRO	Commonwealth Scientific and Research Organisation (Australia)
CWR	China Water Risk
DAWR	Department of Agriculture and Water Resources (Australia)
DIRDC	Department of Infrastructure, Regional Development and Cities (Australia)
DOI	Department of Industry (NSW)
DPI	Department of Primary Industries (NSW)
DWWA	Department of Water of Western Australia
EDO	Environmental Defenders Office (Australia)
EIA	Environmental Impact Assessment
EU	European Union
FAO	Food and Agriculture Organization (UN)
GDRC	Global Development Research Center (Japan)
GOSC	General Office of the State Council of China
GWF	Global Water Forum
GWP	Global Water Partnership
HWCP	Headquarters of Water Cycle Policy (Japan)
IGANWI	Intergovernmental Agreement on a National Water Initiative (Australia)
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
JCOLD	Japan Commission on Large Dams
JFS	Japan for Sustainability
JICA	Japan International Cooperation Agency

JMA	Japan Meteorological Agency
JSWA	Japan Sewage Works Association
JWRC	Japan Water Research Center
JWWA	Japan Water Works Association
LID	Land Improvement District (Japan)
MCA	Minerals Council of Australia
MDBA	Murray-Darling Basin Authority (Australia)
MEE	Ministry of Ecological Environment (China)
MEP	Ministry of Environmental Protection (China)
METI	Ministry of Economy, Trade and Industry (Japan)
MHLW	Ministry of Health, Labour and Welfare (Japan)
MHURD	Ministry of Housing and Urban-Rural Development (China)
MLIT	Ministry of Land, Infrastructure, Transport and Tourism (Japan)
MLR	Ministry for Land and Resources (China)
MNR	Ministry for National Resources (China)
MOA	Ministry for Agriculture (China)
MOE	Ministry of Environment (Japan)
MOH	Ministry for Health (China)
MRC	The Mekong River Commission
MWR	Ministry of Water Resources (China)
NGO	Non-government Organisation
NRC	Natural Resources Commission (NSW)
NSW	New South Wales
NSWG	NSW Government

NSWOW	NSW Office of Water
NWC	National Water Commission (Australia)
NWI	National Water Initiative (Australia)
NWQMS	National Water Quality Management Strategy (Australia)
OECD	Organisation for Economic Co-operation and Development
SAG	South Australian Government
SARC	South Australian Royal Commission
SCMP	South China Morning Post
SDL	Sustainable Diversion Limit
SNWDP	South-to-North Water Diversion Project (China)
SWC	Sydney Water Corporation (Australia)
UN	United Nations
USDA	United States Department of Agriculture
WCED	World Commission on Environment and Development
WCWA	Water Corporation of Western Australia
WEF	World Economic Forum
WEPA	Water Environment Partnership in Asia
WHO	World Health Organisation
WSAA	Water Services Association of Australia
WWC	World Water Council
WWI	Water and Wastewater International

CHAPTER 1

WATER SECURITY IS CENTRAL TO NATIONAL SECURITY

1.0 THE CRITICAL ROLE OF WATER SECURITY

This thesis analyses the way Australia, China and Japan, all important actors in the Asia Pacific region, are addressing water security and the major challenges they face. Water security is crucial for human health, hydration and sanitation and makes a major contribution to standards of living and quality of life. It sustains livelihoods and economic growth in agriculture, secondary industry and energy production and plays a critical role in continued economic progress. Failure to accord water security a high national priority represents a failure to recognise that poor water security has the potential seriously to undermine national security, national stability, community welfare and economic prosperity (Viola 2017: 2).

The World Economic Forum (WEF) has been directing international attention to water security for a decade or more. In 2012, WEF (2012:1) stated that 'Water security is the gossamer that links together the web of food, energy, climate, economic growth, and human security challenges that the world economy faces over the next two decades.' In its 2018 meeting, WEF participants were counselled that continuing water insecurity 'threatens the well-being and livelihoods of millions of people' and 'raises the spectre of failing systems, large-scale involuntary migration, political instability and conflict' (Contreras and Nelson 2018: 1). In 2019, WEF (2019: 5) found the majority of risks facing the world included failure to address water security, water crises and climate change. In short, world security and world stability are closely linked to achieving global water security.

The present and future security of many nations is being challenged by increasing water scarcity. To counter this threat requires effective planning in dealing with the water-related risks inherent in population growth, climate change, industrial spills and water-based conflict or sabotage. Increasing demand for water is widespread whether for agriculture, food and industrial production, hydropower or domestic use – the latter particularly in expanding cities. Inadequate policies and actions by some states have led to failure to curb this demand, while other states have been unable to contain the adverse health and environmental effects of waste generation and water contamination. Water security also relies on the effective management of risks to those water-based systems, their ecosystems and natural biodiversity, on which nations and their peoples depend for resources and services.

Where climate change contributes either to increased evaporation or decreased precipitation, it is a significant contributor to shrinking rivers, lakes and groundwater as well as prolonged droughts and increased desertification. In other regions or at other times, water security is threatened by severe climate change-induced flooding, caused by prolonged heavy rainfall and other extreme weather events. There are interdependencies and a clear nexus between water security-energy security-food security and climate change. So, for example, in working to overcome and anticipate climate change, the energy sector is undergoing transformation which in turn has significant implications for the water sector and water security (Hussey *et al* 2015: 2). Equally, changes in the water sector can have serious implications for irrigated agriculture and therefore food production and food security.

Within nations, governments frequently try to manage climate change and the energy, food and water sectors as if they were all independent of one another. In this process they are often relying on a variety of quite different actors, conventions, policies, laws and culture. As a consequence, those responsible for water management, planning and security in each nation find themselves governed by a suite of legislation, public policy and programs with diverging and too often conflicting orientations, priorities and goals largely determined by varying lead ministers, ministries or instrumentalities. The Global Water Partnership (GWP 2017:1) perceived just how important this issue can be when it stated: ‘A water secure world means ending fragmented responsibility for water and integrating water resources management across all sectors.’

This thesis analyses and contrasts the implications for national water security of the way water sources are managed and responsibilities assigned in the respective countries. The outlook of each of the countries studied is already significantly affected by climate change - with further change projected. China continues to be challenged in meeting the needs of its massive population, in providing reliable supplies of potable water and in reducing pollution. Japan has experienced increased flooding and rainfall in some regions, with all to the associated damage to cities, infrastructure and people’s lives. Australia has recently faced the enormous cost in human, environmental and economic terms of protracted drought followed by raging bushfires.

2.0 RESEARCH ORIENTATION AND METHODOLOGY

The thesis provides a broadly-based assessment and critique of how the three nations are dealing with water security, including the contributions and the effectiveness of significant policies, programs and processes at work in key sectors of each. The research differs from other comparative research through its examination of the way political, legal, planning and administrative systems and institutional arrangements constrain water resource management and water security outcomes. Because the vastly different arrangements operate collectively in limiting actions and responses, the national idiosyncrasies and country specific considerations have been reviewed early in each chapter. These introductory sections explore matters as diverse as national geomorphology and climate, sources of political power and blockages to reform created by existing legislative and administrative arrangements. Examination of all these factors helps in gaining an understanding of why efforts to improve national water security are frequently impeded. It has also contributed to the exploration in the final chapter of what are realistic expectations for future water security and sustainable use of water resources.

A critical aim is to create a sufficiently comprehensive picture of national water security in each country, to draw sound conclusions and to make comparisons. Clearly, all the countries exhibit considerable regulatory and institutional complexities. There are varying roles played by levels of government and non-state actors in water management and significant differences in perceptions of what constitutes water security. An assessment framework has been fashioned to ensure that, despite these differences, there has been a consistent mode of analysis of water security in each state and to facilitate comparisons. The framework has been developed by the author with reference to the established literature and comprises eight elements, four of which are water security domains and four are factors which can have a major impact on water security outcomes. The national policies, plans, programs and projects which affect water security in each country have been assessed by applying this tool. For example, it is possible to gauge the impact of a particular approach to water source management on both water security for human welfare and water security of users. Water security for the state itself, human welfare, the environment or consumptive users are described as water security domains in this thesis. The framework and its formation are reviewed in greater detail in later sections.

It was important at the outset to validate this methodology. Australian data, policies and institutional arrangements have been found to be comprehensive enough to test the assessment framework. This validation process has been aided by the national harmonisation of some aspects of water resources planning, management and sharing in Australia, over the years 2003 to 2013, and by the fact that data, plans and reports were assessed against nationally agreed criteria by an independent National Water Commission (NWC). As a result, a robust and detailed evaluation of key themes has been made, including the many positive and negative impacts and influences on water security. Use of this assessment tool has also helped in drawing conclusions on the other two countries and in comparing the present water security and future preparedness of all three.

Work on the thesis has involved detailed literature research to establish how governmental policies and measures have been implemented, their outcomes and their contribution to water security, explicit or implicit. The national approaches to water security, the priorities assigned and national positioning to face future challenges are compared and contrasted in the thesis conclusions. Just how effective each nation has been in overcoming challenges to water security depends on the way water resources are being managed and risks being assessed as well as the effectiveness of the policies, planning, strategies, programs and legislation. That, in turn, is dependent on factors such as political leadership and commitment, governance, political ideology and framing, devolution of policy and regulatory responsibility, public management, and the application of good science and social science.

Because the focus of the thesis is on national water security many literature sources examined have been derived from government or official sources. Wherever possible, the themes and results found in official documentation have been re-examined in the light of expert academic publications, the findings of learned, public interest and public policy institutions as well as international bodies with a reputation for engaging in critical appraisal of national data and statements. Some significant contributions to national water security have been assessed, when these have resulted from activities at subordinate levels of government or projects led by international, industrial or community groups. National compendia of water-related data and statistics have been reviewed in each country and drawn on where the data are presented or aggregated in ways relevant to assessing water security.

Politics, political decisions and political influence play a critical role in water security outcomes. There is international research that explores conceptual frameworks and political theories about management of complex water resource-based and environmental systems (see, for example, Mollinga 2008; Eakin and Luers 2006). This research rarely reviews the way political actors, interventions and influence have actually shaped water resource management outcomes and national water security. Too frequently political decisions have little regard for scientific and social-scientific research and advice that would have favoured alternate paths to those chosen. The research in this thesis shows just how important the exercise of political power and influence can be in shaping water security outcomes, as well as situations in which the alignment of powerful political, bureaucratic and industrial interests can be deterministic. The impacts and influence of political power, political interventions and politically-based decisions on water security have been examined in detail in many sections of each chapter and are considered in the conclusions.

The thesis reveals the strengths and weaknesses of each nation's approach to water security, and the close connection of those considerations to how each is tackling management, planning and policy development for water resources. One outcome of this research has been to establish whether each nation has the building blocks on which to forge future policies and programs that can lead to improved outcomes for national water security. There are a small number of national and international reports or research studies that have compared water security, often indirectly, in a number of countries. These studies have generally used international data bases to build international indicators including Worldwide Governance, Human Development, World Development and River Basin Vulnerability Indicators (Varis *et al* 2017: 37). The Asian Development Bank (ADB 2016) has developed composite numerical indices for the following water security dimensions, namely household[1], economic[2], urban[3], environmental[4] and disaster-related[5] water security. Each water security index is a composite of several sub-indicators, drawing on data for the period 2000-2014 which were almost exclusively provided by governments to international organisations. In this way the Bank has been able to provide broad comparisons of indices and sub-indicators for 50 countries in the

[1] Made up of sub-indicators dealing with population access to piped water supply and sanitation as well as health impacts of water-related diarrhoea
[2] Spans sub-indicators focused on reliability and variability in rainfall, storage and water withdrawals as well as productivity and efficiency in water use by primary and secondary industry
[3] Covers sub-indicators for urban population access to piped water supply, sanitation and wastewater collection as well as flood and storm damage and river health in urban surrounds
[4] Includes sub-indicators based on climate, population and the impacts of water demand on the health of rivers providing water supply - as well as government efforts to protect the aqueous environment and river flows
[5] The sub-indicators deal with aspects of exposure and vulnerability and the capacity of countries to cope with various water-related disasters

Asia-Pacific region (ADB 2016: 96-108). Information derived from the ADB report has been referenced on several occasions in subsequent chapters.

The approach adopted in this thesis differs in several notable ways from those above which basically involve creating and comparing numeric macro-indicators. Firstly, this research has not required the author to make the sorts of assumptions that are necessary in developing aggregate scores or indicators. Secondly, the thesis creates a detailed picture of national water security in the context of national political and economic arrangements, as well as the limits and constraints they impose. It analyses specific policies, programs and sectors in terms of water security outcomes and assesses a number of major impacts on water security by applying its assessment framework. Thirdly, the research seeks to test and validate data and claims from governmental sources as described above. Finally, based on the analysis in the chapters dealing with each referent country, it is possible to assess the current positioning and future preparedness of each in respect of water security. In some areas it has then been possible in the last chapter to recommend policies and approaches that could if implemented improve national water security.

This thesis accepts that each country has its own idiosyncratic political, legal and administrative systems, priorities, policies and programs. It aims to span sufficient of these features to gain the best possible picture of water security in Australia, China and Japan. The research has very largely had recourse to documents and reviews in the English language, supplemented by some official translations. That has included publications by many Chinese and Japanese governmental institutions, critical papers, books and reviews by national scholars and leading academics and national reviews and country specific data presented by a wide a variety of international organisations. In China, data and national information are seldom aggregated nationally in ways that facilitate forensic assessment. For that reason, the research has examined available national data, supplemented by critical assessments of program results provided by leading Chinese academics and by external independent bodies. In Japan, many sources of information and aggregated data have been accessed more directly from government publications or senior government official sources. The thesis focuses on assessment of national policies and water security outcomes in each country from the turn of the century to the end of 2019. Where practicable, critical events or changes with a significant bearing on national water security that have emerged during 2020 have been analysed and referred to in the text.

This chapter reviews the important contribution water security makes to national security. The thesis as a whole examines the way national policies, programs and approaches to water management and planning advance or retard national water security. Because the term 'water security' is defined and used differently by various states, government sectors, academic researchers and disciplines, the concept of water security is explored further in this chapter. The definition used as a guide in the country analyses is provided below along with details of the assessment framework. Later sections explain the rationale for selecting the eight elements in the framework, namely four water security domains and four factors impacting on national water security. A further elaboration of the framework has involved a series of issues to be considered under each element in the framework. These have been introduced into the analysis to give greater definition to each element, to reduce uncertainties and overlaps between the elements and to improve consistency in country conclusions and comparisons. This current chapter concludes with a brief summation of the content and aims of the final chapter.

3.0 THE CONCEPT OF NATIONAL SECURITY

Most definitions of security contain a normative position on the values or policies of a referent actor of which the state is foremost when it comes to national security. However, it is the state which must span and take account of the needs, values and interests of an array of diverse actors. Many definitions also have a second element which sets out subjective positions or arguments on who or what needs to be protected and the nature and magnitude of the possible threats to the condition, values or policies (Baldwin 1997: 5). National security is held by most states to be the *key* value each must embrace in order to survive, to protect its sovereignty and to compete in a globalised order (Buzan, Wæver *et al* 1998: 5, 21; Hetherington 2012: 13). In common usage, security often describes a situation where safeguards are introduced in an effort to reduce perceived threats or danger. Often that involves reductions to the point where there is a very low probability of the threats materialising or where important systems and infrastructure are sufficiently resilient to withstand major impacts. In essence, security is a socially constructed concept, and given the entrenched differences in definition, values, goals and outlook security it is also a contested concept.

In examining non-traditional contributors to national security, political scientists came to recognise the critical importance of health security, water security, economic security and climate security, amongst others. Of course, in each such security arena the goals and values to be secured vary from one country to another, as do the priorities, timing and perceptions of risks and threats. The nature of the discourse also varies from government to academe and from the media to the community (Jovanović *et al* 2016: 12). However, when the state is involved, the actual priorities and goals are usually largely determined by the state as the prime actor. As well, even if nations focus on the same security arena, their responses to challenges and threats may differ considerably as may the priorities they set.

The state must determine priorities, goals and resourcing. That may lead to the advance of several security sectors at the same time or to situations where the goals and values associated with one sector are sacrificed in favour of another. Once a nation ascribes a high priority to one sector of security, the question arises as to how much or what level of security is needed. In practice there is seldom a stark choice between security sectors for priority and resourcing. However, where that is the case, the rationalist decision maker is inclined to argue that resources should be allocated to a given security sector only to the extent that the marginal return is greater than the gains to be made by applying the resources elsewhere (Baldwin 1997: 20).

Some definitions of threats to non-traditional security sectors tie definitions back to concepts of safeguarding and defending the state. For example, the US National Research Council (2013: 1-13), indicates that the US should be alert to situations arising from climate change which reveal inadequate coping with, response to or recovery from threats to national security. Others like the Consortium of Non-Traditional Security Studies in Asia (2007:1) have stated that:

> ‘Non-traditional issues are challenges to the survival and well-being of peoples and states that arise primarily out of non-military sources, such as climate change, resource scarcity, infectious disease, irregular migration…’

4.0 DEFINING WATER SECURITY

The term water security is used in quite different ways, often according to the discipline or government sector involved. As a result, understandings of the concept and usage of the term diverge from primary production to scientific research, from water engineering to public health and from social development to public administration. Cook and Bakker (2012: 94-

102) analysed almost 100 published research articles that dealt with aspects of water security. They noted four dominant, at times, overlapping themes, namely:

- Water availability, dealing with water stress, shortages and the need to supply sufficient safe and affordable water;
- Human vulnerability to hazards, spanning protection of vulnerable water supply, storage and distribution systems and protection against natural hazards;
- Human needs, including access to water and its importance in achieving food security, protecting health, safety and welfare as well as productive capacity;
- Sustainability, ascribing a high value to water, encouraging the management of risks, engaging in equitable sharing and striving to maintain ecosystem health.

They concluded that water security cannot adequately be construed as a narrow technical concept. Instead they argued for 'broad and integrative framing' of water security and for 'good water governance' in order to advance community-wide water security (Cook and Bakker 2012: 100-101).

The United Nations also views water security as a very broad concept, with water security playing a central role in advancing human security. UN Water (2013: 1) states that:

> 'Water security encapsulates complex and interconnected challenges and highlights water's centrality in achieving a larger sense of security, sustainability and human well-being. Many factors contribute to water security, ranging from biophysical to infrastructure, institutional, political, social and financial…water security lies at the centre of many security areas, each of which is intricately linked to water.'

A definition of water security is presented here which explicitly recognises the importance and interdependency of human and environmental welfare and the need for patterns of water development and water extraction to consider the resilience of aquatic systems. Throughout this thesis 'resilience' refers to the capacity of complex aquatic systems to absorb and recover from shocks and disturbance. A resilient system can respond to both human needs and those of other water-dependent species in ways that maintain its integrity and the viability of its critical ecosystems. The following definition has provided a useful reference point in analysing water security in each country:

> Water security requires the sustaining of water-based systems, their ecologies and their resilience, in the face of uncertain change, while recognising human needs for access to water of useable quantity and quality.

Analysis in the country chapters, shows that achieving water security requires national leadership, political commitment and effective management and planning. Future national welfare and prosperity call for water security to be assigned a very high national priority and for major water-oriented policies, programs and projects to make positive contributions to water security. This thesis has found that considerable political resolve is also needed if many obstacles which militate against achieving national water security are to be overcome in each state. For instance, water managers must deal with the unpredictable, often adverse consequences of anthropogenic, natural or climatic change in heavily used, complex aquatic systems. However, they are often not empowered to adapt management strategies and interventions in ways that can contribute to improved system sustainability and water security. These issues are explored further throughout the thesis and notably in the final chapter, which also identifies some of the policies, approaches and actions that have been found to be most effective in advancing national water security.

5.0 MAJOR FACTORS IMPACTING ON WATER SECURITY

There are many actors and processes involved in shaping national approaches to water management and in determining water security outcomes. The contributors include powerful political forces, ministries and departments at several levels of government, river basin commissions, and multiple stakeholders, interested parties and experts. Political decisions and interventions, patterns of water governance, administrative structures, institutional arrangements and management processes also determine how water is used, who has access, who benefits and who is advantaged or disadvantaged.

Preliminary literature research indicated that a smaller number of critical factors could be identified, which have a strong influence on national water security outcomes in all nations. Analysis of the impacts of these selected factors has contributed to building a broad picture of water security in each nation. The four factors are: the extent and nature of political intervention; whether or not a nation engages in good water governance; the extent to which management of complex aquatic biophysical/socio-economic systems is approached as whole system management; and, how the impacts of climate change, present and projected, are being taken into account. The following sections explore the importance of each of these four factors and reflects the way each has been viewed in carrying out the country analyses. In Section 6, a number of issues have been listed under each factor which give greater definition to each as well as helping to assure consistency in analysis. In the country examinations there are times when several factors have been found to interact or reinforce one another in exerting impacts on water security. Where the interplay has been significant it has been explored in the country chapters. Some examples, where potentially important interactions between factors could occur are described in the following text.

5.1 Political Influence on Water Security

Internationally, there are now many situations where water scarcity has become so acute that the future of industries, settlements and regional economies is at serious risk. The three countries studied have all tried to moderate water scarcity, control water demand and regulate the way water resources have been shared. They have engaged, to varying extents, in reducing the adverse impacts of water-oriented development and climate change on water sources, the environment and communities. Their political decisions reflect the relative importance each has accorded to command and control strategies, state controls versus market instruments and to treatment of water as a public and/or private good. These sorts of considerations have led experts to view the management of water resources and the allocation of water as intrinsically political issues (Mollinga 2008: 10; World Water Council [WWC] 2015: 7, 24).

There are many situations where political intervention and commitment are central to achieving the major water management and water security goals identified in this chapter and to overcoming major institutional blockages to water reform. In this regard, the analyses in the country chapters show that the absence of political will and drive is sufficient to prejudice sound water resources management outcomes, to impede advances in water security and to leave some aquatic systems in an unsustainable state.

On the other hand, interventions by those with power have often tended to be expedient and reactive in the management and distribution of water. Where water scarcity is a continuing problem, politicians world-wide have often ignored both scientific and social-scientific advice and well-tested procedures. Political decisions approving greater access by some consumers to surface or groundwater sources, water storages or water quarantined for the environment have frequently accentuated long-term risks to national water security. Such situations have been identified in the country chapters. Throughout this thesis the politics of water has largely been examined in terms of the impacts of political decisions, interventions and influences on water security, a subject that has received little attention in most national and international studies (Rogers and Crow-Miller 2017: 1239 ‘Introduction’).

Where contestation has occurred over water allocation or economic water-based development, a common political strategy in many countries has been to emphasise the importance of achieving a balanced outcome. Examples include political calls for economic as well as environmental and social factors to be taken into account, or for the ‘triple-bottom-line’ to be secured, or for necessary trade-offs to be made. In the cases reviewed in this thesis, such propositions have almost always failed to recognise that the health and the sustainability of the aquatic source is the deterministic factor. As a consequence, the state of the given water source may have been placed at serious risk and the future water security of all actors and the environment may have been significantly diminished. Equally, it has been uncommon for nations to review critically issues such as equity in current legislative and administrative arrangements governing water rights, water allocation and water sharing. This research has identified few instances where the exercise of political power or influence over water, its use and allocation, has been examined in terms of legitimacy, accountability, equity and transparency.

5.2 Good Governance and Water Security

As a developer and promoter of the concept of good governance the World Bank defined good governance in the following terms:

> ‘Good governance is epitomized by predictable, open and enlightened policymaking (that is, transparent processes); a bureaucracy imbued with professional ethos; an executive arm of government accountable for its actions; and a strong civil society participating in public affairs; and all behaving under the rule of law’. (World Bank 1994: vii)

Certainly, good governance is central to effective water management, including to achieving sustainable management of whole systems. The Global Water Partnership defines water governance as:

> ‘The range of political, social, economic and administrative systems that are in place to develop and manage water resources and for the delivery of water services at different levels of society’ (Adeyemo 2003: 169).

To deliver enhanced water security requires governments to meet these and further tests. Good water governance entails strong government leadership, effective and accountable political and public sector actions, adequate state resourcing and a legislative, administrative and institutional framework that accords priority to the goal of water security. The quality of water governance is also influenced by the way risks to water sources are assessed, water resources are allocated, water rights are assigned and water markets established and operated. Good water governance needs government to recognise and work to overcome the lack of a coherent focus frequently created by fragmentation of administrative arrangements across various sectors and levels; that includes overcoming the differences between hydrological boundaries and administrative borders (OECD 2015a: 1; Noda 2018: 190).

Sound water resources management, national water security and good governance are not achieved through the actions of the state as a controlling or sole force. Good governance also relies on the contributions of stakeholders, non-state actors and communities in a variety of settings (Pahl-Wostl *et al* 2008: 24). The government of the day can strengthen those roles by disseminating information, accepting that water policy is improved through the contributions of non-state experts and by ensuring that governance processes are fair and transparent. Customary discourse, traditional policy and norms and institutional framing often run counter to good governance by blocking necessary change (Marshall and Alexandra 2016: 679-684; Rubenstein *et al* 2016: 90). The International Water Centre (2020) wraps these many facets of water governance into what it describes as 'integrated water governance'. Based on ADB (2016: 28) research data, the Water Centre argues that 'better water governance leads to better water security' (Water Centre 2020:3).

Water supply, treatment and distribution systems are vulnerable to terrorist attacks, malicious disruption and chemical or biological poisoning, but most governments and their agents have been reluctant to disclose the risks or to rely on a well-informed public for early detection (Gleick 2006). Each of the countries under review has broad governmental strategies to deal with potential terrorist activities and major natural disasters. However, it is largely non-government bodies that have drawn public attention to possible threats to the security of water systems, including the vulnerability of water infrastructure and control systems to terrorist and cyberattacks (Nicolaou *et al* 2018; Maiolo and Pantusa 2018; UN Office of Counterterrorism/UN Counter-Terrorism Committee Executive Directorate 2018; Agilient 2020).

The analysis in this thesis supports other research in finding that when good water governance is accompanied by whole system management of major water systems the prospects for national water security are greatly advanced (see below). Critical water resources are also more likely to be managed in sustainable ways.

5.3 Integrative Management

Since the beginning of this century, participants in the global water discourse have debated whether and to what extent there is a global 'water crisis'. A common conclusion is that at the core of the crisis lies poor management of water resources - not least because current water management practices and water usage patterns have frequently had adverse impacts on critical environments, their ecosystems and local hydrological cycles, while also diminishing present and future water security and food security. The work of Zeitoun *et al* (2016) helps to understand why. They carried out a comprehensive review of dozens of research studies into various aspects of water management. In the majority of cases they found the study scope to be limited by simplifying assumptions about factors such as economic and social change, climate change and water demand. These latter studies were shown to be reductionist in character leading to underestimates of the complex interactions between many factors. As a result, management responses were frequently flawed. Of course, there is considerable appeal in restricting the scope of all such studies - because that offers the promise of 'solutions' which are clear, readily understood and readily implemented, often by economic, technical or engineering means (Zeitoun 2016: 145-149; Varis *et al* 2017: 36).

By contrast, integrative strategies call for efforts to understand socio-economic-hydrological systems better as well as the underlying processes and interdependencies. The major reviews conducted by Cook and Bakker (2012) and Zeitoun *et al* (2016) both suggest that focusing on the whole system and adopting integrative approaches to the management of complex systems are central to improved water security. Given the uncertainty in projecting the responses of complex systems to wide-ranging anthropogenic change, improved outcomes usually require adaptation, innovation and experimentation.

Three approaches described below apply some form of integrative management and rely on significant administrative and institutional change. The first involves whole system management within a river basin, while the second entails ensuring that the main land and water system variables are managed in ways that render development sustainable. A third approach involves joint custodianship or stewardship of the common resource. Each approach has been applied at some level within a number of countries.

5.3.1 Integrated Water Resources Management (IWRM)

During this century, world expert forums, many governments and academics have embraced the concept of integrated water resources management (IWRM). The Global Water Partnership in 2001 (GWP 2001:1) perceived IWRM as:

> ‘a process which promotes the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.’

Generally, the river basin is the framework within which the integrated management, institutional coordination, monitoring and testing takes place. The management task is conceived as working to understand the complex interactions between water, land and natural systems with prevailing socio-economic systems in a given river basin. It offers the promise of better management of water resources in the face of major anthropogenic changes caused by population growth, land development, the construction and operations of water infrastructure and patterns of industrial, agricultural and domestic use of water resources. It also seeks to understand and manage climate induced changes to basin geomorphology, river flows, water quality and water quantity. The process involves blending the results of social, economic, physical and biophysical science research while engaging many interests and stake-holders. It also calls for water extraction volumes and practices to be revised in the light of experience. Success may also require explicit decisions to modify past policy choices, institutional arrangements and to depart from traditional norms and practices.

In implementing IWRM, decision makers and managers are seeking to understand the way complex natural and modified systems work and how such systems are likely to respond to further change. It is this inter-connected array of systems, functioning as a whole entity that determines how a river basin responds to a given intervention (Crawford 2003: 19-23; 2008: 5-7). Thus, how river flows change at one location cannot be used to determine how the whole complex basin system is responding to human interventions (Senge 1993: 43-67). IWRM requires feed-back loops, so managers can respond to the consequences of various interventions (Klinke and Renn 2002: 1085-7). This process, known as adaptive management, is iterative and experimental and frequently requires modifications to management interventions to be made in the search for the optimal result.

5.3.2 Sustainable Resources Management

In the report on 'Our Common Future' (Brundtland 1987: 8) sustainable development is defined as development which secures 'the needs of the present without compromising the ability of future generations to meet their own needs'. Underlying sustainability as a concept is the continuing requirement that patterns of development and natural resource use, including use of water resources, must be managed in ways that preserve the capacity of natural systems and their ecosystems to meet both present day and future needs - taking due account of climate change. Regional resource management and landscape management are two well-known approaches focused on sustainable management of natural resources.

Governmental, academic and industrial literature sources refer to some aspects of sustainable water resource management in similar terms to those used about IWRM (see, for example, Loucks 2000: 6; Morelli 2011: 23; Electric Power Research Institute 2010: 3-1). State leadership is held to be important in establishing mechanisms to contain the potential negative impacts of resource use and development. Hydrological, environmental and ecological integrity of the water resource systems needs to be retained, so present and future water demands can be met. The best available scientific, socioeconomic and environmental advice should be sought in order to develop effective water resources management strategies. Finally, the whole approach depends on reducing water demand by harnessing water conservation, reuse and recycling.

5.3.3 Water Resources Stewardship

Since the beginning of this century, 'stewardship' of the environment and natural resources and the links to sustainable resources management and conservation have become significant arenas for discourse and research (Worrell and Appleby 2000: 263-266). Shepheard (2018: 127) sees stewardship as a 'foundation element for resource management arrangements that connect natural resource use with landscape ecological limits and the social well-being of communities.' The following definition reflects the importance of integrative management in stewardship:

> 'Stewardship is the responsible use (including conservation) of natural resources in a way that takes full and balanced account of the interests of society, future generations

> and other species as well as of private needs and accepts answerability to society.' (Worrell and Appleby 2000: 263)

The outcome of stewardship depends on the levels of collaboration in planning, management and decision-making in the management of natural resources and the environment. Because the treatment of major river basins is critical to water security outcomes in each of the referent countries, it is useful to examine several models of water stewardship (Huitema and Meijerink 2017: 42). Where autonomous river basin executive authorities or commissions exist, they undertake most water-related resource management and regulatory functions, including those over water-based development. Other basin commission models restrict the commission role to policy and standard setting and planning, while still others focus on simply coordinating the activities of government agencies, stakeholders and interest groups. Where the national interest is engaged it falls on government to exercise a significant role in water stewardship, which may, at times, lead it to exercise executive powers in influencing outcomes (Mathevet *et al* 2018: 363-364).

In principle, government can decide how and when to lead, encourage, mediate or regulate. This recognises that other parties have rights and interests and may also possess knowledge, skills and capacities which the government lacks. At a more localised level, wholly civil society-based partnership arrangements for water management exist which have been created by watershed groups and water user associations. Examples of these approaches are reviewed in Chapter 4 dealing with Japan. These latter arrangements seem to work best where the user regime has the capacity to resolve conflicts within the group, but has due government recognition of its role (Ostrom 2010: 653). Ultimately, no matter whether the model adopted involves government leadership or leadership by other parties, stewardship focuses on achieving fair and transparent arrangements for the sharing of available water resources, while ensuring that threats to that supply source and water security are minimised.

5.3.4 Integrative Management in This Thesis

Over millennia, evolution and displacement of species has occurred as well as dramatic changes in river courses, wetlands, marshes, lakes and riverine forests. However, the issue at play in this research is that major river systems of each of the referent nations have been modified by human activity, often substantially and with deleterious effects. These systems have been harnessed to provide water for people, agriculture and power generation, and to provide transport, recreational and touristic services. They have also been modified in efforts to protect citizens against the ravages of drought, floods, earthquakes and climate change. This research supports the conclusions of Cook and Bakker (2012) and Zeitoun *et al* (2016) that most actors, the environment and water security benefit when such complex aquatic systems are managed in an integrative way. The management approach is best selected and adjusted to meet the needs of every complex system, because each responds differently to the way it has been modified and the patterns of water extraction (Voulvoulis *et el* 2017: 364; Zeitoun *et al* 2016: 149).

In the country analyses, assessments have been made of heavily modified aqueous systems where integrative management would have benefited users, system sustainability and resilience and water security. Few cases of integrative management have been observed, often because nations have attempted to simplify the management challenge. In no case was it obvious that one public entity had been designated to represent the needs, health and sustainability of major water systems in the many political and bureaucratic forums and processes that have shaped national river-oriented decisions.[6] Because integrative management often requires institutional change, the research has examined the extent to which each nation has recognised the importance of effecting change in legislative, administrative and governance modes and refining patterns of land and water development in order to advance national water security.

5.4 Climate Change and Water Security

Climate change is the fourth critical factor affecting water security. Climate change can alter the hydrological cycle, the patterns and intensity of rainfall, run-off, evaporation rates and moisture retention in soils. As the incidence and severity of droughts, floods and other major climatic events increase so too does the presence of contaminants such as sediments, nutrients, pathogens and salts. Climate change, in many countries, is contributing to the increased intensity and incidence of bushfires and wildfires, to post-fire water contamination and water scarcity, as well as deleterious seawater intrusion into freshwater systems. The destructive impacts of climate change on cities, towns, water infrastructure, communities and economies can be very significant in the absence of adequate planning and research. This also

[6] This position is also informed by the author's experience in managing the major sources of water supplying Sydney and surrounding cities and towns, conducting public inquiries into the health of the rivers and lakes of NSW and examining water management in other national jurisdictions.

highlights the importance of national efforts to curb greenhouse gas generation. The response of governments and their instrumentalities to climate change and their level of preparedness offer a further insight into whether jurisdictions are equipped to deal with its threats to water security, as reviewed throughout this thesis.

Links can be drawn between climate change and the other selected factors. Because IWRM has a significant focus on the ecological resilience of water-based systems subject to stress, Jiang argues (2017: 33, 37) that it represents the best available tool for taking account of the wider-ranging impacts and uncertainties associated with climatic change events. Good governance can also play an important part in the way nations cope with projected and present climate change. In the case of major complex aquatic systems, the way governance responds to climate change can have a significant influence on the availability, quantity and quality of water in those systems.

6.0 ASSESSMENT FRAMEWORK: MAJOR IMPACTS

The way politics, governance, management and climate change influence and impact on water security in each country has been considered in the country chapters, by examining major programs, policies and projects, such as water reform, water planning, water rights and water allocation. These four major impacts represent key elements in the framework described in earlier sections. Assessment of the way each nation has responded to these impacts - which they experience in common - has played an important part in gauging national approaches to water security and in effecting comparisons. This approach has helped in overcoming differences in priorities and understandings of water security in each nation (De Löe *et al* 2007). The detail in Section 5 above provides a sound guide as to the way these factors are understood in this research. In seeking analytical consistency, a list of issues has been developed which have also been considered under each major impact on water security. These issues are identified in sub-sections 6.1-6.4 below.

6.1 Politics

- The political priority accorded to or implied for water security; the role of political leadership and commitment in advancing water security.
- Whether most political interventions are transparent and consultative or designed to advance specific interests.

- The role political interests and political compromise have played in shaping major water programs and reforms in ways that advance or impede water security.
- The extent to which political actions and discourse influence the national priorities accorded to consumers as opposed to the environment.

6.2 Governance

- The clarity of national legislation, regulations and policy statements that could improve water security.
- Assessments of progress in implementing strategies to advance water security, explicit or implied, including public assessments of outcomes.
- Progress in overcoming major obstacles to water security such as path dependence, legislative and regulatory complexity.
- Progress in concerting water resources management and reforms involving multiple agencies and in rendering coordination more effective across levels of government.
- The extent to which government is held accountable for water management outcomes, particularly the sustainability of aquatic systems when economic and infrastructure development occurs.

6.3 Management

- Establishing if water resource management takes place according to agreed and transparent procedures, including taking account of the rights and interests of stakeholders and citizens.
- Whether the integration of surface water and groundwater extractions and groundwater recharge rates are considered in water management and water planning.
- Whether there have been effective efforts to bridge sectoral differences between agencies and to coordinate and integrate across levels of government.
- Whether water management takes account of the health of critical ecosystems and uses socio-economic studies to inform the management and planning roles.
- Whether high order, whole system management is a national priority, as instanced by the sophistication of basin management.
- The roles of hazard, risk and adaptive management in water management and in taking decisions about water allocations.

6.4 Climate Change

- The extent to which legislation, water management, planning and allocations have been designed or adapted to deal with the impacts of climate change on water security.
- Where climate change has been identified as a significant influence on the direction of water reforms, which might also help improve water security.
- Whether national studies have identified key situations where water management needs to focus on revised arrangements to deal with climate change.
- The effectiveness of follow up and monitoring of situations where climate change demands early attention and action.

7.0 ASSESSMENT FRAMEWORK: DOMAINS

As indicated above water security is a broad concept, best framed in ways that reflect its breadth and critical importance in advancing human and environmental welfare and human endeavour. For the purposes of analysing national approaches, it has been useful to divide water security into four domains. This has helped in gaining an understanding of where priorities, policies and programs are advancing or retarding water security and in teasing out contributions at various levels of government and by non-state actors. The four water security domains selected are the state, human welfare (including domestic use), consumptive (spanning most commercial) users and the environment. Each of these domains features in definitions of water security or explorations of the concept (See for example Varis *et al* 2017: 36; ADB 2016; Zeitoun 2011: 291-296).

The way national approaches to various aspects of water policy and management have been developed and applied has been examined in terms of consequences for these four designated water security domains. As was the case for the four major impacts on water security, it has been useful in seeking consistency in the analysis and in drawing conclusions to develop a list of issues under each of the four domains. Clearly, in sub-dividing such a broadly framed concept for the purposes of analysis, there are resulting overlaps and blurring at the fringes of these domains. For example, water security outcomes for human welfare are strongly dependent on the water security of aquatic environmental systems. For that reason, the issues identified in the sub-sections below have served as an aid in differentiating the ambit of each domain as understood in this thesis. The final chapter draws together the strands of country analyses and the research on the four domains in order to build a robust picture of present national water security and the level of state preparedness to face future challenges.

7.1 The State

- The nature of state laws, planning, definitions and policy statements have a bearing on water security and related goals.
- The national priority, stated or inferred, attached to advancing water security and the extent to which the power of the state has aided efforts to attain water security.
- Whether water ownership is vested in the state and whether water rights and entitlements are determined by transparent state statutory provisions.
- The level of state preparedness, actual and political, to confront future challenges and potential threats to water security, as defined or implied in state actions.

7.2 Human Welfare

- Whether water quality controls and water allocations are protecting human health and livelihoods.
- The way water-related threats, risks and hazards are being faced, particularly so that aquatic systems retain the capacity to deliver human services.
- The extent to which urban water supply, distribution, and wastewater treatment and disposal meet health and environmental standards, and attempt to deal with risk and conflict.
- The way the physical and spiritual needs of citizens and equity are treated in water reform and water allocations, including those of ethnic groups and indigenous peoples.

7.3 The Environment

- The primary vehicles used by the nation to protect freshwater aquatic ecosystems and aquatic environments and their overall effectiveness.
- The relative priority accorded the environment in major approaches to water management, planning and entitlement.
- The extent to which water allocated to the environment is assured through monitoring and enforcement, including during periods of water scarcity.

- The effectiveness of sewage and wastewater treatment in protecting the aqueous environment.
- Whether there are effective environmental limits on water access and supply and on the adverse impacts of economic development and water infrastructure on rivers, lakes and groundwater.

7.4 Consumptive Users

- Where, when and how legislation, regulations and planning have advanced the interests of consumptive users.
- The extent to which water allocations, water rights and water markets have improved water access, water quantities and quality in advancing water security for consumptive users.
- The response of primary and secondary industry when required to implement controls and standards, relevant to improving water security.

8.0 THE FINAL CHAPTER

The final chapter, titled 'Water Security Imperatives', compares and evaluates the overall approach of China, Japan and Australia to water security and how each is placed to meet future challenges and imperatives. The strands of analysis, drawn together in that chapter, show the dire consequences of government failure to accord water security a high national priority. In fact, each of the countries has too often adopted a narrowly focused approach to economic development which has compromised efforts to improve water management, system sustainability and water security. This is most evident in the way each state has managed heavily used, highly modified river systems that are also subject to the impacts of climate change, present and projected.

The chapter compares a series of factors, whether political, legal, administrative or institutional, which act to advance or impede water security, as well as the effectiveness of. country policies and programs in improving or retarding water security. This brings into relief the level of commitment of each state to water security as a high priority supported by adequate resources and expert skills. It reveals the extent of national resolve to carry through necessary water reform and institutional change. The chapter concludes with a series of recommendations, directed at advancing water security in each country. Those recommendations recognise that carefully assessed efforts to improve water security can make a material contribution to national security, welfare and prosperity.

CHAPTER 2

A CRITIQUE OF WATER SECURITY IN AUSTRALIA

1.0 INTRODUCTION

Australia faces severe challenges in dealing with variable rainfall, prolonged droughts and associated water scarcity as well as the legacy of water overuse and over-allocation in some of its major river basins. Section 2 examines these issues and sets the historical, geographic and climatic context that governments encounter in providing water security. Each of the nations examined in this thesis has a different legal and administrative framework. Section 3 explores the idiosyncrasies of the Australian framework, especially notable because of the constitutional power of the Australian states to control use of the nation's water resources and therefore to have a major influence on national water security. Since the 1990s, and more actively since the early 2000s, the governments of Australia have sought to harmonise approaches to water policy, management and planning. The results of this process have been independently scrutinised and entered into the public domain. Section 4 deals with this National Water Initiative (NWI), its key elements and its early goals. Section 5 introduces the subject of water security and highlights the influence of politics and political decisions on water policy, water resource management and water sharing in Australia. The exercise of political power and its impact is a recurring theme in this chapter.

Sections 6 to 12 are structured around major programs such as water planning, urban water supply and water markets. In each section the basic approach adopted in Australia is reviewed, as well as the main results under sub-section titled 'Results and Challenges' and the problems to be overcome under 'Consequences for Water Security'. This latter sub-section provides a critique of various contributions to water security to the end of 2019 and provides some indications of future prospects. The data and information have been drawn from very diverse sources including national and international researchers, national scientific institutions, water associations, governmental departments, authorities and corporations. Independent national and international bodies including the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the National Water Commission (NWC) and the Global Water Partnership (GWP) have also helped in filling some gaps in data and in evaluating programs. 'Water Planning', as examined in Section 6, is the pivot around which much of the NWI was built. More than 150 water plans were forensically examined by the

NWC between 2004 and 2014. NWC reports and data base have been drawn on in compiling this Section.

For most of this century, the water-oriented programs mounted by the various Australian jurisdictions have had similar orientations and goals. The implications of the way policies, programs and plans have performed have been considered in terms of the four water security domains established in Chapter 1, namely the state, human welfare, consumptive users and the environment. Throughout this chapter, and other country chapters, 'Consequences for Water Security' have been assessed in terms of the four designated water security domains. Chapter 1 also identifies four major internationally recognised impacts on water security, namely political interventions and influence, governance, water resource management based on management of whole systems and climate change. The four major impacts have generally been found to have the greatest influence on the matters reviewed under 'Results and Challenges'. The analysis in each chapter follows this model, except where the results of detailed analysis have best been reported under additional sub-sections with idiosyncratic titles.

As identified in Section 3, Australia comprises a federation of states and territories, each with its own government as well as a national Australian Government. As a result, the contribution of the Australian states and territories is important in determining the shape and orientation of water security in the nation. Various programs and activities at this level of government have therefore been examined in this chapter. Nonetheless, as in the cases of China and Japan, efforts have been made to examine significant contributions to national water security, made by any level of government or led by non-state actors. Overall, the public and timely reporting of extensive water-oriented information in Australia has been of great benefit in refining and validating the assessment framework on which inter-country comparisons of water security are based. As a result, this chapter has been able to draw on more detailed data and to engage in deeper analysis than has been the case for China and Japan. Use of the assessment framework has also contributed to the confidence with which this chapter presents a picture of water security in Australia, now and in the future, as well as in assessing some major problems and challenges to be faced.

2.0 WATER CHALLENGES

Australia receives annually about 1% of the available freshwater in the world, with rainfall varying dramatically from high falls in the tropical north, to variable rainfall in the populated and temperate south and south-east, and rare rainfall events in the central desert regions. Some 85-95% of the rainfall in Australia evaporates or is harnessed in plant transpiration, with the rates of evaporation being lowest in the temperate zones (Lehane 2014: 3-4). The variable climate has in the past led to long periods of drought in much of Australia, punctuated by periods of heavy rainfall and flooding. That has created natural limits on both the quantity and quality of available surface water. In the catchments surrounding the major cities the available water resources are often fully allocated for domestic and industrial use. In parts of the nationally critical Murray-Darling Basin water resources have frequently been over-allocated, primarily to serve the needs of irrigation (Young and Prosser 2011: ix).

In 2016-2017, Australian users consumed about 16,500 gigalitres of water (Infrastructure Australia 2019: 601). In 2014-2015, 83% of water extracted nationally came from surface water, 16% groundwater and 1% was desalinated water (Bureau of Meteorology [BOM] 2015:1). In some years, groundwater meets as much as a third of national demand (BOM 2019: 37). In the same time frame agriculture consumed 60% of extracted water, households and supply authorities took 23%, mining and manufacturing 8%, and the environment was notionally allocated 9-10% of available water (ABS 2015: 1). When rainfall has been plentiful, the percentage of water used by agriculture and irrigation has generally risen, as for example in 2000-2001 when agriculture used 67% (Academy of Technological Sciences and Engineering [ATSE] 2012: 26).

To understand the pressures on water security in Australia today it is important to note some of the factors which led to the current situation. In Australia, after World War II, water was allocated as part of a land right rather than as a separate right. This program was established to support extensive local, regional and national development. The charge for water to these users was essentially zero. As demand increased, government responded by providing significant investments in various forms of public water infrastructure - more based on political assessments than any cost-benefit analysis (Freebairn 2005: 10). In ensuing years, the water resource base progressively came under significant stress from overallocation, population growth, climate variability and early climate change, urbanisation, changes in land use patterns, changed social and environmental values and inertia in transformation of governance structures (ATSE 2012: 13-14).

While there have been downturns in demand during dry and drought periods, overall demand for water has come to exceed available and accessible water resources. As a result, governments nationally have been obliged to introduce quantitative measures such as water restrictions in towns and cities, have required water utilities to find ways of reducing demand, and at times, often with reluctance, have increased water prices. Faced with the scale of problems of both water quantity and quality the governments finally agreed in 1994 in the Council of Australian Governments (COAG) to a suite of reforms, particularly, in the way water was to be allocated to consumptive users, domestic and urban users and the environment as described in Section 3.

Today water security continues to come under pressure because of the rising needs of irrigators, those engaged in meeting national and international demands for food, power and manufactured products, as well as mineral development, irrigation and urban supply. The very variable climate has created a challenge for urban utilities in maintaining reliability of supply, for example, leading Melbourne Water to store 10 times the per capita requirement that is set aside by London (Young and Prosser 2011: ix). The situation is projected to grow more challenging with climate change, particularly in south-west Western Australia, where despite a period of above average national rainfall in 2011-2012, the moisture level retained by the soil continued to fall (Lehane 2014: 5). In the case of freshwater extracted from groundwater systems, overuse has led to salinisation and contamination of some systems. That has prevented further use of some groundwater systems and has impacted on freshwater dependent ecosystems (Young and Prosser 2011: xi). The community is both aware of and very concerned about these matters. For instance, a Lowy Institute (2020: 7) poll found that 77% of Australians hold that ‘drought and water shortages pose critical threats to Australia’s vital interests in the next ten years.’

3.0 THE LEGAL AND ADMINISTRATIVE FRAMEWORK

Under the Australian Constitution the states have primary responsibility for the management of Australia’s water resources. Greater detail of the legal and administrative arrangements in water resources management and water planning for each jurisdiction is provided in Appendix A. Formally, the Australian Government has only limited direct powers impinging on water, which span the territories, meteorological activities, the marine zone, international and defence policy and agreements, and powers over national and international trade and commerce. However, the national government has become heavily involved in national water policy and reform in several ways, namely, through its power to allocate funds for water related activities under the Australian budget, its leadership roles in various national governmental councils and its ability to support targeted research.

Water ownership is vested in the Crown (state), representing a vehicle of ownership and control by the jurisdictions of the Australian states. Each state and territory has a major statute which provides the framework for water management and planning and the assignment of water entitlements and allocations, though several have developed planning hierarchies under which their water plans have been shaped. Some governments have made the contestable determination that significant water use for extractive industry, stock and domestic purposes is satisfactorily handled under separate statutory provisions. After reviewing these arrangements, two national commissions have asserted that these arrangements have the potential to undermine the transparency of water accounting and confidence in existing water entitlement systems (NWC 2014a: 1, 13; Australian Productivity Commission [APC] 2017: 86). Water rights assigned under the statutes of the states are restricted to the holder of the water allocation and are often deemed to be perpetual. Such rights are tradeable and are commonly treated as if they were property rights. However, water rights do not confer ownership but rather provide access to a shared consumptive pool. In theory, that means the state could carry through water reforms that modified or annulled water rights (Mckenzie 2009: 15)

Australian water resource systems are usually divided into regulated and unregulated systems. Regulated systems have one or more storage which can be used to regulate flows and quantities available for extraction, use and trade, under set conditions. The water in most unregulated systems is only available for use when predetermined seasonal flow conditions are met, and includes further conditions such as maximum daily extraction quantities and scales and times of pumping (Australian Government 2017d: 2). Further commentary on the development of water markets is to be found in Section 11.

In each state or territory, there is generally one agency or department with responsibility for overseeing water resource management and distribution, though in recent years it has been quite common for water agencies and other instrumentalities to be merged to create wider ministerial portfolios. In the largest cities, major authorities exist that are responsible for water supply and sanitation and associated water supply, distribution, treatment and wastewater removal services as well as some aspects of water risk, engineering, storage and quality control. Other authorities, which deal with matters such as agriculture, health, environment protection, catchment management, spatial and land use planning and public works, frequently have intersecting or overlapping responsibilities.

4.0 THE NATIONAL WATER INITIATIVE (NWI)

In 1994 COAG (1994: 2) established a reform framework to address ‘the efficient and sustainable reform of the Australian water industry’. The Council focused on reducing the costs of existing services, disentangling land and water property rights and entitlements, facilitating trade in water entitlements and institutional and water pricing reforms (COAG 1994: 2-3). It was also concerned to halt the degradation of water quality and river and groundwater health and to ensure that water entitlements were allocated to protect the environment. Shortly thereafter the outputs of the National Water Quality Management Strategy (NWQMS) and the National River Health Program were linked to the COAG process.

In 2004 the governments of Australia developed an Intergovernmental Agreement on a National Water Initiative (IGANWI and later simply NWI) and established the NWC to guide and oversee the roll-out of the initiative (IGANWI 2004). A key to improving water resources management nationally was the development of statutory water plans for all the nation’s significant fresh water regimes. By 2013 all water planning was statutorily based under a variety of regimes in the states and territories (see Appendix A), and all national water use, aside from that in remote areas, was covered by such plans. The key goals for water plans, agreed by governments, are set out in Table 2.1, and are notionally placed under the water security domains identified in Chapter 1 (NWC 2014a: 3).

The NWC conducted it final assessment of 172 water plans prepared under the aegis of the NWI in 2014. This was followed by a 2017 progress report by the APC. The roles of these two Commissions differ. The NWC role resembled that of a national water management auditor, involved in annual assessments of individual water plans and other program elements against NWI targets. The APC makes triennial assessments of global progress in water reform, with a strong orientation towards national productivity and efficiency. It therefore focuses less on issues such as sustainable water resources management, water security and integrated resources management. While the APC does have political influence, the NWC had a direct reporting line to national leaders in COAG.

Table 2.1 Nationally Agreed Goals for Water Planning

(NWC 2014a)

Water Security for the State

1. National compatibility in water access entitlements, in order to foster investment and minimise transaction costs in water trades

Water Security for Human Welfare

2. Planning processes that consider *public*, private and environmental benefits in an open manner
3. Recognition of indigenous needs

Water Security for the Environment

4. Statutory protection of 'water sources and their dependent ecosystems'
5. Environmentally sustainable levels of extraction, by reducing over-allocation and overdrawing
6. Identification of systems of high conservation value for adequate protection

Water Security for Consumptive Users

7. 'Security and commercial certainty of water access entitlements'
8. Protection of water access entitlements during periods of economic growth or land use change

Impacts of Governance on Water Security

9. Recognition of regional variability in demand for water in allocative decisions
10. Assignment of risk, where changes occur as a result of decisions on water allocation

Impacts of Integrative Management on Water Security

11. 'Adaptive management of surface and groundwater systems'

In responding to the UN '2030 Agenda' for achieving sustainable development goals, the Australian Government (2018: 48) relied heavily on the impetus created by the NWI, leading 'all levels of government to work towards common goals.' The claims that Australia would meet future challenges through the current ‘high level of integrated water resource management’ and through national efforts ‘to balance economic, social and environmental interests’ are contested in this chapter, particularly in the analysis of the Murray-Darling Basin (Australian Government 2018: 48).

5.0 THE POLITICAL CONTEXT

In Australia the role of politics and political ideology in water policy formulation and decision-making is frequently elided. In fact, this Chapter demonstrates how often political interventions have had adverse consequences for national water security. There is no nationally accepted definition of water security nor associated legislation and institutional arrangements to facilitate achieving water security as an explicit national goal. However, since the turn of the century at the national, state and territory levels, the political narrative has increasingly involved use of the terms ‘water security’.

In January 2007 the conservative Prime Minister John Howard announced ‘A National Plan for Water Security’ (Australian Government 2007: 1-22). This Plan was primarily directed at overcoming long standing problems suffered by the Murray-Darling Basin as a result of poorly coordinated management, water overuse, water over-allocation and serious environmental deterioration. It did not focus on the delivery of wide-ranging national water security or the sustainable management of Australia’s water resources. *Inter alia*, the announcement represented a gambit by the Australian Government to gain control over the management of the whole Murray-Darling Basin system.

To encourage the states to cooperate in referral of some of their constitutional powers to the Australian Government, that government created a ten-year plan of public funding mostly to be used to modernise irrigation infrastructure and to buy-back water with the aim of promoting water saving for environmental purposes (Australian Government 2007: 1-22). Because it did not gain assent from all participating states to referral of the necessary powers, the Australian Government exercised its own limited Constitutional powers in introducing the *Water Act 2007* (McCormick 2013:1). Under the Act, provision was made for a statutory Basin Plan to be prepared by the newly constituted Murray-Darling Basin Authority (MDBA), with its reporting lines changed from COAG to an Australian Government minister. The disparities in the interests and aspirations of the various jurisdictions meant that it took a further five further years for the Plan to be adopted. At the conclusion of this process the Australian Government presented the Act and Plan as if they provided a statutory basis for inter-governmental agreement. The detailed examination undertaken in Section 7 suggests that that view is highly contestable.

The second arena where water politics has dominated lies in dramatic policy and administrative changes between 2013 and 2019. In 2007, at the end of the long national drought, the conservative Liberal-National Coalition Government established a Ministry of Environment and Water Resources. This conservative government appeared to accept that there should be a policy nexus between management of water resources, the environment and climate change. At that time, many NWI programs were being advanced in a cohesive way by state and territory jurisdictions. However, as the ideological discourse changed, the commitment to better manage national water resources, the environment and climate change fell away dramatically. Beginning in 2013, agencies, statutory commissions and programs of the Australian Government with orientations towards managing complex aquatic and environmental systems were terminated, merged or budgets cut. As well, the NWC, Climate Commission, the COAG Standing Council on Environment and Water and the National Water Security Plan for Cities and Towns were all abolished (Department of Agriculture and Water Resources [DAWR] 2017: 1). The environment portfolio was merged with the energy portfolio and the water portfolio merged with agriculture, helping to break the nexus between environment, water and climate change. The key assessment role of the NWC was transferred to the APC which reports solely to the Australian Treasurer. These political decisions were accompanied by reductions in professional skills and capabilities in water and related fields in government entities.

Australian Government white papers and other official papers also began to focus on how to enhance water supply and diminish the impact of existing regulation on private sector water users. The Deputy Prime Minister, drawn from the National Party which represents country people and interests, called regularly for primary production to be freed from environmental impediments, for existing water allocations to be entrenched and for environmental and green groups to be barred from the process of setting environmental policy (Australian Government 2014b; Australian Broadcasting Corporation [ABC] 2014:1; Hannam 2017: 1-2). This contributed to the *Environment Protection and Biodiversity Act* being weakened by removing third party rights of challenge to project approvals and by agreement to refer some nationally significant projects to the states for assessment (Dale 2015: 2; Rose 2015: 1-2). The role of the act was diminished further, as a response to the economic impacts of the Corona virus (COVID -19), when Prime Minister Morrison (2020: 12) announced that approval processes under the act, including for major dams, would be completed within 30 days. All these actions reduced or had the potential to erode national water security.

During this period the water discourse was reframed around water as an economic good, with dam building, mining, irrigated agriculture and water resource exploitation argued to be appropriate tools to raise national productivity and 'improve' water management (Australian Government 2014a). This occurred despite international experience having demonstrated that such approaches had failed elsewhere and that they did not provide certainty and security for consumptive users (see, for example, McCormack 2001: 23). The previous Chair of the NWC, Ken Matthews (2015: 3-4) observed that 'COAG no longer pays serious attention to water reform issues…Incentives for state governments to resume reform progress no longer exist'.

The policy and administrative actions of the Australian Government were paralleled in several states. Climate change strategies were moved away from strategies for sustainable aquatic and land system management, particularly by the NSW Government (NSWG 2017b: 37) which focused on promotion of primary production and future investment. Provisions governing clearance of native vegetation were repealed or relaxed, leading to increased risks of sedimentation, water and soil acidification, salinity, deterioration in water quality and loss of native animal habitat and biodiversity (Slezak 2016: 1-3; Hannam 2018:1). Experts referred to extensive examples of state and political capture by a variety of vested industrial and economic interests (Marshall and Alexandra 2016; Grafton and Williams 2019).

One state did take action to strengthen policy positions rather than weaken them. In 2016, the Victorian Government (2016b: 6-7) established a Water Plan for that state drawing on detailed planning, evaluation of past water reforms and public involvement. The plan sought to achieve 'water security' for major industry and irrigated agriculture; cities, towns and their communities; Aboriginal peoples; and the environment. The plan recognised that climate change could lead to less available water while the state population would continue to grow. It foreshadowed heavy investment in improving the health of waterways and river catchments.

6.0 WATER PLANNING

Unlike Japan and China Australia does not have a national spatial or economic plan which guides subordinated planning and connects intimately to the nation's legal network. This relates in part to the way the constitution divides major national responsibilities and in part to the long-standing political disinclination to engage in centralised planning. From time to time the Australian Government does issue plans and white papers which set out its views as to the preferred path for national development, in relation to issues such as future population, national infrastructure, public sector competition and agricultural development (See, for example, Australian Government 2007; 2019). These documents have varying impacts on the states in the exercise their responsibilities, but tend to be more influential where the states have been widely consulted and where the Australian Government attaches public funding to any proposals.

Water planning has occupied a central role in Australian efforts to secure effective present and future management of the nation's water resources. The water plan has been the foundation building block on which water entitlements have been created, water allocations made and water markets and water trading established. Because Australia as a Federated State differs from Japan and China and because of the pivotal role played by water planning further detail concerning state and territorial approaches to water planning is provided in Appendix A. Under the NWI, water plans in each jurisdiction established the nature of the water resource covered and the quantum available for extraction, the basis for determining water access entitlements for users and the environment as well as providing a tool for integrating management of surface and groundwater. Water security is not an explicit goal in national water planning, but the way it has been implemented and refined has proved to be significant in making water use more sustainable and efficient and in securing some gains for water security.

6.1 Results and Challenges

The above independent commissions have assessed data and plans submitted by authorities and jurisdictions, providing a sound basis on which to chart national progress in water planning, its strengths and weaknesses. The ensuing paragraphs examine the basis on which water plans have been founded, the role they have played and whether they have achieved their stated outcomes - as well as improving water security. The role of communities and Aboriginal peoples in the development and refinement of plans is shown to be modest in many situations. The priority and treatment of environmental and ecosystem needs and climate change are explored below. The section concludes with a brief examination of desirable changes in the national water planning process.

Table 2.2

NWC Assessment of Conformity with NWI Criteria	**Percentage**
Water Security for the Environment	
Adequate assessment of the hydrology of the water resources and the socio-economic values attaching to that resource	73
Accountable environmental management arrangements,	51
Water Security for Consumptive Users	
Sustainable levels of extraction provided for under plans	67
Trade in entitlements is consistent with NWI guidelines	63
Impacts of Governance on Water Security	
Levels of interception adequately covered by each plan	44
Clear and measurable outcomes, including those for the community and the environment	28
High quality monitoring to meet state/ territory compliance and enforcement requirements	9
Impacts of Management on Water Security	
Conjunctive management of surface and groundwater	60
Impacts of Climate Change on Water Security	
Recognition of the potential impact of climate variability on water resource availability	37

In 2013, many water plans only partially met nationally agreed criteria under the NWI framework, as shown in Table 2.2 (NWC 2014a: 1, 531-6). That table also shows that only 9% of plans conformed with NWC criteria for monitoring and assessment. This led the NWC (2014b: 1) to examine separately the contribution of monitoring, evaluation, risk assessment and adaptive management to water planning. The Commission (2014a: 1) found significant weakness in all these areas as well as in priority setting. If poor implementation in these areas continued, the Commission argued that plans would neither be publicly accountable nor meet plan objectives. Only where competition for water resources was high were any water plans guided in their development by those scientific and socio-economic studies widely held to be central to effective water planning (NWC 2014a).

NWC assessments frequently identified inadequate community consultation and the absence of social data and social assessments in the development of water plans. While some local and catchment committees sought to influence the water discourse and planning outcomes, Alston and Mason (2008: 135) found that the dominant influence was ‘to preserve and protect water as an economic resource’. Even today, NSW Regional Water Strategies focus heavily on the economic needs of consumers, through plans to augment water storages, build pipelines and diversify water sources (NSW Department of Industry [DOI] 2017: 1; Liverpool Plains Shire Council 2018: 1-10).

In 2014 the NWC (2014e: 1-37) issued a report focused on engaging Aboriginal people in formulating water plans and strategies. The Commission instanced some cases where communities had been granted specific water reserves or water allocations for cultural and economic purposes, but found that indigenous rights to water for economic, cultural and spiritual purposes had generally not been adequately considered. Since that time, the APC (2017: 357-364) has pointed to some further modest gains as a result of greater Aboriginal representation in water planning processes and through more explicit recognition of cultural objectives. It commended an Aboriginal Partnership Program in South Australia; licences provided in NSW for Aboriginal cultural and community development; and, the creation of indigenous reserves under some water plans in Queensland (APC 2017: 360,362; Australian, State and Territory Governments [AST] 2017c: 22, 24). In 2017, the governments of the nation sought to provide more effective and consistent treatment of Aboriginal peoples by releasing a report entitled *Engaging Indigenous Peoples in Water Planning and Management* (AST 2017c).

Since 2013, water planning and more comprehensive water resource planning is occurring under the guidance of state authorities, supported by triennial APC reports (APC 2017). That Commission (2017: 72, 350) argued that most jurisdictions had made progress in reviewing earlier water plans and incorporating best available information into a more transparent water planning process. In 2017 all water plans were statutory, except in Western Australia, while the updating of many plans was behind schedule or infrequent. The Commission reiterated the need for government to invest more in monitoring, evaluation and reporting and to foster adaptive management in the effort to secure plan objectives (APC 2017: 75, 166-167). Yet, prevailing national administrative priorities and political positions suggest that the necessary increased resources and skills nation-wide are unlikely to be provided, in most jurisdictions in the near future.

Under the NWI, some form of provision of water for the environment was made in all plans, whether by setting extractive limits, allocating water, protecting minimal flows through dam releases or restricting pumping from unregulated river systems. However, those measures have failed where state commitments were not met to move water to needy sites; water abstractions and trade in environmental water were not regulated; and, water consumption was not monitored (APC 2017: 350-355). There were other situations where systems had been designated as ‘working rivers’ or where priority had been accorded to pre-NWI water entitlement holders leading to reduced water security for the environment. The APC (2017: 149) concluded that the next phase of water reform should deal with maximising environmental outcomes.

Water planning nationally has been informed to varying extents by historical climate variability and hydrological data and modelling. In 2014, only a small number of revised or replacement plans nationally had begun to take account of then current climate change modelling, notably in Tasmania and Western Australia. In the latter case the state was responding to the impacts of extended droughts on aquifer inflows and recharge. The APC (2017: 28, 91-92) held that all water plans should be revised in response to climate change, especially where reduced water availability necessitated the rebalancing of allocations between consumptive use and the environment. The collective jurisdictions held a similar viewpoint – at least in principle - having issued new guidelines showing how to incorporate climate change projections into water planning in ways compatible with NWI policy (AST 2017a: 36-40). Jurisdictions now have improved tools and the incentive to deal with climate change risks in water planning far more effectively.

Experts and commissions have argued for independent assessment of all plans, integrated planning and plan adjustments to deal with climate change. A good example is to be found in the recommendations of the NSW Natural Resources Commission (NRC 2018: 1), which the responsible minister adopted in requiring that a series of plans be replaced, in order to:

- Establish linkages between plan strategies, objectives and performance indicators
- Link monitoring to improvements in plan outcomes, including to environmental flows
- Aid stakeholders and protect Aboriginal cultural values through consistency in plans
- Update calculations and assumptions in plan revisions

The APC (2017: 149-151) has made several major recommendations concerning water planning. It proposed that water planning, as presently practised, should be aligned with water-oriented environmental, natural resource and land use management and planning (APC 2017: 151). The Commission also advocated the establishment of a ‘catchment-based organisation’ to set environmental priorities and objectives, inform operational planning and coordinate water delivery and management (APC 2017: 153, 173). Both recommendations call for major policy and institutional reforms, which appear unlikely to take place in the near future.

The Commission also favoured the ‘optimal’ allocation of available water resources between present and future demands by making ‘trade-offs’ between ‘economic, social and environmental considerations’ (APC 2017: 74; 89). Such wording can also be found in the statutory Murray-Darling Basin Plan which calls on jurisdictions ‘to optimise social, economic and environmental outcomes’ [Australian Government 2012a: para 5.02 (1) (c)]. Yet, water resource health and system resilience must be recognised as necessary preconditions to any allocation or sharing process. Unless such requirements are met, economic development is at risk of becoming unsustainable and water services to be progressively severely compromised if system health deteriorates.

6.2 Major Factors Impacting on Results

There is so much detailed data and assessments concerning water planning in Australia (see also Appendix A) that it has been possible in this particular case to examine the impacts of the four major factors identified in Chapter 1 on Australian water plans and water security. This analysis has also helped in validating these elements of the assessment framework. The ensuing paragraphs examine the impacts of political decisions and influences on water planning; the extent to which good governance enhances water planning; the extent to which integrative system planning is occurring, and, whether climate change is influencing the design of water plans.

The political will to establish a National Water Initiative and its key elements has been instrumental in achieving considerable national convergence and harmonisation in statutory water planning. On the other hand, politics has failed to play a key part in addressing poor water plan outcomes and in making necessary changes to administrative and regulatory arrangements. Table 2.2 reveals the higher political priority accorded to water planning as a tool to advance the water security of consumptive users rather than the security of environmental water.

Water planning has been a key tool in improving water governance and has brought some benefits to national water security. However, good governance has been eroded and confidence in water security in all four domains designated in Chapter 1 has been weakened by shortcomings in the planning process. Nationally, water plans have differed widely, with some covering several catchments or a region, while others have dealt with a single catchment or a single source of surface water or groundwater. This has occurred in part because of the differences in legal and institutional arrangements in the states and territories, as illustrated in Section 3. As well, water plans have frequently failed to demonstrate how significant plan objectives are to be achieved, leading to the very poor result under 'clear and measurable outcomes' in Table 2.2. In many jurisdictions the impact of water interception, overland flows, water overallocation and over use have not been fully evaluated in water planning to date.

Water plans have increasingly focused on conjunctive management of surface and groundwater systems. Despite earlier claims by water planners, few have achieved integrated and assessment and effective management of these two connected systems. Throughout the national water planning reform process there has been little or no focus on catchment or whole system management and planning or on understanding the socio-economic stresses encountered by major hydrological systems. These failures diminish confidence in water allocations and could undermine efforts to achieve wide-ranging water security.

Climate change is slowly being taken into account in new and revised water plans. To date, plans have tended to respond to current and projected climate change where water resources and river systems have been under current significant stress. The absence of a concerted approach to climate change in much national planning, and the failure to update many water plans to take full account of projected climate change have contributed further to water security uncertainty.

6.3 Consequences for Water Security

Many actors, governmental and non-governmental, processes and influences combine to determine water security for the state, human welfare, the environment and consumptive users as identified in Chapter 1. The contribution of water planning to these four nominated water security domains is evaluated below.

The position of the state in relation to national water security has been strengthened in some ways through water planning. Statutory water planning has played a central role in harmonising the management of the nation's water resources. All jurisdictions have committed to the principles and frameworks laid down under the NWI. All areas of intensive water use are now covered by plans. The water security of the state has been somewhat strengthened as a result of use of water plans as the prime vehicle for encouraging the unbundling of land and water rights, as the basis for assignment of water rights and water allocations as well as in establishing water markets and water trading. The state has benefited from independent assessments against agreed criteria and identification of major deficiencies.

Water plans have played a positive part in securing improved water security for human needs. However, this position has been weakened by frequent lack of consultation in plan development and monitoring of outcomes. Plans and associated trading regimes have generally not taken account of the implementation of current policy on riverine communities, small downstream farmers or future generations. In the latest round of water planning involvement by Aboriginal peoples has increased with more explicit recognition of their life-style, cultural and economic needs and interests. However, since many Aboriginal peoples lack formal entitlements, explicit acknowledgement of their rights, or the means for engagement in the planning and other processes, they remain at risk of continuing to experience inadequate water security.

Water security for the environment has improved since the time the NWI was initiated, largely as a result of the statutory basis of water planning and the legal requirement that environmental water be provided in various ways. However, the physical security of significant portions of this water has not been safeguarded, despite water purchases by environmental water holders which exist in most jurisdictions. Contributors to this situation include the failure by empowered agencies to regulate illicit extractions, the political influence of major irrigators leading to decisions to allow trade in environmental water and the setting aside of plan provisions for various reasons. Overall, water security for the environment is more uncertain, less reliable and less favourable than is the case for consumptive users.

Water planning has contributed to improved water security for the majority of consumptive users. They have benefited from the provision of long-term water rights and the fact that water allocations, entitlements and trading in regulated systems are all underpinned by a common approach to water planning. The security of consumers of water from stressed groundwater sources and unregulated river systems is more uncertain. Plans are in place at national and state level for a return to dam and pipeline construction as ‘solutions’ to water scarcity and the ambit of environmental impact assessments has been reduced. Those steps place the water security of many actors, including consumptive users, as well as the environment at considerable risk.

7.0 THE MURRAY DARLING BASIN

The most critical catchment in Australia with the potential to influence national water security is the Murray-Darling Basin. The Basin covers one seventh of Australia’s land mass including 24% of the nation’s agricultural land and supports 41% of the gross value of the nation’s agricultural production, largely comprising a mix of irrigation and dryland farming (ATSE 2012: 33; APC 2018: 4). The water of the basin supports dairy farming, horticulture, livestock and pasture development, as well as 100% of the nation’s cotton production and 94% of the rice production (McCormick 2013a: 1). The Basin supports the livelihoods of 2.1 million people and their settlements and provides a further 1.4 million people with drinking water outside the Basin. The management and planning of the Murray-Darling Basin system, which in all comprises 23 river systems, is a partnership arrangement between NSW, Victoria, South Australia, Queensland, the Australian Capital Territory and the Australian Government, reflected since 2008 in the latest Murray-Darling Basin Agreement (MDBA 2017c: 1). The management of other river catchments is explored briefly in sub-section 7.5 below and Appendix A.

Present and future management of the Murray-Darling Basin involves many areas of contestation. In order to gain a good understanding of the *status quo* and the many present and future challenges, the succeeding paragraphs consider three main areas of contest. The first focuses on the continuing tendency for management and planning decision-making to be opportunistic and to favour short-term consumer and economic interests. Those interests are shown frequently to supplant long-term strategic approaches to whole basin management, sound risk assessment and adaptation in response to monitoring and experience. The second concerns politics versus science. That involves examination of the political interests and actions of those jurisdictions party to the Agreement, when set against science-based advice and efforts to secure sustainable patterns of basin resource use and to maintain system resilience. The third examines conflict between the demands of influential water consumers and those measures needed to secure basin health, critical basin environments and ecosystems. Contemporary results under recent legislation and agreements are explored below in the context of these three major arenas of national contestation.

7.1 Opportunistic versus Strategic Management

Joint management has represented a longstanding challenge for all jurisdictions involved in the Murray-Darling Basin. In the 1990s, the previous Murray-Darling Commission developed a Natural Resources Management Strategy, a Basin Sustainability Plan and established a Community Advisory Committee. If given the opportunity to operationalise these were seen by the Global Water Partnership as elements of an integrated water resources management (GWP 2013: 1-2). However, that Commission could not achieve whole system management, because like all preceding intergovernmental arrangements for the Murray-Darling system, it did not have the power to allocate water, limit water access and hold states accountable for the way water was being used.

In 2007 that Commission was replaced by the MDBA which operates according to the provisions of the 2007 Act and the 2012 Plan. The Act and the Plan represent responses by the then Australian Government to severe problems associated with water allocations in the Murray-Darling system in the 2000s. Water had been widely over-allocated, drought had impacted severely on water availability for many commercial operations, and climate change was projected to reduce annual flows further in much of the Basin. As a consequence of these pressures on water availability there were widespread private sector and farming community protests at lack of accessible water.

Today, as previously, the basin is not managed and regulated as one entity, primarily because the states have retained their constitutional power to manage, regulate and distribute water resources in their own jurisdictions. The water is shared between the states in accordance with a 2008 agreement, the latest in a series of intra-state arrangements, none of which have been based on independently assessed limits aimed at maintaining system sustainability (MDBA 2017c: 4; MDBA 2018f: 2). So, neither the Australian Government nor the MDBA owns the basin waters and neither can over-rule the states (MDBA 2017c: 1-4). The MDBA manages much of the public water infrastructure in the basin, tracks flows and volumes system-wide, moves water to meet human and environmental needs with state assent and consults stakeholders. It has the technological skills to research hydrological, climate and environmental change (AWP 2019a: 1-7) However, as the APC (2018: 2) observed, the role of the MDBA is deeply conflicted, because it must act as the agent of the Basin governments in Plan implementation while also being required to ensure that those same governments comply with the Plan.

The next generation of water resource plans for each of the rivers in the basin can take account of existing state policies and institutional arrangements. However, these plans are also supposed to be subject to MDBA scrutiny, take a risk-based approach to water resources planning and management, recognise hydrological connectivity, require monitoring of plan implementation and provide for plan review (MDBA 2013; 2017e). Such an approach would offer considerable promise if implemented by the states. However, the process would also have to deal with current inadequate enforcement of state regulatory requirements, continuing unsustainable patterns of water extraction, unacceptable environmental impacts and inequities in the sharing of available water. In practice, to date, some states have failed to prepare new water resource plans, or to meet the revised plan criteria or have simply extended the review dates for existing plans without amendment or the benefit of independent scrutiny (Alexander 2020: 12). That suggests that the contribution of new water resources plans to strategic and sustainable management of the basin and to improved water security is likely to be modest (APC 2018: 2,12). Similarly, while an Independent Assurance Committee was formed by the MDBA (2018b: 1-4; 2018f: iv, 2) to consider questions of compliance and enforcement, the committee could not report on time because of failure by the states to provide the necessary information.

To support the Basin Plan, the Australian Government provided some $10 billion to be spent over 10 years (Maywald 2015: 5). Modernisation of irrigation infrastructure, estimated to cost some $6 billion, was one major arena for expenditure. It was claimed that this modernisation process would improve efficiency of water use in irrigation. The water recovered through these efficiencies was to be returned to support the environment and improve stream and river flows. About $4 billion was also allocated for water entitlement buy-backs in the Murray-Darling system. $3billion further funds were provided to support a number of national water management and water savings projects (Australian Government 2007: 3-11; Department of Agriculture and Water Resources [DAWR] 2017: 1).

Even at the outset it seemed that the process of water buy-backs was essentially opportunistic not strategically designed or targeted to system pressure points. Crase (2010: 2-3) predicted that the whole approach would not generate much water for the environment, and that the price of water purchased would be too high. At that time, other experts argued that the funds should have been used to pay property owners to stay on their land as environmental custodians or as agents of environmental restoration (Quiggin 2008:1; Walker *et* al 2009: 19). As the process matured, it became clear that some purchases had occurred at inflated prices, others were ephemeral in the sense that water only existed on properties during floods, and, in still other cases, water recovered was used illicitly or redirected to irrigators (Thompson 2017: 2; Besser *et al* 2017: 1-2; Slattery 2019: 1; Davies 2017: 1-6). Recently, Grafton and Williams (2019: 'Water Entitlement Purchases') scrutinised the scheme and questioned why purchases should be covered by commercial-in-confidence arrangements.

In 2019, several investigations showed that there was essentially no accounting for how funds had been expended nor for the net quantities of water saved (Rubensztein *et al* 2019: 3; The Australia Institute 2019: 1; Williams and Grafton 2019: 'Conclusions'). By the conclusion of the buy-back process it became clear that the scheme was beneficial to some water consumers and property owners, who were often well-resourced and well politically connected, while it disadvantaged other businesses and riverine communities. Even more importantly, the quantum of water recovered was far smaller than that promised and less than that necessary to restore stream flows and the riverine environment.

Public funds spent on existing water infrastructure were supposed not only to generate efficiency in use, but to improve recycling of irrigation tail-waters and encourage existing irrigators to stay on the land. Leading economists argued that the proposed $6 billion public funding for augmentation and restoration of irrigation infrastructure largely represented a transfer of public wealth to some private sector interests (Young 2011: 61; Quiggin 2008:1). By 2019, $4 billion had been provided to irrigators with the claim that this would increase efficiency in water use and improve water flows. The Australian Government justified this commitment on the basis of an efficiency dividend involving the return of water for the environment. Detailed analysis by Williams and Grafton (2019: 'Conclusions') revealed that increases in river flows were far less than the government had argued would eventuate. They estimated that the cost of generating increased river flows by funding irrigation efficiencies could be far higher than claimed by government. In the same period, research in 2019 revealed that up to 30 large dams had been constructed on private land at taxpayer expense, in a little publicised program and with virtually no public or environmental review (Grattan 2019: 1-2). Some dams were of sufficient capacity in new locations to foster greater irrigation, while actually increasing water evaporation and reducing natural flows to wetlands (Slattery 2019: 1-2; Rubensztein *et al* 2019: 1-3).

It is unclear whether other options than upgrading water infrastructure, subsidising irrigation efficiencies and buying-back water entitlements were explored in establishing these programs. None of these approaches could be construed as playing a significant part in a coherent structural adjustment process aimed at managing water access and use and improving basin health. Given the identified need for systemic change the funds might far more effectively have been used to provide strategically-based structural adjustment in the effort to render long-term water use and development sustainable. That would have required a re-assessment of what constitute sustainable patterns of use of water in key river reaches, including as climate change progresses. Then funds could have been provided to support water-efficient crops and technologies, land regeneration and ecosystem services, adjustment to patterns of water and land use as well as providing financial assistance to industries and communities to adjust to extensive change.

7.2 Politics versus Science

Politics and science continue to struggle for supremacy in the management of this critically important basin. Over a century of differing intergovernmental arrangements, political decisions and compromises have failed to resolve conflicts between the needs of the basin system and states' water interests and those of consumptive users. Equally they have not delivered certainty for users, water security for the environment or basin sustainability. The Australian Government played the lead role in determining a new national approach to overcoming the systemic failures evident in 2007. However, its deeper political interests were revealed in the new authority structure adopted for basin management, in changes in the authority's reporting lines, which removed national oversight, and in the framing of the 2012 Basin Plan. In recent years, the Australian Government has accentuated its advocacy for the rights and interests of primary industry over measures designed to secure basin system health based on scientific assessments.

Under the 2012 Plan a long term, basin-wide average 'sustainable diversion limit' (SDL) was to be set for the quantities of surface and groundwater that could be extracted. After much contestation involving the states, irrigators and riverine communities, an early scientifically-based average figure was progressively reduced to an average of 2075 gigalitres across the whole basin (APC 2018: 5-9). Evidence adduced by many experts, deriving from environmental studies and scientific modelling, revealed that this quantum was grossly inadequate to sustain basin health (See, for example, Wentworth Group 2012: 2-3; Environmental Defenders Office [EDO] 2012: 3). Others argued that at least the proposed limit should have been tested in experimental trials *before implementation* (Crase 2012: 2; ATSE 2012: 37).

Over-allocation of water by several states to meet economic and political goals has continued, despite the provisions of the Plan. That is responsible for non-sustainable patterns of water extractions and systemic risks (ATSE 2012: 33). In recent years, NSW officials have acknowledged that the regional economic benefits of cotton production have trumped the enforcement of water regulations; others have shown that publicly acquired water for the environment has been illegally pumped out of at least one sub-basin by NSW cotton growers (Davies 2018: 1-3; Besser *et al* 2017a: 1-6). In 2019, the NSW Water Minister derided the validity of modelling by the state's own independent NRC. The NRC report had shown that the generous water licences issued in 2012 in the Barwon-Darling had exacerbated the three to five year drought and contributed to its much earlier onset (Loussikian 2019: 26 August).

Notwithstanding the increasing publicly accessible evidence, NSW continues today to contest the need for further limits on water extractions in its portion of the Murray-Darling and for significant changes to be made in the next generation water resource plans (NSWG 2017a:1; Department of Primary Industries [DPI] 2016: 1-2). Having finally submitted these plans in 2020 it seems that the state is engaging in brinkmanship in an effort to reduce agreed water flow and other requirements (Hannam 2020b: 1) The NSW government and its agencies have gone far as to suggest publicly that the state may abandon the Basin Plan altogether (Besser *et al* 2017b: 1). Marshall and Alexandra (2016: 693) view the alignment of political, bureaucratic and irrigation interests in NSW as so serious as to constitute a high level of state capture.

This whole pattern of behaviour is not compatible with the 2008 national agreement to manage basin water as a common resource or to focus on basin-wide sustainability. Nor does it draw on accessible and validated science and advice. In 2018, the State of South Australia demonstrated its unwillingness to suffer continuing disadvantage through the failure of other parties to honour legislative and plan commitments. The state had suffered extensive and frequent water scarcity and heavy economic and environmental damage and loss. A Royal Commission (SARC) was established by that state into the operations and effectiveness of the Murray-Darling Basin system, its management, planning, regulation and water sharing (South Australian Government [SAG] 2018: 1). The Commission had extraterritorial powers to compel witnesses from the rest of Australia to give evidence, but found little cooperation from partner states or the Australian Government.

During Commission proceedings the SARC focused on the contest between politics and science in the Murray-Darling Basin. The Commission criticised the current SDL as simply a ‘political fix’ because the requirement under the Water Act that the SDL be based on ‘best available scientific knowledge’ had been ignored (Beasley 2018: 3492-3493; SAG 2019: 53). It regarded the requirement in the Basin Plan that environmental, social and economic outcomes be ‘optimised’ as little more than a political device (see Section 6). The Commission also found the MDBA to have failed to meet its responsibilities under the Act and the Plan, resulting in mismanagement of public funding, ‘unlawful plan implementation’ and maladministration (Beasley 2018: 3492-3493). Other charges included failures to ensure that contemporary climate change modelling was incorporated into the Basin Plan and a revised SDL; to make scientific assessments of risks to key river reaches and lakes; and, to be ready to assess SDL compliance by the states (SAG 2019: 56, 58, 67-68).

Nation-wide, the Commission elicited muted responses and outright rejection of its findings by the Australian Government. But, one previous senior Australian Government official argued that the Commission had revealed many failures of some parties to meet the provisions of the Act and the Plan. He pointed to the ‘persistent lack of political commitment’ to plan compliance and enforcement, leading to ‘a culture where water theft and compliance with licence conditions have been optional’ (Horne 2018: 2).

In 2019 as drought gripped more and more of the Murray-Darling Basin and seasonal rainfall diminished, the efficacy of water buy-backs and water infrastructure expenditure, water sharing arrangements and recent large farm dam building were all contested by a wide variety of experts. Many criticised the past and present actions of the NSW and Australian governments and the MDBA as well as questioning the structure and operations of the Plan. Some called for independent auditing of water use and return, levels of transparency in data holdings and the quality of records of industrial monitoring (Grafton and Williams 2019:

‘Conclusions’; Grafton *et al* 2020: 19). Various influential national and state politicians and senior public officials, including those with water resources responsibilities, aligned themselves with business interests in dismissing all these expert views (Slattery 2019: 1). They rejected the need for a review of the Plan, prior to 2026, despite its obvious shortcomings, and the call for a detailed examination of how to achieve basin sustainability. Instead they opted for traditional measures such as financial support for drought affected farmers and communities, while arguing for urgent action to build more dams. This reinforced the continuing dominance of politics over science.

7.3 Consumer versus Environmental Welfare

This section shows how political and consumer interests have often overridden the needs of the environment. In so doing, it builds on the less detailed commentary on this subject in the previous two sections. It is clear that the present environmental state of the Murray-Darling Basin results from past practices, which collectively have led to land, forest and wetland alienation, significant threats to native species and ecosystems, increases in invasive species, soil erosion and turbidity. The prevailing patterns of water extraction and land clearing continue to be significant contributors. Heavily used groundwater sites and river reaches remain under considerable stress. Salinity, much of which is associated with past irrigation and farming practices, has also had serious impacts (Bartel *et al* 2018: 213). Extensive modelling has shown that the water requirements of all the natural systems and the environment are much greater than those proposed in the Basin Plan (Carmody 2015:3). Many of these serious environmental problems are being exacerbated by climate change. As early as 2008, CSIRO (2008: 5) found that climate change could lead by 2030 to a decline in surface water availability across the entire basin by a median figure of 11%. That would reduce water availability by a median 4%, under current water sharing arrangements.

In the ensuing paragraphs, attention has firstly been directed to positive achievements. A key purpose of the Australian *Water Act 2007* was ‘to return extraction in the Basin to long-term sustainable levels’ (EDO 2012: 3). The Water Plan requires the determining of a long term average SDL, preparation of environmental water, water quality and salinity plans, rules for water trading, targeted local reductions in water extractions and for an ecological buffer to be created (McCormick 2013a: 2-3; MDBA 2017b: 1-2). Some of these plans are now in place. Independent statutory environmental water holders have been created which can hold water, purchase water, move water to meet environmental and ecological needs and assess whether proposals are environmentally worthy of support (Besser *et al* 2017a: 1-6). Targeted programs have produced improvements in water quality and flows in some river reaches and some progress has been made in restoring wetland, riparian and floodplain environs. Salt interception schemes are combining with improved farming and irrigation practices to divert salt from key river environs (MDBA 2018a: 25). Research is underway into how to protect and preserve key native fish and bird species. The MDBA has been working with the Bureau of Meteorology, CSIRO and the Basin states to better respond to the recent results of climate change modelling across the entire system (MDBA 2017b: 1-2; 2017c: 5-6).

The Basin Plan accords top priority to 'critical human water needs' leading to a staged approach to water movement throughout the system. When needed, sufficient water must be conveyed through the entire system to ensure that the needs of people in NSW, Victoria and South Australia are met. While the water, cultural and spiritual rights of Aboriginal peoples continue to receive variable state attention, the Basin Plan does now recognise 'cultural flows', as representing water entitlements, of indigenous peoples (NWC 2014e: 8). While the arrangements made by the MDBA fall short of full empowerment and recognition, the authority has recognised the interests of 46 Aboriginal Nations and established an 'Aboriginal Partnerships Action Plan' (MDBA 2018a: 34; Grafton *et al* 2020: 19).

These represent useful responses to specific problems, many of which are legacies of the past, but they are dwarfed by the continuing problems. There remain wetland, forest and lake ecosystems that have been accorded a national and international priority for conservation and restoration which require a high priority in water allocation. As identified above, political obstacles have prevented necessary changes being made in the Basin Plan or to science-based revisions of the SDL. Nor has the position of existing entitlement holders been reviewed, particularly those that are protected under state water plans (Neave *et al* 2015: 107; ATSE 2012: 37). Given the focus in this sub-section on consumer versus environmental welfare, the need to rebalance water use between the two remains a critical problem. The dimensions of this challenge were made very evident a decade ago in the detailed research of Walker *et al* (2009: 20) on the Goulburn-Broken catchment, a major sub-basin in the Murray-Darling system. They found that catchment to be approaching a tipping point, where whole-of-system resilience was at risk and patterns of development and water use of the time were unsustainable - the system could no longer meet water demands. They observed that other catchments in the Murray-Darling Basin, which were under significant pressure, could face similar risks.

Even though water security for consumptive users continues to be a primary goal of basin governments and the Authority, the results of their combined efforts have been quite mixed for water consumers. For example, water markets have been promoted as creating greater water security for consumers, more efficient irrigation and agricultural practices and at having the potential to release some water for the environment. However, those with greater access to funds, organisational capacities and education have benefitted from these water markets, while others have seen the viability of their communities and businesses reduced (Hasselman and Stoker 2017: 514). There are a number of reports which suggest that there are deep-seated problems associated with the operations of the market and the recording of transactions. These shortcomings have serious implications for many consumers. For example, it is reported that four licence holders now control 75% of the water extracted from the Barwon-Darling section of the Basin (Pannett 2019: 22). Recent submissions to an Australian Government inquiry have revealed that the values of transactions have often been recorded as zero or as other non-commercial values (Simons 2020: 7). This is contrary to the principles underpinning market formation and has become so commonplace as to undermine the integrity of the market and the rights of market participants.

Early in 2019, the Australian Academy of Science (AAS 2019) was asked to report on fish kills in the Menindee Lakes in the west of NSW which are directly linked to the Darling River system. The Academy found that upstream extractions and rapid drawdowns from the lakes had depleted inflows to the point where there was insufficient water to support ecosystems and critical human needs (AAS 2019: 2, 49). Later in 2019, the NSW NRC (2019: 1) in its extensive review of the Barwon-Darling sub-basin found:

> ‘The *Water Management Act* 2000 clearly prioritises protection of the water source and dependent ecosystems, followed by basic landholder rights including native title, and then other extractive users. The current Plan has not effectively achieved this prioritization…The (current) provisions benefit economic interests of a few upstream users over the ecological and social needs of the many’.

This example demonstrates with some clarity that the requirements of the Act and the Plan in respect of water for the environment, protection of ecosystems and their services have not been met. At the same time, it reveals the bias inherent in the whole current strategy of managing much of the Murray-Darling system in favour of major consumptive users. The gains made in the past decade are modest when considered against the extent and scale of the problems in the whole system and the failures of present approaches to meet tests of both sustainability and equity.

7.4 Consequences for Water Security

In the Murray-Darling Basin, water security for the state has been strengthened by some measures and eroded by others as a result of the way the *Water Act*, the Basin Agreement, the Basin Plan and the funding program have severally and collectively been implemented. The many current influences on system sustainability, including state support for the inadequate diversion limit and opposition to systemic governance and management change, have compromised the water security not only of the state, but many users and the environment.

Basin management and planning has accorded the highest priority to water security in order to maintain human welfare, notably in urban surrounds. Under the Basin Agreement water can be moved throughout the system by the MDBA to support human welfare. The water rights of *some* Aboriginal peoples have improved as a result of consultative arrangements, agreements, partnerships and recognition of cultural flows as perpetual water entitlements.

Water security for the environment and the sustainability of some systems has been eroded by decades of water over-allocation, water overuse and inadequate management, monitoring and regulation. Today, the health of major river reaches, wetlands, lakes, forests and ecosystems is continuing to deteriorate. That situation has been exacerbated by recent droughts, advancing climate change and political actions leading to an unsustainable diversion limit and failure to safeguard environmental water. The future water security for the environment cannot improve unless governance and management provisions are changed. That would require basin governments to commit to meeting revised arrangements and to the drafting of new water resource plans to be implemented in accordance with changing system needs.

The water security of consumers is inextricably linked to that of the environment. Basin governments and the NWI have accorded, explicitly or implicitly, the needs of irrigators and other major users a very high priority. Many consumers have benefited from water planning, assignment of water rights, water markets and heavy public sector expenditure on water infrastructure. Water sharing and water diversion limits have also kept their interests at the forefront. However, the failure of national and state authorities to plan for long term drought, in the knowledge that it will be exacerbated by climate change, has damaged the commercial security of some farmers and communities. More generally, if levels of water extraction continue to be unsustainable the capacity of the basin to meet consumer needs will be compromised. Even those who have benefitted from current priorities and governmental actions cannot confidently expect their existing advantageous water security position to be maintained.

7.5 Other Catchments

Appendix A contains a summary of recent approaches to catchment management in NSW, Victoria and Queensland. Across the nation, past and present catchment management authorities (CMAs) have been heavily engaged it trying to balance catchment productivity and water demand against the need to protect and restore critical catchment areas and water systems. This has left little room for systemic and integrated catchment management, so central to both water security for all users and the health of the aquatic systems (see Chapter 1). At the level of individual states and territories, the most effective approaches to catchment management have arguably been mounted by city-based water authorities. Nonetheless, as shown in Section 8 below, no city authority has sufficient powers to integrate the management of water in the catchments from which it draws water.

8.0 URBAN WATER SECURITY

Urban water services in Australia's capital cities are largely provided by governmental water utilities and corporations. This section deals with some of the approaches adopted and challenges being faced in water supply and treatment, as well as ownership and governance, health and environmental compliance, pricing and efficiencies, wastewater reuse, reductions in power use and whole system management. Many of these issues have direct implications for city water security. Because it is imperative that the major cities deal effectively with climate change, present and predicted, that has been considered in a separate section.

As the driest inhabited continent, Australia has developed 'the highest per capita surface water storage capacity of any country in the world' (Australian Water Association [AWA] 2017: 2). For example, the city of Sydney harnesses the capacities of 20 supply dams and weirs to hold more water per head of population than any other city (Utility 2014: 1). Nationwide the capital cities operate more than 60 storages of assorted scales as well as canals and pipelines which collectively provide part or all of the water supplies to all urban domestic and industrial consumers and to some agricultural users (AWA 2017: 3-4). The urban water sector generates $16 billion annually, in 2017 dollars. On the other hand, about half the costs incurred by these utilities involve transportation of water and wastewater, while water and wastewater treatment and bulk water supply represent the other major cost contributors (APC 2017: 176).

8.1 Results and Challenges

COAG initially called for greater cost effectiveness in urban water management, through increased competition, realistic pricing, introduction of markets, and improved management of demand and supply at all stages of the water cycle (DAWR 2016: 3). Many of these targets were achieved in subsequent years. The NWC (2011: 13; 2014c) found that cross-subsidies in city supply had been largely removed and that capital investment in water supplies for major cities had improved water security between 2004 and 2013. The APC (2017: 219-221) indicated that large metropolitan utilities and jurisdiction-wide suppliers were generally pricing in ways that reflected 'the full cost of service delivery'. By 2017, virtually all jurisdictions had established independent bodies to set or review water service prices (APC 2017: 181). Yet, both the NWC and the APC held that political, institutional, trade and regulatory impediments had interfered with the ability of urban supply authorities to provide affordable, high quality supplies and deliver future water security, especially through the better access to the beneficial use of wastewater (NWC/PwC 2011: viii, ix, 1, 9; NWC 2014c: 3, 10; APC 2017: 188-190; 200-202).

Today, the major government-owned water utilities have often been corporatised with significant emphasis on commercial performance, competitive positioning, demand management and efficient pricing. As a result, most are now able to pay significant dividends to government. Many of these authorities are sufficiently powerful bureaucratically and financially to solve water supply and sanitation demands from rates revenue without recourse to external entities and funding. By and large, the utilities manage water supply and treatment in ways that deliver good water security for urban citizens and businesses. Their performance is reported in most states through regular benchmarking and regulatory performance reports, which collectively span myriad indicators and metrics (Akimov and Simshauser 2018: 13-16)

Even though these utilities are powerful they are not fully positioned to achieve management of whole water catchments either separately or in collaboration with other instrumentalities. Serrao-Neumann *et al* (2014: 7) examined 96 documents dealing with urban water management, water resource planning and climate change in Brisbane, Perth and Melbourne. They found that to achieve improved urban water security would require greater efforts to integrate policy and action across agencies and levels of government, as well as dedicated efforts to remove institutional impediments (Serrao-Neumann 2014: 12). These institutional blockages have also precluded greater integration between water planning and management and city and energy planning, waste and land management and food production (NWC 2014c: 3, 10). In similar vein, the APC (2017: 183-200) argued for more integrated water management, land use planning, industrial development and local government planning.

National reports developed by COAG, NWC and the Department of Environment have continued, over decades, to call on regulators to maintain their efforts to secure healthy, safe and reliable water supplies, to work to protect the environment and its critical ecosystems, and to improve waterway and aquifer health. Nation-wide, health authorities have imposed regulations leading to the effective management and monitoring of virtually all urban water quality in ways consistent with the Australian Drinking Water Guidelines (APC 2017: 461-463; NWQMS 2011). The APC (2017: 181) indicated that healthy and safe water supplies have been 'largely achieved' nationally in urban situations. For example, the Sydney Water Corporation (SWC 2016: 32-33, 56) demonstrated almost total compliance with health, drinking water and environmental standards set by external, independent authorities in 2015/16.

The NWI established goals for water reuse and water use efficiency and promoted water sensitive urban design. The APC (2017: 464) found that jurisdictions had developed water efficiency and reuse policies that are improving water conservation, wastewater and stormwater reuse and recycling - by cost-effective means. There is still however a long way to go. In the case of SWC, less than 10% of wastewater collected by the corporation was treated and recycled in 2016, leaving significant gains to be achieved through greater potable and non-potable reuse (SWC 2016: 71). On the other hand, NSW developed guidelines for better management of water recycling, a Water-Smart Cities Program and a Metropolitan Water Plan (DPI 2015; NSWG 2017c). It is too early to report on the contribution of utility actions directed at implementing these guidelines, plans and reuse strategies.

Kenway (2015: 141-142) showed that urban water utilities used 13% of available national electricity in delivering water and wastewater services in 2006/7. The energy demands generated by these water services were slated to more than double by 2030, one of the target dates for the nation to meet its international energy abatement commitments. Kenway (2015: 145) argued that if the urban water sector were to meet its contribution to the national goal, it would need to make substantial reductions in its energy use. That challenge is already being recognised by some of the nation's water utilities. In the case of SWC, the corporation has increased its 'self-generation' of energy from 16.6% in 2011/12 to 21% in 2015/16 (SWC 2018). The energy so-saved relates to the electricity the corporation uses in water treatment, water distribution and wastewater removal and treatment.

In its survey of the quality of urban drinking water in 2016, AWA found that 98% of respondents were confident in the continuing supply of 'high' or 'acceptable' quality urban drinking water (AWA/ARUP 2016a: 50). However, both urban industry and community groups were so concerned by short-term political thinking, inadequate strategic planning and under investment that they believed that water shortages would recur in the cities (AWA/ARUP 2016a: 29, 37). Only 6% of industry respondents felt that Australian governments were actually focused on urban water security as a high national priority (AWA/ARUP 2016a: 31-32). Infrastructure Australia (2019) expressed similar concerns as the nation continued to be gripped by drought and urban authorities faced the joint challenges of climate change, population growth, seriously ageing assets and rising community expectations.

Chapter 1 points to a less developed area of water infrastructure and systems, namely security against physical and cyberattack. Australia has an act which establishes a framework for identifying and managing the vulnerability to cyberattack of critical infrastructure and facilities, including urban water and sewerage systems (AG 2018). That complements earlier efforts to identify categories of critical infrastructure and to place the burden of tailoring individual risk management approaches on state and private providers (Australia-New Zealand Counter-Terrorism Committee 2015). The situation has evolved since then and continues to improve annually. However, Infrastructure Australia (2018: 245), in reviewing the national approach to infrastructure resilience, argued that 'evidence about the scale of risks, their impacts and the costs of addressing them is often weak or not accessible'. That was corroborated by the Victorian Auditor-General (2019: 7-9) who observed that providers of water services often lacked a comprehensive view of these risks and system vulnerabilities.

8.2 Coping with Urban Climate Change

In planning for climate change the major water utilities in the nation's capitals are often better positioned than other planners and managers because they have a broader range of the skills, research capabilities and resources to draw on. This is well illustrated in the cases of

Perth and Sydney where the cities face different climate change challenges. Perth, as the capital of Western Australia, faced crippling supply problems during the prolonged drought of the early 2000s. Climate modelling indicated that the Water Corporation of Western Australia (WCWA 2009: 6) would need to cope with a much drier climate by 2060. In that time frame it might well need to supply twice as many people, while providing continuous water security with minimal environmental dislocation. To meet such tests, a plan was developed which aimed, by 2060, to reduce average customer water use by 25%, to increase wastewater recycling by 60%, and increase the volume of treated water from new sources by 40% (WCWA 2009: 2; 2016: 20). The WCWA now has two desalination plants which together provide about half Perth's water needs and on which the corporation can draw in serving the future population and dealing with climatic change. In 2017, wastewater was being highly treated to replenish groundwater stocks, that could be tapped later to augment water supplies (APC 2017: 94).

The responses in Sydney have involved two different approaches, the first by the Sydney Water Corporation (SWC) and the second by state politicians. The SWC recognised that in facing climate change it would need to deal with more hot spells in the city of Sydney as well as reduced rainfall and run-off, particularly in its drier western sector (NSW Office of Water [NSWOW] 2009). Taking account of climate change projections, SWC built a suite of programs to deal with climate uncertainties which today inform its entire operations, including the protection of water supply and treatment processes (SWC 2014: 6-7). SWC (2012) also created a software product known as 'AdaptWater' which is now used by other metropolitan utilities to identify the impacts of climate change, including hazard mapping, asset planning and the quantifying of likely costs. As a result, the Water Services Association of Australia (WSAA 2016: 17) argues that SWC is well positioned to predict the way interdependent bulk water, energy and telecommunications systems will respond during projected climatic events, while also protecting the integrity of its assets and operational systems.

The political decision in 2007 to construct one of the largest desalination plants in the world in Sydney was controversial at the time. The project was opposed by highly informed experts, agencies of the state and residents. Formal submissions to an inquiry variously argued that the plant was not needed, that its operations would have negative impacts on the environment, and that wastewater recycling and stormwater harvesting were preferred options. Successive NSW governments were unpersuaded by the extent and substance of this opposition, and decided on a political solution to the media claimed ‘urban water crisis’. The plant was completed in 2010 and mothballed in 2012, leaving Sydney citizens to contribute to its maintenance in case of its later need. The plant was restarted to meet some demands during 2019 and ceased those operations in 2020.

Sydney and Perth were not alone. The prolonged drought of 2000 to 2010, led to substantial water restrictions in many cities and to massive national expenditure in excess of $20 billion, largely on desalination plants (Kenway 2015: 144-145). The problems of the time were exacerbated, depending on the city, by the rising costs of providing city water and sanitation under pressures of population growth, urban sprawl and advancing climate change. Since that time, the NWC, APC and many experts have called for much improved water, financial and political planning in order to avoid such future nationwide dislocation and enormous unplanned expenditure (NWC 2011: vi-ix; Kenway 2015: 144-145). They favour direct and indirect potable reuse, recycling, demand management and increased water trade between urban utilities and irrigators (APC 2017: 182-187). *Inter alia*, that requires clear definition of water security objectives for cities and far better alignment of the roles, function and resourcing of government, service providers and regulators as well as transparency in decision making (NWC 2011: vii-x).

8.3 Consequences for Water Security

The guiding influence of COAG, NWC, APC and National Competition Policy collectively has considerably strengthened the position of the state in achieving urban water security. As financial standards have risen, urban water security for the state has been further enhanced through the actions of independent bodies, established by governments to ensure fair and efficient utility pricing for water, its distribution and treatment. State oversight of new and refurbished infrastructure has contributed to progress towards both economic and environmental sustainability.

Community health and environmental standards and expectations have largely been met as a result of regulatory action, the introduction of national and jurisdictional water quality and pollution control guidelines and the efforts of urban water utilities. In most cities safe, healthy and reliable water supplies exist today, which meet both Australian and international standards. Traditional supplies have been supplemented in major coastal cities by desalination, to deal with drought and the increasing drying effects of climate change.

However further water security for urban residents would result if water conservation, recycling and re-use of treated wastewater were more widely practised.

Past decisions to channel and dam major water sources around Australian cities have frequently had deleterious effects on aquatic systems and the environment. Modest increases in water reuse, water efficiency, water conservation and water sensitive urban design are leading to some reductions in environmental impacts on the rivers, water storages and city environs. Changed industrial and domestic patterns of water use are also contributing to reduced city water consumption. Some urban water utilities, as major consumers of electric power, have moved to self-generate power for use in water treatment and water distribution.

Consumptive users in and around the nation’s major cities have benefited from the long term focus on their interests under the NWI. They have also benefitted from improved management of urban supply and demand by utilities. However, water security would be further assured if, as observed above, greater recycling, potable reuse and water conservation by water managers and utilities were to take place. The urban water managers are arguably the best equipped and resourced in Australia to deal with the impacts of climate variability and climate change.

Urban water industry experts and informed citizenry hold that Australian governments do not attach the necessary high priority to water security and that short-term thinking, planning and underinvestment will lead to recurrences of urban water scarcity. The failure of governments to foster more whole system, integrated governance arrangements in managing the nation’s water resources has acted as a further brake on efforts to overcome future water scarcity and improve the water security of cities.

9.0 RURAL WATER SECURITY

This section explores briefly the provision of water services to townships, communities and farms in rural Australia where remoteness and costs continue to lead to problems with supply and drinking water quality. A second major theme involves the way dams, weirs and storages for agriculture, farming and irrigation, including cotton and rice farming, impact on rural water security. A third strand focuses on potential problems associated with construction of a proposed new generation of dams and storages in rural Australia.

9.1 Rural Water Storage

Given the variable rainfall, the dry continent and particularly the dry summers, Australia has built many large dams, 820 of which exceed 91,000 gigalitres in capacity and 90% of which are sited in the nation's south (AWA 2017: 5). Away from the major urban conurbations, locks, weirs and dams have been constructed and bores drilled to better provide drinking and irrigation water (Infrastructure Australia 2019: 596) In the early days of settlement water infrastructure was designed to improve navigation on the Murray River, where today this water infrastructure in the whole Murray-Darling Basin has collectively been responsible for a 75% reduction in river flows (Andrew 2015: 11). It has also contributed to major downstream environmental problems including algal blooms, loss of wetlands and native species, salinity build-up and extensive deposits of sediment as well as seawater intrusion. The cumulative impact of farm dams on the environment is also significant. However, given the variability in upstream situations, climate, numbers and variations in dam configuration little research has been carried out to model the impacts of farm dams on stream flows, sub-surface flows and rates of groundwater replenishment (Makarewicz 2017: 5-7).

Many of the nation's most significant highly engineered dams, including dams in rural situations, were built in the period 1960 to 1990. After that, dam building fell away dramatically, largely because the critical preconditions for future construction and operation were not met in most Australian environs (Larsen *et al* 2014: 2). This included the need for reliable inflows, especially during rainy periods; suitable geography, geology and landscape to minimise water loss through seepage and evaporation; the difficulty in finding the right location and conditions for the construction of major dam walls; and the need to manage social and environmental impacts at acceptable cost. This downturn in dam construction coincided with the rise of community concern about both the environment and the significant impacts of major water projects and infrastructure.

The Australian Government set up a ministerial working group to identify 'how investment in water infrastructure, such as dams and storages, could be accelerated and to identify priorities for investment…' (Australian Government 2014a: 74-75). The group concluded that the government should support construction and upgrading of dam, weir, pipeline, groundwater recharge and water reuse and treatment projects. It recommended that each project should be in the national interest, 'promote economic growth and productivity', meet future supply needs and 'deliver net economic and social benefits'. The group designated 6 irrigation projects that warranted immediate support and a further 21 projects, largely involving significant dam construction, requiring further study (Australian Government 2014a: 76). As a result, the government set aside funds for feasibility studies.

There is no indication that the ministerial group considered the impacts of its proposals on water sources, geomorphology, hydrology, the environment, projected water and land demand or communities (ANAO 2018: 14; Department of Infrastructure, Regional Development and Cities [DIRDC] 2018b: 1-2). Risk and cost-benefit assessments were not mentioned, nor were the challenges acknowledged that are inherent in managing greatly modified aquatic systems to deliver equitable water sharing, wide-ranging water security and system resilience. This failure to focus early in such deliberations on such critical assessments reflected the deleterious implications of the changed political outlook explored in Section 5.

The group's recommendations provided the impetus for the creation of a National Water Infrastructure Development Fund, valued at $1.3 billion. In 2018 expressions of interest were sought to provide support for projects, that could draw on those funds and a newly established $2 billion National Water Infrastructure Loan Facility, which was designed to provide concessional loans to states and territories (DIRDC 2018a: 1-6; 2018c: 1-6; Australian National Audit Office [ANAO] 2018: 14). In 2019 the government announced the creation of a National Water Grid Authority to give further impetus to these proposals (McCormack 2019: 1-2).

Major dams have often been modified in Australia to deal with flood stress or to improve flood mitigation. This process is even more critical as climate change will have an increasingly significant impact on rainfall patterns, river flows and the incidence of extreme events. As part of the assessment of any new major dam, it is therefore important for proponents to assess the effects of evaporation from each dam on the local climate and environment, as well as the impact of major droughts and floods on dam storage, dam safety and water security (Larsen *et al* 2014: 4).

Water for irrigated agriculture is usually delivered either by bulk services from dams via watercourses or by transporting water through pipes or canals. There are more than 2 million farm dams with capacities varying from several kilolitres to several hundred megalitres, with a cumulative capacity of some 8,000,000 megalitres (Land and Water Australia [AWA] 2010: 1; Makarewicz 2017: 1). While farm dams are often relatively small in size, their cumulative impact on individual river systems can be very significant particularly in downstream areas during prolonged dry or drought periods (Makarewicz 2017: 2). Many of these dams have been constructed in the upper reaches of rivers and streams as on-farm storages, frequently on hillsides to collect and store run-off (Land and Water Australia 2010: 1). Other farmers rely heavily on water pumped from major dams, rivers or groundwater or have secured water supply by open channels. Rather fewer farm dams and weirs intercept water directly from surface water courses.

Throughout the nation, regulation of farm dam construction and governance of this smaller water infrastructure has been weak. That situation is changing somewhat as government instrumentalities are providing guidance to farmers on appropriate locations and size, how to prevent contamination, nutrient build-up, sedimentation, riparian land erosion and excessive evaporation and seepage. In some jurisdictions licensing provisions have been tightened for dams likely to have more significant impacts including those holding more than 1 megalitre (NSWOW 2017: 1; Department of Water, Western Australia [DWWA] 2014: 1-23). However, confidence in such governance arrangements has been significantly diminished as a consequence of political interventions. In one case this was directed at securing a free water licence for a specific farmer and in another it involved attempts to legitimise an illegally constructed dam (Visentin 2018: 8).

When politics plays a significant part in the public funding of water infrastructure, market inefficiencies and distortions tend to arise. Costs of water supply have increased where political decisions have effectively led to water subsidies being provided to some irrigators in the Murray-Darling Basin (Crase *et al* 2015: 15 – 16, 36). In this regard, the APC (2017: 23) has stated that it is ‘crucial that poor past decisions and outcomes are not repeated’ and that governments ensure that ‘the environmental sustainability and financial viability of new infrastructure (are established) before any government resources are committed for construction’. In similar vein, the Victorian Government (2016: 67) has developed criteria that must be met to support *future state* investment in water infrastructure, including land use considerations and cost-benefit assessments focused on projected social, environmental, cultural and economic outcomes.

9.2 Cotton and Rice Production

The production of cotton and rice, which takes place almost exclusively in the Murray-Darling system, is intimately linked to dedicated water storage dams, water infrastructure and water usage in rural Australia. There are about 1200 cotton farms in Australia varying considerably in size from small farms to major commercial enterprises, and some 2000 rice growing businesses with an average holding of 400 hectares (DAWR 2018b: 1). The majority of cotton farms use flood/furrow irrigation systems, with a minority using travelling irrigators (Ashton 2018: 11). Rice is a wholly opportunistic crop depending on available irrigation water (DAWR 2018b: 1). The area of cotton planted and the value of the crop varies enormously, with water availability and water price both representing important variables in determining crop profitability (Ashton 2018: 2; Grafton and Williams 2018: 11). In the years 2017 and 2018, 85% more cotton was planted annually than in the drought years of 2007 and 2008 (Reading 2017: 3). In those earlier years essentially no rice was produced. Public funding of irrigation water infrastructure has also led to the development of further high-value crops, such as nut production which usually applies drip irrigation (Grafton and Williams 2018: 11).

In 2015-2016, the water application rate for cotton was 6.8 megalitres/hectare, only exceeded by12.1 megalitres/hectare for rice (ABS 2017:1). However, that is not the full story because particularly in the case of rice production there are high return rates of water to basin surface and groundwater. Grafton and Williams (2018: 11) point to the importance of monitoring ‘net diversions’ if the actual impacts of particular crops on available water, river health and other consumers are to be established. In southern NSW cotton planting is replacing rice because of greater profitability and reliability and less water required for crop growth (Reading 2017: 3). Some cotton producers have benefited from publicly funded water buy-backs and the commercial set-backs caused to others by prolonged drought. On the other hand, while cotton producers do use futures markets and hedging in their businesses, only some engage in water trading even in dry years (Ashton 2018: 2,12). DAWR (2018a: 1; 2018b: 1) claims that the Australian rice and cotton industries are now world leaders in water use efficiency.

9.3 Rural Water Quality

State governments work with local government to assure the supply and funding of water supply and storage schemes in rural townships (AWA 2016: 10-12). Contemporary drinking water standards in much of rural Australia are guided by the Australian Drinking Water Standards. While the APC (2017: 181) noted national progress, it identified problems in achieving healthy and safe water supplies especially in remote parts of Queensland, Tasmania, Western Australia and the Northern Territory.

Water supply authorities in rural towns are required by state and territory governments to monitor water supplies, which are often drawn or piped from storages, and as well to provide samples to government laboratories for testing (NSWG 2011b). In fact, 100,000 NSW residents were obliged to boil water in the period 2012-2017 because testing revealed the presence of various pathogens, parasites and bacteria, often resulting from upstream discharge from farms or from poorly maintained sewerage systems (Miskelly 2017: 1). Many country council and township supply authorities do not filter water but instead rely on UV disinfection or treatment with chlorine. Recently, this latter treatment has been shown to be an inadequate defence against parasites such as cryptosporidium and does not meet specifications in the national guidelines (Miskelly 2017: 2-3).

Water supply security for rural farms is even more variable. State and territory governments now often provide advice to farmers on a variety of ways of obtaining safe drinking water from rainwater collection, surface water and groundwater, including recommended means of filtering and disinfecting (Agriculture Victoria 2017). For remote Aboriginal communities there are many reports of seriously contaminated water supplies which fail to meet basic drinking water standards. In addition, levels of hygiene and sanitation do not meet UN Sustainable Development goals and contribute to the spread of often preventable diseases (UN 2015; Lansbury Hall *et al* 2016: 1-4; Infrastructure Australia 2019: 605).

9.4 Consequences for Water Security

Legislative, administrative and financial reforms, including greater water use efficiency in agriculture and irrigation, have provided benefits to the state in terms of improved water security. However, rural and regional water supply systems are far more variable in water quality, reliability and security than those found in urban surrounds. The failure of state instigated governance and management to focus on the sustainability of the nation’s rivers contributes to this situation.

Water security for human welfare is very variable in rural Australia. Drinking water quality tends to meet national standards for much of the time in the townships, with the quality often monitored by the state. The quality of drinking water in more sparsely populated areas is much more variable, even though it too is subject to national guidelines. Human water security on rural farms is patchy, while remote Aboriginal communities frequently lack water security, including drinking water of acceptable quality.

Water security for the environment in rural Australia has been severely compromised and has only been partially addressed in recent times. One significant factor lies in the relatively high surface water storage capacity per capita nationally. While the major dams provide water necessary for townships, irrigation and domestic health and use, they intercept river flows thereby contributing to a variety of downstream environmental problems. The pause lasting several decades in dam construction resulted from community concern, construction costs, social and environmental impacts, difficult siting requirements, climate change and evaporation. The stated aims of the new publicly funded dam building program are to promote economic growth, national productivity and irrigation. Environmental water security will be seriously compromised unless the program is accompanied by comprehensive prior assessments of environmental impact, risk and cost-benefit and determinations of whether modified systems can be managed sustainably.

In regional and rural Australia large dams and farm storages have played a significant part in meeting the demands of many irrigators and enhancing their water security. However, water availability for many other consumers has been reduced through over-allocation, illicit use and by the retention of water in shallow farm and enterprise storages, which are subject to significant evaporation. The problems of these latter consumers have often been exacerbated by rising energy prices, increased global competition in their product markets and climate change. The cumulative effect has been reduced security for many water consumers, particularly those in downstream situations. While water use efficiency of the cotton and rice industries has improved there has been little or no exploration of the impact of their heavy water use on the consumptive security of other actors.

The politics of water management, sharing and supply are never far from the surface in rural and regional Australia. Politicians and governments led in earlier times in constructing extensive storages of assorted kinds on major river systems. In recent times the influence of major irrigators over national and state politicians, has led to reduced constraints on access to water, frequently at the cost of efforts to achieve sustainable water resources management and improved water security for the environment.

10.0 GROUNDWATER SECURITY

In many regions of Australia and over vast tracts of land, groundwater is the only source of available water for townships, farms and mines (Harrington and Cook 2014: 2). Agriculture is responsible for more than 50% of groundwater withdrawals and, in 2017, 30% of

Australia's water supplies came from groundwater (Hartsuyker 2017: 1; OECD 2015a:1). Perth drew 50% of its drinking water from groundwater in 2012, while the Western Australian state as a whole quadrupled its use of groundwater between 1983 and 2010 (Harrington and Cook 2014: 6,10). Much of the groundwater in non-coastal Australia is too saline for drinking or for use in agriculture, a situation which is aggravated by the way salts are concentrated in aquifers through evaporation, transpiration, over-use and low aquifer recharge rates (Harrington and Cook 2014: 5). The results, challenges and consequences for water security are set out in succeeding paragraphs.

10.1 Results and Challenges

There has been a continuing political focus on the economic importance of the groundwater resources and how further to exploit them to support agricultural, mineral and energy development. As a consequence, it has been rare to find any political commentary on the linkage between groundwater and water security. However, in 2017, Assistant Minister to the Deputy Prime Minister observed that:

> 'Groundwater is integral to our national water security and economic growth. It supplies more than 30 per cent of our consumptive water supplies and underpins many billions in economic activity each year… It is also important for us to consider the role of groundwater in urban and rural water security, and the potential impacts of climate variability on groundwater availability and quality.' (Hartsuyker 2017: 1).

The reality is that many aquifers have suffered from lowered water tables, because water rights have been over-allocated and groundwater over-extracted. The processes leading to aquifer recharge and the rates of recharge vary considerably from one source to another. In 2010, it was assessed that thirteen heavily used aquifers were likely to have their water recharge volumes reduced by an average of 20% under the drying influences of climate change (Barron *et al* 2011: 3; Harrington and Cook 2014: 15). Though one of the commitments by all Australian jurisdictions in 2004 under the NWI was to develop a National Groundwater Strategic Framework, this strategy was not promulgated until 2016 (AST 2017b). The following statements in the document highlight the uncertainties and challenges ahead:

> 'Australia is still a long way from answering important questions such as scale of groundwater use, the depletion of its groundwater resources, quantifying recharge

> rates, and the effects on connected surface water resources… the overall need to support knowledge development and basic data collection has been largely underestimated and under-resourced’ (AST 2017b: 7). ‘In considering future groundwater developments it is important to assess the risks to the use of groundwater resources in light of scientific uncertainties about the resource’ (AST 2017b: 12).

Assessing the risks is not straightforward. The aquifers of Australia vary enormously in size, location, depth and surrounding geology and respond in idiosyncratic ways to climate change, patterns of demand and exhibit differing recharge rates. To characterise a groundwater system with any accuracy involves understanding the dimensions, structure, permeability, discharge and recharge rates and groundwater flows (Herczeg 2011: 59). Accurate data and statistics on groundwater abstractions, contamination and integrity have often been unavailable. Instead aquifer recharge has very frequently been estimated based on crude measures based on defined proportions of rainfall or river flows (Barron *et al* 2011: 133). Nationally, there has been limited investment in research, infrastructure for monitoring, metering, reporting and inspecting groundwater as well as inconsistencies in methods of water accounting (Harrington and Cook 2014: 6). Instead, groundwater management needs to be risk-oriented and adaptive, with continuous monitoring over extended periods. Unless that occurs, current patterns of extraction could leave many aquifers in an unsustainable state and water security of users will not be assured (Herczeg 2011: 59).

The impacts of climate change on groundwater security are under active review in some key locations. Between 1975 and 2014, Perth suffered a decrease of 10-15% in rainfall caused by climate change as well as a 50% reduction in surface run-off (Barron 2014: 139). This led to high-tech examination beginning in 2013of the four key aquifers serving Perth and the surrounding region. That resulted in aquifer management scenarios which are now reported to be capable of dealing with the impacts of projected population increase and the drying climate (Kelly 2017: 1-2).

Other approaches have relied less on precise examination of a given aquifer and more on rules and legal and administrative change. Some experts have favoured changing laws to ensure that climate change is taken into account when groundwater allocation levels are set (Bennett and Gardener 2014: 2-3). Given such an approach, allocations could be varied seasonally, far more than is currently the practice, both to improve groundwater sustainability and to ‘bank’ groundwater for use during severe droughts. Given the increasing national dependence on groundwater, an expert contractor was called on to prepare a suite of management rules, applicable to all aquifers and locations (Gutteridge, Haskins & Davey [GHD] 2014: v-viii). The rules established were based on risks to the hydraulic and ecosystem health, aquifer linkages to other water sources and seasonal impacts.

There is the additional problem that groundwater systems are not stand alone entities. Unfortunately, as noted in Section 6, the NWC found little effort by states and territories to focus on the interactions between surface and groundwater systems in implementing water plans. Yet, the 2016 strategy and world-wide research both recognise that conjunctive management of groundwater and surface water is imperative (AST 2017:12). That is critical in Australia because of the widespread use of groundwater in agriculture, mining, water supply and as a storage medium for injected, treated water. The APC (2017: 73) argues for greater research, funding, monitoring, even though a National Centre for Groundwater Research and Training was established in 2009 (NCGRT 2009). It was recommended that the above rules be implemented as long ago as 2014 (GHD).

10.2 Consequences for Water Security

As water scarcity, aggravated by climate variability and climate change, has become a major influence on the Australian economy the nation has drawn heavily on groundwater resources. Yet, neither politicians nor governments seem fully persuaded that access to groundwater requires vigorous regulation; that groundwater sources, their integrity, recharge rates and sustainable yields need to be accurately assessed and monitored; and that the scale of research needed to assure future groundwater sustainability is very significant, especially for future water security.

Groundwater security is very dependent on the actions of the state. In turn, the water security of the state and the nation's economic growth are both very dependent on the continued health of its groundwater sources. While that is recognised in the city of Perth and some areas in the Murray Darling Basin, national regulation is neither comprehensive nor robust. Monitoring and research efforts are weak compared with other areas of water management. Nationally, the position of the state is relatively poor in respect of groundwater security.

In many locations in Australia, citizens' welfare and security relies heavily on the sustainability of groundwater systems. For each important groundwater source to be secure in the long term, requires greater research, resources and priority to be accorded to understanding the rates and scales of water withdrawal and the extent and rates of recharge. Citizen welfare is intimately linked to maintaining each groundwater system in a long-term sustainable state.

Governmental documentation dealing with groundwater refers to the importance of sustaining environmentally significant ecosystems and understanding the complex relationships between ecological and hydrological systems and the landscape. However, like so many preceding strategies, action plans and models it does not accord top priority to maintaining the integrity of aquifers and their ecosystems – nor are the resources adequate to the research and management task. This has contributed to many unsustainable patterns of groundwater extraction and the failure of management to assure water security for the environment and groundwater systems.

Most water policy documents have focused on rendering groundwater extractions secure for consumptive users. Priorities have been set to facilitate ‘optimal’ use, provide investment confidence and explore future development opportunities. Yet, extensive findings of reports and research indicate that the failure to implement sustainable and risk-based management of aquifers has led to poor water security for the very consumptive users, who are dependent on the groundwater systems.

11.0 WATER MARKETS AND WATER TRADING

A further major thrust of national water reform instigated in 2004 involved the business and commercial aspects of water its management, allocation and trade. These have all been aided by the water planning process described above. As the problems of water scarcity, over-allocation, river and groundwater degradation beset governments they were attracted collectively to promoting the alignment of prices and costs and to developing water markets. It was held that the markets would help generate efficiency in water use and that water trading would promote migration to higher value-added uses.

11.1 Results and Challenges

Most jurisdictions have legislated for the separation of water rights from land rights and embedded these water entitlements in water access licences. The entitlements are statutory and tradeable and confer a perpetual entitlement to a share of the consumptive pool of available water - which may vary in size as determined by the relevant authority. The actual seasonal allocation is made in proportion to each entitlement (Australian Government 2017a, b). The nation's governments establish the market and trading frameworks, rules and regulations. In principle, those governments are expected to ensure that trading information, documentation and water accounting is adequate, that monitoring and auditing requirements are met and that controls preclude unregulated trade.

The water markets in each state vary in size, extent of activity, rules and hydrological connectivity, though the boundaries for trading are usually well-related to physical water boundaries (NWC 2013: 7). A further goal of the NWI was to establish reliable and compatible registers of entitlements to provide both public access and greater security for entitlement holders. Only some jurisdictions have substantially completed the registers, while there are considerable differences in the way each register functions, the recording of allocation and entitlement trades, and the accessibility and reliability of trade data (APC 2017: 97). The shortcomings in these areas alone, which have been identified in sub-section 7.3, are sufficient to undermine the reliability and validity of the trading system, especially in the Murray-Darling Basin. In 2015/2016 89% of national trading in surface water entitlements and 96% in surface water allocations occurred in that basin (ABARES 2017).

Water entitlements of assorted kinds have been granted nation-wide to water authorities, irrigators, industrial users, urban and rural communities, extractive industries and the environment. Water delivery rights allow utilities to deliver water either directly to a domestic user or an irrigator, or, indirectly to some irrigators via a bulk entitlement. Water rights that derive from native title, in principle, empower Aboriginal people to abstract water for non-commercial purposes at designated locations.

Water markets and trading have played a part in improving water efficiency in key industries, the management of bulk water in irrigation areas and some water service delivery (APC 2017: 119). They have particularly enhanced the ability of irrigators to deal with market and climatic variations, because the tradeable entitlement represents both a financial asset to the holder and a useful business tool (APC 2017: 9). The dominant participants in water markets are major irrigators. These actors often have access to the funds needed when water prices become inflated by water scarcity. So, as envisaged by COAG, water security has improved for irrigators as consumptive users. In unregulated river systems small numbers of large, profitable irrigators have over some years traded heavily and used their market power to purchase water to fill very large, shallow on-farm storages (Besser *et al* 2017a:1). This has served to increase their market concentration and political influence – to the disadvantage of other users (Garry 2007:2). In such circumstances, the rights, particularly, of downstream users have often been compromised, including through the increased costs they must incur in obtaining water (APC 2017: 118).

The way water allocations are made and the provisions under which a water market operates have a clear influence on water security outcomes. Young (2013: 5) argues that ‘abstraction arrangements must be defined by hydrological integrity’ if ‘perverse consequences’ are to be avoided through market operations. Operating conditions for markets and management of extractions should consider the scale of overland flows, water return flows from consumers, and surface and groundwater connectivity. Because there are few situations where hydrological integrity and equity have both been addressed, water markets have made quite variable contributions to water security. Heavy promotion of water markets by governments has also tended to mask an imperfect system of water allocation and trading, not least because of the variations in rights, entitlements, allocations and the registering of water trades between jurisdictions.

Both the NWC and the APC have emphasised the importance of managing the risks of climate change on water allocations, water markets and water trade – their focus being on risks to the water security of consumptive users. NSW and Queensland have adopted a risk-sharing framework developed by the NWC while other jurisdictions have relied on more flexible market arrangements, qualifications to water rights and changes in water licences. The APC (2017: 356-357) holds that the mechanism is less consequential than the legal process which must ensure that risk sharing between parties is clearly established and that conditions under which adjustments are made to entitlements, markets and trading arrangements are well understood.

There are situations where state political and economic interests have been placed ahead of market efficiency. That has occurred when limits have been placed on the volume of water that can be traded; unnecessary delays have occurred in approving trades; trade between urban utilities and irrigators has been precluded; water buy-backs have been blocked; and, the movement of water entitlements away from an irrigation district has not been permitted (APC 2017: 111-131; Byron 2015: 223). In such cases markets are not operating efficiently because the necessary governmental administrative and legislative arrangements are absent or are being politically overridden (Crase *et al* 2015: 17). Where these barriers have been removed, the APC (2017: 9-10) found improved trading conditions, better availability of market information and quicker and easier trade approvals.

There has been in principle agreement by all Australian jurisdictions to align costs and prices in all water supply situations (Crase *et al* 2015: 15). In practice, national reforms aimed at securing much greater efficiency in water pricing by implementing volumetric charging and cost recovery have varied considerably in the extent of implementation between jurisdictions and across urban, environmental and irrigated water use. Each state or territory determines water prices in its own jurisdiction, which is a key reason for the emergence of a complex pattern of water pricing across the nation. As well, within each jurisdiction there are marked differences in prices being paid by consumers in urban and rural situations and for environmental water. Nationally, water prices have not generally been set to recoup supply, storage and delivery costs but rather have been influenced by the nature of the particular service supplier, costs of delivery, costs of infrastructure access, mode of irrigation district management – and at times the political and economic goals of the jurisdiction (Crase *et al* 2015: 15-19).

11.2 Consequences for Water Security

Water markets, water trading and water pricing have combined to improve water security for the state. They have contributed modestly to reductions in over-allocation of water and to increases in the water allocated to the environment. On the other hand, the health of water sources, present and future, has frequently not had sufficient influence on the way water allocations have been made nor on the structure of water markets and trading. That has resulted in adverse consequences for the water security of various actors and the environment. Equity in the sharing of available water and the water security of the state have both been eroded by political interventions in water markets, weak national oversight of market operations, and various structural weaknesses in the various markets.

There has been little serious consideration of the implications for future generations of entrenching water markets and trade in water entitlements. It is widely acknowledged that markets are not the best instrument for allocation of social and environmental rights or for securing social justice. The relative benefits and costs to citizens, consumers and the environment are skewed because of the heavy focus in establishing markets on economic resource values in defining market and operational rules. As a consequence, the introduction of markets has led to inequities and loss of social well-being for some, including riverine towns and communities. This matter has received little visible consideration by Australian jurisdictions. The rights and interests of Aboriginal people has been explored in Sections 6,7 and 9.

Statutory water planning, legally-based water allocations, water-buy-backs and environmental water holders have all been shown in earlier sections to have contributed in some way to more water being allocated to the environment. Efficiency in water use through the introduction of water markets and trading has also made some contributions. On the other hand, where water markets have contributed to the entrenched position of major water consumers, the water security position of small consumers, communities and the environment have all been placed at risk. More generally, water security for the environment has been further weakened, because water markets, water trading and economic outcomes have frequently been promoted over hydrological integrity of major systems. When development is not sustainable and water source health not accorded top priority, water security for the environment is inevitably prejudiced.

The fact that most jurisdictions have legally separated water rights from land rights and made water entitlements and seasonal allocations tradeable has improved water security for irrigators. Water markets and water trading have particularly enhanced the ability of irrigators to deal with market and climatic variations and to increase their water security as well as market concentration and political influence. However, water scarcity and climate change may oblige governments to consider altering water allocations, water markets and water trading arrangements.

Unsurprisingly, from the perspective of the major users, water markets have been found to operate more efficiently when economic and political limitations on water trade, water movement and buy-backs have been removed. The water security of some consumers has been eroded by weakness in jurisdictional trading frameworks and trade limitations, the accuracy of trading information and the way water trades are registered and audited. Where major actors have come to control large shares of accessible water, whether by market trading or illicit drawdowns, the water security of downstream users, modest scale farmers and irrigators has been diminished.

While COAG promoted the principle that water prices should reflect costs incurred in water supply and treatment, in practice each jurisdiction sets its own prices and cost recovery policies. Considerable differences have resulted in the cost of urban, rural, irrigated and environmental water within and between jurisdictions. Overall, nationally, water prices have not reflected supply, storage and supply costs, resulting in greater water use and less efficiency in many situations. All this has led to an uneven playing field for many actors, differing conditions governing water markets and trade, and varied levels of water security for consumers and the environment.

12.0 EXTRACTIVE INDUSTRIES

This section deals with the relationship between the way extractive industries in Australia manage water resources and the consequences for other users and the environment. Because current political and community discourse is heavily focused on the benefits and dis-benefits of the coal industry in present and future energy and water policy it has been accorded greater attention in the assessment of extractive industry's impacts on water security.

Extractive industries tend to be localised intensive water users and to return substantial quantities of wastewater back to aquatic systems. Since the turn of the century, these industries have progressively become more serious competitors for water resources, particularly in Queensland, Western Australia and the Northern Territory (APC 2017: 17, 81-82). This has led to the 2009 COAG National Framework for Compliance and Enforcement Systems for Water Resource Management and a National Partnership Agreement on Coal Seam Gas and Large Coal Mining Development (Australian Government 2012b). Nationwide legislation is also in place to deal with the environmental impacts of major extractive projects.

12.1 Results and Challenges

The main national mechanism for water to be allocated for domestic, urban, agricultural and industrial use has been water planning and assignment of water entitlements under the NWI. These have not been the preferred instruments used by most jurisdictions for allocating water for extractive industries or for thermoelectric power plants. Extractive industries are usually regulated under different statutory provisions and frequently hold no volumetric entitlements or associated licences (Timms and Holley 2016: 359). One consequence is that in situations where these industries are significant actors in aquatic systems, it has proven to be difficult to monitor the cumulative effects of water extraction and wastewater returns on either the aquatic systems or water security.

The NWC found that water resources were not generally being managed sustainably in the case of fossil fuel extractive industries, including hydraulic fracturing for oil and gas, as well as fossil-fuelled thermoelectric power plants. The Commission (NWC 2014d) called for the public benefits of mining and gas extraction and for the cumulative effects of regional activity to be assessed *prior* to any project approvals and for approved arrangements governing these industries to be made public. The APC (2017: 17, 84-86) argued that water plans and entitlements for the fossil fuel industry must be regulated under statutory water entitlement and planning frameworks, unless there is a compelling reason not to do so.

In response to Commission and public concern, the mineral industry has developed a water-accounting framework which helps track water quantity and quality inputs and outputs from any given mine site (Minerals Council of Australia [MCA] 2014: 1-2). The coal mining branch of the industry has stated that it is committed to becoming actively involved in integrating ‘environmental, social and economic aspects of resource development’ and will give priority to the use of ‘low quality’ water and wastewater (MCA 2017: 1). The NSW government has introduced a tighter regulatory and monitoring framework for mining which includes water triggers to provide early warning of risks to water tables and groundwater pressures (Timms and Holley 2016: 361). That needs to be considered in the context of national and state failures, past and present, to deal with the impacts of extractive industries on water security and the environment. In that context, the Australian Government has been at best equivocal in its commitment to water reform (see Section 5), as it has to reducing levels of greenhouse gas generation and renewable energy targets.

Though coal mining uses only a small proportion of available national water, historically, it has frequently disrupted the sustainable management of aquatic surface and groundwater systems. The water security of local communities, landholders, streams and the environment have been frequent casualties. Notwithstanding the level of public concern and contestation over specific projects, the fossil fuel industry has been able to influence legislation and regulation, decision making and governance. An alliance of political and fossil fuel interests has often seen water, land and environmental security given a low priority in the process of granting project approvals. The way the Adani mine proposed for the Galilee Basin in central Queensland has progressed represents a good case study into the exercise of political power.

12.2 The Adani Coal Mine

Adani Mining proposed to mine coal by a mix of open cut and underground mining and was slated to be one of the largest coal mines in the world. In its original configuration it was projected to produce 2.3 billion tonnes of coal over 60 years of operation, while contributing 4.7 billion tonnes of greenhouse gases through mining and the burning of extracted coal (Environmental Law 2017: 2). The concept of such a massive and environmentally disruptive project was the subject of a major national opposition from 2013 involving traditional owners, environmentalists, scientists and social scientists, the media and legal experts. There were many court actions focused on the mining licence, native title, rail transport of coal, coal port development and harbour dredging. There was also contestation over impacts on the Great Barrier Reef, water and wastewater management and the nature of ministerial approvals including mining conditions (Environmental Law: 2017: 1-17).

This level of public opposition did not sway key politicians who were often persuaded by the number of jobs to be generated and the national and regional economic benefits (EDO 2017: 1-2; Rose 2015: 1-2). Yet, expert advice based on detailed examination of the proposal revealed that the *net* number of jobs likely to be created and the long-term *net* economic benefits would be far less than those claimed for the project as originally proposed (Krien 2017: 10-13). Decisions to fast-track the project were supported by the Australian Government through modifications to legislative procedures and processes governing third-party appeals against project approvals. The Queensland Government introduced legislation enabling the state to control and speed up approvals.

The decision to grant Adani approval to take up to 9.5 billion litres of groundwater per year, with only a fraction required to be treated before return to the aquatic environment, was taken with the knowledge that the integrity of aqueous systems and wide-ranging water security were at risk (EDO 2017: 1). In addition, Adani can draw 12.5 billion litres of surface water per year via a pipeline from the Suttor River, approval for which was expedited by the Australian Government (Hannam 2020a: 4). The responsible Queensland Minister stated that the mine would be required to ‘stop operations’ if groundwater conditions were breached (Lynham 2017: 1). This was widely contested, because previous adverse groundwater results had only led to ‘make-good’ financial arrangements by operators with local landholders (Davidson 2017: 1; Lynham 2017:1).

Even though the scale of the project has been reduced by more than 80%, major contestation has continued. For those most concerned about water security in the entire Galilee Basin, a key objective was to deny Adani the ability to start mining. That was going to be difficult to achieve because the Queensland Government had released the 'Galilee Basin SDA Development Scheme', which would allow basin resources to be exploited in a 'well-regulated and orderly way', and had given in principle approval to five mines to proceed (Queensland Government 2019: 1; iMINCO 2015: 2-3). By 2019, this position in Queensland was reinforced by considerable bipartisan political support for continued coal mining in other jurisdictions - despite the known impacts of fossil fuel mining and burning on global climate change and the significant potential environmental risks of many such projects.

In 2019, as national elections loomed, the responsible Australian Government minister approved a revised groundwater plan dealing with a complex network of streams, groundwater and Great Artesian Basin springs. His approval gained regional, electoral and fossil industry support, despite scientific claims that the plan was deficient and that the project risked future water security (Crothers 2019: 1). In approving the plan, the minister cited scientific support which was later revealed to have been much more equivocal than claimed. Later in 2019 the final obstacle to project initiation was removed when the Queensland environment department gave a necessary environmental approval (ABC 2019: 1)

12.3 Consequences for Water Security

All Australian jurisdictions have recognised and harnessed the substantial benefits of various extractive industries, their products, export, use and ability to create large numbers of regional jobs. However, the NWC and APC found that to avoid poor economic and environmental outcomes it was important to change the legislative, management and planning arrangements to those applying to all other industries in relation to water access and use as well as wastewater return. The failure to effect those changes and rigorously to regulate and monitor access and use of water by the extractive industry, including the fossil-fuel sector, has limited the water security of the state, present and future, in some regions.

Politics has had a major and continuing influence on decision making concerning fossil fuels and their use. The corporate fossil fuel sector, miners and users, have very often been the beneficiaries of these political, pro-business decisions and approvals, in ways that have impacted negatively on the security of communities, landholders and the environment.

Despite some recent improvements in regulation and monitoring, it has been commonplace for the water security of extractive industry to be advanced at the cost of the water security of other water users and the environment.

13.0 CURRENT WATER SECURITY

The conclusions in this section of the chapter are presented within the framework created in Chapter 1, drawing on examinations of data, findings, reports and research in the preceding sections. Sub-sections 13.1 to 13.4 focus on the influence and impact of politics, governance, management and climate change on national water security. Sub-sections 13.5 to 13.8 also build on the analyses in this chapter but through the lens of the four specified water security domains, namely the state, human welfare, the environment and consumptive users. Where the conclusions could be positioned under more than one item, they have been presented in detail in one primary location. Shortcomings and deficiencies in policies and programs as they impact on water security are explored, as well as the likely contribution of current national reforms and initiatives to near term future water security. All these conclusions have been considered in the final chapter in making the country comparisons of present national water security, in examining future prospects and in assessing the wider contribution of water security to each nation.

13.1 Impacts of Politics

The sense of common purpose in reforming national water management and planning has diminished markedly since 2013. It has been replaced in many Australian jurisdictions by political discourse oriented towards the importance of water resources in the economy. The political leadership of successive conservative Australian Governments has focused national attention on the benefits of greater exploitation of water resources, increased dam building and reduced administrative and environmental regulatory constraints on industry. This represents a direct threat to the future sustainability of major national water systems and national water security. The political influence of some industry and interest groups over governments and decision makers has increased these risks.

Water planning has been widely supported politically as a primary instrument for national harmonisation of water management. National politicians sought greater efficiency and productivity in water use from the clear assignment of water rights, alignment of prices and costs nationally and the development of water markets. Significant gains have been made in each instance. However, the gains have been compromised where political influence on water pricing, water markets and the public funding of water buy-backs and water infrastructure has occurred. Political interventions and structural market problems have led to distortions and inequities in water sharing, reduced water use efficiency, and eroded gains in water security.

The capital city water utilities are well-focused on the need to maintain water security and system integrity in order to deal with climate change, including the prospects of a drying climate and prolonged droughts. Political failure to encourage greater use of highly treated wastewater as an alternate resource has hampered their efforts somewhat to cope with the growing impacts of climate change. Though only a modest user of water resources extractive industries, particularly involved in the mining and processing of fossil fuels, continue to be an arena of continuing public and political contestation. Public opposition has often not swayed key national and state political leaders - given the promise of economic growth and jobs. Governments have made legislative changes to fast-track fossil fuel development proposals, while failing to resolve past major water use, treatment, contamination and security issues. Few politicians have recognised the vulnerability of many of the nation's groundwater systems, including in industrial use.

A key issue for politicians and legislators in respect of the Murray-Darling Basin revolves around the current demands which are leaving the basin and some of its major water catchments in an unsustainable state. In some catchments system resilience is already threatened. Claims that current management, planning, administration and funding arrangements have all improved over the past structures, do not address this pivotal issue. As political and economic interests continue to be deterministic, at the national level and in some states, joint custodianship of the common resources is failing and national commitments to achieve sustainable basin management are not being met. As a result, pressure on fragile systems continues, or is worsening, and uncertainty over water security is increasing.

13.2 Impacts of Governance

Considerable national convergence in water planning has led to changed governance arrangements, though improvements in water security since 2004 have been very patchy. There are a number of reasons. Plans have varied in water source coverage and few have dealt with the impacts of water interceptions and changes in river flows. The large majority of plans have not shown how objectives are to be achieved or when and why plans will be revised. Plans and regulation have not ensured that environmental water is protected from reallocation or theft, particularly during times of water scarcity.

The MDBA, in its current configuration, is the vehicle established by the governments of Australia to provide leadership in governance and management throughout the Murray-Darling Basin. Its ability to manage the whole system continues to be limited by political decisions, state interests and decisions. If compliance, enforcement and auditing systems in the basin states were harmonised, as recent inquiries have recommended, there would be some improvement in basin-wide governance and water security.

Nationwide there are many statutes and intergovernmental agreements dealing with the operations and impacts of major extractive industry. Under current varied regulatory regimes water sources have frequently been over-used and contaminated. Though operational and regulatory improvements have been made, it is still not possible to gauge the long-term cumulative impact of major projects and operations on aquatic systems, neighbouring land and water security.

In the management and regulation of major city water utilities, critical governance goals have included delivery of safe and reliable water supplies, while meeting advanced health, environmental and water quality regulation. Administrative oversight of water planning, water pricing and major infrastructure development is in place in most jurisdictions, but to varying degrees. Challenges to future water security and governance arrangements include population growth, climate change and the consequences of unplanned political interventions. Beneficial use of wastewater offers promise if the national focus were to turn to removing political, institutional and regulatory impediments to its use.

Australia has constructed very few rural storages of significant size this century. The way these storages operate is generally well understood, but the contribution of each to water security varies, according to the season, the management regime in place and the patterns of land and water use. Where deemed necessary, major storages have been modified to cope with new knowledge about the scale of projected climatic events. Proposals by the present Australian Government to build more dams of significant size raises issues concerning governance, assessment, regulation, winners and losers as well as water security. Governance and regulation associated with the development and operation of much smaller water storages has been relatively weak nationally.

13.3 Impacts of Management

The previous generation of water plans made some effort to deal with conjunctive management of surface and groundwater systems, leading to modest gains for water security. The failure to focus on the complex interplay of surface and groundwater systems, ecosystems and use of surrounding land has undermined government attributed levels of confidence in water rights and allocations as well as future water security. Management of water use and wastewater return by industry and agriculture has been variable. It is too soon to gauge the effects of water-accounting frameworks and tighter regulation.

The MDBA has the critical role of operating the whole basin system according to the provisions of the current Act, Plan and Agreement. Its efforts have advanced efficiency in water use and environmental management through tracking flows and volumes and moving water to where it is most needed. However, there is a basic conflict in its role to serve as the agent of basin partners, while also ensuring that they comply with Plan requirements. Its ability to manage has also been circumscribed by political constraints, the prejudicial actions of some jurisdictions and the failure of most to focus on collective stewardship of the common water resource. The widespread failure by basin partners to develop, refine or complete the next generation of water resource plans renders problematic the potential of these plans to improve future management and patterns of water use.

Water supply and water treatment by Australian capital city water utilities would be enhanced if these entities were encouraged or permitted to join other instrumentalities in the planning for and management of whole city water basins. Several overseeing commissions have argued for greater integration and realignment of water planning and management in city, land and energy planning.

National goals designed to align costs and prices in all water supply situations have not been met. There are marked differences between jurisdictions and across urban, environmental and irrigated water use. The nation’s trading frameworks, rules and regulations vary in size, activity levels, rules and ambit of operation. Well-capitalised enterprises have too frequently been able to use to use Australian Government funding to increase the scale of their operations and market power and to accrue a large percentage of available water in the market. These variations have contributed to an imperfect system of water allocation, access and trade and to differences between locations in water security for users and the environment.

13.4 Impacts of Climate Change

Since 2014, the ability to question policy and advocate reform in response to climate change, by bodies such as the Climate Commission and the National Water Commission has been lost because these entities were abolished. Departmental mergers and loss of the close nexus between environment, water and climate change at the Australian Government level have compromised efforts to advance national water security and contributed to uncertainty and loss of community confidence. The setting of a low national target for greenhouse gas reductions by 2030, and the absence of a clear plan to meet the Intergovernmental Panel on Climate Change (IPCC) target of no emissions by 2050, have adverse implications for water hydrology, water scarcity and major water system health as well as national water security.

In the first generation of water plans only a small number took account of climate change modelling to project impacts on basin systems, surface flows and aquifer inflows and recharge. New guidelines and tools for the next generation of water resource plans, if implemented, could improve this situation. The way the risks associated with impacts of climate change on water allocations and water markets are assigned nationally generally favours the water security of consumptive users.

Existing major dams continue to be assessed and modified, structurally and operationally, to withstand the effects of climate change. Efforts to curb and control water evaporation have been limited, including study of its impacts on local climates and the hydrological cycles. Some major water utilities have taken significant steps to maintain water and system security in the face of climate change, including protecting water supply, treatment and other major systems, increasing wastewater recycling and building desalination plants.

The aquifers of Australia vary enormously in size, location, depth and surrounding geology. They differ in their response to climate change and patterns of demand and in their rates of recharge. Many remain poorly managed, especially to cope with increased demand at times of surface water scarcity. Usage guidelines have been developed, but are far from universally applied, not least because each aquifer needs to be researched to determine its hydraulic and ecosystem health and to establish rules governing seasonal water extractions.

All parties to the Murray-Darling Basin Agreement claim to be willing to respond effectively to significant climate variability and climate change. That should include making reductions in water extractions and diversions throughout the basin to deal with the consequences of recurrent serious droughts. While the MDBA is engaged in developing new tools to help forecast more accurately local and system-wide climatic and streamflow variations, recovery buffers and climate change reserves some states are failing to meet *existing* obligations. Some of the partners seem unprepared to consider modification of the existing Plan, Agreement and the average SDL in order to take account of climate change modelling or the observed consequences of a prolonged catastrophic drought.

13.5 Water Security for the State

There are no explicit national goals or defined national positions on water security in Australia. The Australian states have ownership of water resources but the granting of perpetual rights to water users makes the exercise of the ownership power more problematic. The water security of the state has been strengthened as a result of harmonisation of key aspects of water planning, rights, allocations, markets and trading as well as urban water supply across all Australian jurisdictions.

The water and economic security of the state are placed at risk because some signatories to the Murray-Darling Basin Agreement are not meeting commitments. The basin partners have not accepted the extent of structural adjustment needed to overcome widespread water scarcity, the overhang of water over-allocation, water wastage, water misappropriation and climate induced changes.

National initiatives, regulation by the state jurisdictions and reforms carried out by urban water authorities have strengthened the water security of the state in respect of the nation's cities. Independent bodies overseeing utility pricing for water, its distribution and treatment have also made a contribution. Rural water security and national growth both depend on the sustainability of key surface and groundwater systems. National regulation, monitoring of and research into groundwater systems has been comparatively weak. Australian jurisdictions have not invested in the considerable benefits for state water security associated with better integrated management of the nation's critically stressed aquatic systems.

Australian government funding programs, water markets, water trading and water pricing have led to modest increases in the water allocated to the environment. The state position in water security has been undermined when the sustainability of water sources and equity considerations have not been prime influences on water allocations and the structure and operations of water markets. The state position has been weakened further by political interventions and flaws in the structure of water markets which have led to reductions in environmental water and inequities in water allocations and water sharing.

13.6 Water Security for Human Welfare

Advanced quality, health and environmental standards have been applied nationally in the major cities leading to the supply of water of high quality water for human use by international standards. At present, water is available in sufficient quantities to meet the needs of citizens in the largest cities. Governments and the supply authorities perceive urban water security to be assured in the long term as a result of intensive planning and effective management – though some water experts are more equivocal. The water security of some Aboriginal peoples has improved. However, many lack the means to gain recognition of their rights, while others suffer from contaminated water supplies which fail to meet basic drinking, hygiene and sanitation needs.

If water is available, basic human needs in the Murray-Darling Basin can be improved by changing water sharing arrangements in order that water be moved to specific locations. Water supply authorities in rural towns are required by state and territory governments to monitor water supplies which are then tested in government laboratories. Elsewhere in rural Australia, water security, water availability and water quality depend on the prevailing climate and its impact on usual water sources as well as the operations of neighbouring storages and town utilities. The welfare and water security of many rural citizens relies on the quality of groundwater systems and the way access is managed and monitored.

Various water reform and planning strategies have had an adverse impact on the water security and life choices of people on small farms, in downstream locations and living in riverine townships. Social justice, rights and interests of these people and future generations have rarely been considered in establishing water entitlements, water markets and water trading arrangements. In the first phase of water planning, social data, social assessments and community consultation seldom informed plan development.

13.7 Water Security for the Environment

Provision has been made in all water plans to secure environmental water. That has made a tangible contribution to water security for the environment. Some states and the national government have established independent and statutory environmental water holders, which are able to hold, purchase and move water to meet environmental needs. However, the goal of reallocating overallocated water to aquatic systems in order to improve environmental sustainability and ecosystem security has not been met. Reasons include: inadequate monitoring and auditing of water plan outcomes; counterproductive political interventions; illicit extractions; pressures created by land use change; and, the reallocation of environmental water during drought. Some water use efficiency, water conservation and climate change measures have helped advance water security for city users and their environs. Overall, water security for the environment varies from effective in some situations to weak in others, as described below.

The Australian Government and some state jurisdictions have systematically reduced environmental management, regulation, oversight and resources, with little regard for the impacts on aquatic system sustainability. That has provided a degree of encouragement to those benefiting from exploiting and investing in the nation's aquatic resources. Yet, if the health of water sources is not accorded the highest priority, current services are at risk along with the water security of many users and the environment. The recent prolonged drought in the Northern Basin of the Murray-Darling provides a stark reminder of the consequences of ignoring system sustainability and getting extraction levels wrong.

Australia has created high surface water storage capacity per capita in the Murray-Darling system and elsewhere in Australia. While these storages provide water for townships, irrigation and domestic use, they have contributed to diminished river flows, increased the level and extent of water evaporation and algal blooms, salinity and sediment build up as well as loss of natural environments and species. In targeted reaches of the Murray-Darling Basin water quality and flows have improved, salinity has been diverted or intercepted and wetland, riparian and floodplain environs have been partially restored. These represent important but modest gains for water security when set against the continuing deterioration in river reaches, water flows, wetlands, lakes, forests and ecosystems. The new phase of dam building does not appear to acknowledge that such construction must give the highest priority to maintaining sustainable outcomes for surface and groundwater systems.

13.8 Water Security for Consumptive Users

Water planning has contributed to improved water security for the majority of consumptive users. Water and land titles have been separated in most jurisdictions, allowing water entitlements and seasonal allocations to be tradeable. Water security for some consumptive users has been improved through the operation of water markets, the removal of interstate trade barriers and reduced transaction costs. These consumers have often been positioned to benefit both from increasing market access to scarce water and the major Australian Government investment in private water infrastructure. Urban consumers have often been the beneficiaries of improved cost effectiveness in urban supply and treatment, increased emphasis on demand management and regulated water pricing.

Other consumers have encountered significant negative impacts on their water security from perverse market outcomes, illicit extractions, the growing impacts of climate change and the heavy water demands of cotton and rice production. Nation-wide, many consumers have been disadvantaged by the considerable differences in governmental cost recovery policies leading to considerable differences in the cost of urban, irrigation and environmental water and between jurisdictions. These shortcomings have led to inequities in economic and water security for small businesses and other downstream consumers.

In regional and rural Australia large dams and farm storages have played a significant part in meeting the demands of many irrigators, a situation which the Australian Government proposes to reinvigorate. While it has been emphasised by government that groundwater extractions must be made secure for consumptive users, many groundwater systems have not been subject to sustainable and risk-based management, thereby threatening the sustainability of the systems and the water security prospects of consumers.

CHAPTER 3

A CRITIQUE OF WATER SECURITY IN CHINA

1.0 INTRODUCTION

There are a number of factors and forces at work in China which help explain the type and orientation of water reform, the nature of those reforms and the influences and constraints on the results achieved. In China major water reform has been continuous and has become more comprehensive and prescriptive as the 21st century has progressed. In large measure that has been a response to the critical need for China to overcome water scarcity and water wastage as well as widespread water pollution. A brief analysis of what is widely described as a 'water crisis' in China is covered in Section 2 below. While the nation has been engaged in extensive water reforms it has also been undergoing major political, social and economic transformations. The complex political and administrative systems in China have a direct influence on the effectiveness of water policies and reform strategies and their implementation. The way these constraining and limiting factors have contributed to the shaping of current national water security has been examined separately in Section 3.

To deal with this crisis and to better manage the nation's water resources, China has developed many national policies, programs and regulations aimed at conserving water, assuring urban water supply, improving water use efficiency and source water quality, ameliorating flooding and containing and preventing pollution and contamination from multiple sources. These programs are examined by major sector or segment of the economy in Sections 5-9 of this Chapter along with their effects on water security. Section 10 provides conclusions on water security in China, based on the above analyses and by applying the assessment tool described in Chapter 1.

Throughout this Chapter the analysis identifies governmental, water-oriented goals. It examines the extent to which those goals have been achieved to the end of 2019, as revealed by governmental reports, the research of Chinese and international scholars, and assessments by independent and intergovernmental bodies. Under each major subject heading, such as, for example, 'Water Infrastructure', the overall approach, policy, programs and laws have been examined and briefly reviewed. The focus of the analysis is on national outcomes, while recognising that results are dependent on central, provincial and local action. The next sub-section entitled 'Results and Problems' examines the outcomes, some of which are positive and some negative, including the inconsistencies and failures in policy implementation and the reasons. That analysis, informed by Sections 2 and 3, then leads into the concluding sub-section entitled 'Consequences for Water Security'.

The examination of the issues and the presentation of the conclusions are often less detailed than was the case for Australia. There are several reasons for this. Firstly, current data and results of policy implementation are often delayed in official publication and therefore have needed to be distilled from later papers prepared by experts from Chinese ministries, leading Chinese academics and international organisations. Secondly, those data that are available in a timely form are usually not well aggregated around targets and outcomes, nor do they tend to be integrated nationally across ministries and levels of government. The most frequent source of data and results and the most comprehensive evaluation of government strategies have been found and cited in the research of many distinguished Chinese scholars, notable amongst whom are Cheng and Hu, Wang and Zhang, Yong Jiang and Min Jiang. The appraisals by leading Chinese academics are both critical and frank and are to be found in many English language literature sources, some of which have been published in China. In the analysis of Chinese public policy, the chapter draws on governmental literature, translated into English and emanating from sources such as the State Council and key ministries. That includes water law, high order water policy, major water reforms and the various governmental directives dealing with policy and program implementation.

The publications of China Water Risk (CWR), a not-for-profit organisation, have been valuable, because that organisation elaborates and tests major policies and seeks insights from leading Chinese academics on policy directions and policy inconsistencies, difficulties in implementation and actual results. This chapter has also drawn on the work of various international organisations including the Global Water Partnership (GWP), the International Water Management Institute, WHO, OECD, the World Bank and the Asian Development Bank, which have issued reports that have included key data on subjects relating to water security in China. Some local projects led by international organisations or by local groups of officials have been reviewed where they have had the potential to contribute to national water security. Through this detailed examination process a broadly-based understanding of the present and future water security of China has been able to be built with some confidence.

2.0 THE WATER CRISIS IN CHINA

In 2018, former Premier Wen Jiabao is reported to have warned that lack of water threatened growth, stability and the survival of the Chinese state (Carney 2018: 1). Decades of economic growth, rapid urbanisation, population growth and significant climate change have all brought China to the brink of a crisis in meeting current and projected water demands. While about 20% of the world's population lives in China, the nation has only 7% of the world's freshwater resources (ADB 2016: vi). Aggregate national water consumption for all purposes rose steadily from 500 to 610 billion m^3 in the period 1990 to 2015 (Water Environment Partnership in Asia [WEPA] 2018: 20). That has driven major, continuing state efforts to construct dams, drill deeper boreholes and transfer water over massive distances to meet industrial, power generation and urban demands (Wang, Zhang *et al* 2018: 902; Knowles 2016: 5). The fact that the rural population is shrinking and the urban population continuing to grow, to 58.5% in 2017, has increased the challenge in improving the management of urban water supply and treatment (Hu 2018: 4-5). About 400 cities face continuing water shortages (Bray 2018: 2). In fact, those shortages have cost the national economy tens of billions of dollars per year in lost industrial production, crops and economic output (Hays 2014: 2). Air and water pollution combined were estimated to have cost 5.8% of the national GDP in 2007 (Eldis 2007: 1)

A critical arena of responsibility for the Chinese government and its river basin commissions continues to be flood mitigation and drought relief. The construction of dams, weirs and pipelines in the seven major river basins and their tributaries has primarily been directed at flood mitigation, as well as improved water supply for citizens and agriculture and increased national energy security through hydropower. In the agricultural north, climate change has significant implications for five of these river basins and for the South-to-North Diversion Project, especially as rising temperatures are leading to increased evapotranspiration. In the south extreme rainfall events, storm surges, typhoons and higher tides have the collective potential to increase the severity of flooding, its scale, the area inundated, the duration and the extent of seawater intrusion.

In 2018, eight northern provinces were experiencing acute water scarcity (Davies and Westgate 2018: 1). The search for accessible water in the north has caused extractions to exceed safe supplies and groundwater levels to fall, while leading to widespread ecological and environmental damage (GWP 2015: 8). Reliance on groundwater from aquifers has caused land subsidence in some 50 Chinese cities (Davies and Westgate 2018: 1). The risk is high in areas surrounding Beijing where each year the water-table is falling by 1-3 metres, while drilling for water has now reached 70 metres (Carney 2018: 3).

A quarter of the agricultural land of China has been lost to desertification, salinisation or soil erosion and tens of thousands of lakes and rivers have disappeared through over-use, recently aggravated by climate change (Ball 2017: 310; Latham and Westgate 2018: 1). The Yellow River is only a tenth of its 1940 length and the once mighty Yonding River on the outskirts of Beijing is now just a sandy river bed (Carney 2018: 1). Only 19% of the nation's water resources are available for agriculture in the north, which uses 65% of the land in contributing 45% to national GDP (Gu *et al* 2017: 66). Arable land and accessible water are so limited that maintaining food production calls for greatly improved productivity from water used in irrigated agriculture, because current productivity is only about 20% of that of producers in developed nations (Wang, Zhang *et al* 2018: 902-903). Similarly, low water use efficiency in industrial production is an important limitation in meeting growing demand for water for manufactured products (Xu *et al* 2016: 33). While the south receives 81% of the water with its agriculture contributing 55% of national GDP, water quality is not adequate to support projected levels of economic, industrial and urban development and power generation (Gu *et al* 2017: 66).

By the 2000s, industrial water pollution was recognised as a major threat to health, ecological and environmental welfare and as a significant contributor to water scarcity and loss of water security. The primary causes of industrial pollution continue to be wastewater discharge, poor agricultural practices, including inappropriate fertiliser and pesticide use, and many serious chemical and wastewater accidents. Each year, Miao *et al* (2016: 473) and Han *et al* (2016: 1229) hold that more than 100 million people become ill because of industrial water pollution and have estimated that tens of thousands die. Water is also widely contaminated by e. coli deriving from human faeces. That is caused by un-regulated, poorly regulated or inadequately treated sewage. Spills of sewage and municipal wastewater discharge, as well as untreated livestock waste, also contribute to this problem in rural environs. All this is claimed to lead to the illness of 700 million people annually, often with diarrhoea or viral hepatitis (Yu *et al* 2015: 5774).

China's rivers, aquatic ecosystems, wetlands, lakes and many indigenous species as well as biodiversity continue to be at great risk (Jiang 2015: 115). Vörösmarty *et al* (2010: 556) had previously shown that the greatest threats to human water security and river biodiversity in China had occurred in the highly developed, heavily populated reaches of the major rivers. The primary stressors were inappropriate levels of development, water overuse, intensive agriculture and heavy pollution. China grades its surface water quality from grade I, which is essentially pristine, to grades II and III, which are suitable to sustain aquatic life and for drinking water, to grade IV which is acceptable for industry and grade V for agriculture. In 2015 expenditure on environmental protection, including on aquatic issues, reached RMB 960 billion. Yet, despite the scale of that expenditure, 10 percent of surface water was essentially unusable and the proportion of water sources that met Grades I and II decreased by about 6 percent from 2013 to 2014 (KPMG 2016: 48). There has been growing public concern over water scarcity and water pollution, as well as air and food contamination to the point where the authorities have become concerned by the challenge this could represent to social stability (Xu *et al* 2016: 34; Miao 2015: 473)

Mitigation of the impacts of floods and provision of drought relief are critical areas of water-oriented responsibility requiring the continuous attention and involvement of the Chinese government. This is not a new priority, because for millennia each Chinese leadership has striven to overcome the threats and consequences of severe droughts and floods. The flooding comes with the annual monsoon season generally impacting more on the south, while severe droughts are usually most felt in the dry north. The urgency of the situation has increased as climate change has led to more severe floods as well as protracted droughts in some regions of China, as explored below. This leaves the authorities with the responsibility of forecasting, planning and responding to growing risks to human health and welfare, agriculture and food production, the environment and its ecosystems and the economy at large. Collectively, the risks are sufficient to threaten national security.

Throughout this text, the common roots of the water and environmental crises afflicting China have been recognised. Many water-related factors have contributed to widespread alienation of China’s productive land and to significant increases in the rate and extent of desertification. Entrenched industrial and agricultural practices, overharvesting of timber, wind and water erosion of soil, increasing water scarcity and climate change are all contributors (Albert and Xu 2016: 1-4). In 2015, 1.7 billion square hectares of land were estimated to be moving inexorably towards desert, with substantial implications for 400 million people (Albert and Xu 2016: 4). Rapid economic growth and demand for increases in exports and food production, have led to loss of land and water habitats essential for native plants, animals and healthy ecosystems. One consequence is that many nationally and internationally significant species are currently endangered and some are now extinct (Volis 2016: 45). In fact, China's rivers, aquatic ecosystems, wetlands, lakes and many indigenous species as well as the nation's biodiversity all continue to be under direct threat (Jiang 2015: 115).

Climate change in China already affects water quantity, water quality, the sea level in coastal regions, stream flows and the severity of monsoons, cyclones, floods and drought. As the world's largest emitter of greenhouse gases, namely 27%, China faces a massive challenge in curbing these effects (Climate Action Tracker [CAT] 2019: 2). While the nation leads in the development of renewable energy, it is also, paradoxically, the world's 'largest consumer of coal' (CAT 2019: 2). Flooding represents a critical and growing problem for China. In various locations, permafrost is retreating rapidly and glaciers are bursting more frequently, leading to flooding of adjacent river basins and the dislocation of the lives of millions of people (IPCC 2014: 1337-1341; Greenpeace 2018: 1). During the first half of 2020 massive flooding cost China $US 7 billion with 1.8 million people needing to be evacuated and one dam on a tributary of the Yangtze needing to be blown up to reduce the severity of local flooding (The Guardian 2020: 1-2). Meanwhile, in the whole of the north, climate induced temperature change, rapid urbanisation, demands caused by rising living standards and increased industrial development are combining to increase water scarcity.

Many studies have been carried out assessing the impacts, present and projected, of climate change on major river systems. For example, the Yellow River Basin, located in the semi-arid and arid zones of China, is central to development of the north and northwest. For the main reaches of the river, modelling shows that the ambient temperature is likely to increase by 1.6°C from 2001 to 2030, while precipitation will decrease by 2.6% and run-off by 11.6% (Wu *et al* 2015: 'Conclusions'). Of course, there are variations by geographic location in such a long river, but this is indicative of the scale of the challenges facing Chinese authorities, planners and managers. While China is projected to achieve its 2030 greenhouse gas target its actual emissions continue to rise year on year (CAT 2019: 2). Throughout this chapter the impacts of climate change on water security have been analysed.

In 1949 China embarked on an extensive program of structural flood-control projects, including rehabilitating reservoirs, building river levees, establishing flood plain storage zones and improving urban drainage (Osti 2017: vii). Since the 1980s, this has been followed by intensive and extensive construction of dams, weirs and pipelines, *inter alia*, to mitigate floods, to provide extensive hydropower and to improve water security for urban residents. However, there are many situations where the health of rivers, aquatic species and ecosystems as well as biodiversity have been seriously compromised as explored in Section 6.

3.0 SYSTEMIC CONSTRAINTS

The very unequal level of development of provinces and regions, vast disparities in incomes and the substantial variations in the capacities, performance and priorities of local government are ever present in any study of China and arise often in the text of this chapter. The analysis in this part of the chapter has been developed to better understand the context within which water-related plans, laws, regulations, programs and guidelines have been mounted. In contemporary China, the interplay of a complex web of political, economic, social, environmental, cultural, ethnic, administrative, legal and institutional arrangements and influences have shaped current approaches to water management. Collectively they have limited opportunities to introduce those reforms with the potential to improve national water security. By gaining a sense of the major processes as well as the reform inertia created by the systems, it becomes clearer why some water policies and programs have foundered at the implementation stage. It also helps to explain why, in a significant number of cases, water scarcity has increased and water conservation and water quality have actually deteriorated.

3.1 Political Framing

The direction in which President Xi Jinping continues to lead China will have an important bearing on future water and environmental security. As leader, Xi is strongly oriented to the importance of political power, a unified ideology, strengthening the position of the Chinese Communist Party (CCP) and consolidating his own power in shaping the nation's future (Brown and Berzina-Ĉerenkova 2018: 323-337; Farrelly *et al* 2019: xv-xvii). The Fourth Plenary of the 18th Central Committee of the Party reinforced this position by committing to strengthen the legal bases on which power is exercised and by ensuring that the rule of law remains at the focus of governance (Guo and Jiang 2017: 328). President, Xi (2015: 2) has harnessed his political power to shape the nation's prosperity, and sees the 'socialist market system' as the appropriate vehicle for improving national efficiency, productivity and innovation (Brown and Berzina-Ĉerenkova 2018: 323-324). Xi favours a resurgent state over many aspects of free markets and private investment (McGregor 2019: 1). Under his leadership, private investment and the role of the market have both diminished somewhat over past regimes, though as described in sub-section 3.2 he is pragmatic about harnessing private capital when the economy has weakened, the demands on the state are difficult to meet, and to fund major projects (McGregor 2019: 6-7).

As leader, Xi has argued for the formation of a ‘spiritual socialist civilization’ - a nation which eschews Western values as incompatible with Chinese civilisation, ideology and culture (Xi 2015: 2; Brown and Berzina-Ĉerenkova 2018: 8, 17). Past party leaders have encouraged devolution of power to provinces and also tolerated a measure of bottom-up change, examples of which are instanced in this chapter. However, Xi has shown a strong preference for centralised control and top-down policy development and governance drawing on the legitimacy and sovereignty of the CCP (Chen 2017: 651; Babones 2018: 5). In particular, environmental governance has been tightened and centralised under Xi (Kuhn 2018: 382-383). Given the disparities between the economic position of local governments, their motivations and capacities some Chinese scholars hold that administrative recentralisation is better suited to meeting the nation’s environmental challenges and delivering more sustainable development (Kuhn 2018: 383).

Under previous leaders some local initiated reforms in social, economic and administrative arenas received local governmental or provincial support and ‘leeway’ at the level of central authorities (Chen 2017: 666-668). That led to locally beneficial water-oriented change and adoption of local water management innovations across regions. While that is less likely to occur under Xi, pilot and experimental projects have continued to be tested in the regions. That led to the development and testing of possible models for national water trading, under significant state controls and direction throughout (Jiang *et al* 2020: 251-252).

In China, over the millennia, water has been a central element in shaping political power, political legitimacy and social stability. The people have always depended on water not only in their daily lives but to feed the spiritual, philosophical and artistic side of Chinese culture and living (Ball 2017: 6). Since the late 1970s, modern Chinese leadership has continued to hold firmly to the traditional view that mastery over the country’s waters is a powerful symbol reflecting its ‘right to rule’ (Ball 2017: 218). A major example, can be found in Section 6, where the role of China’s leadership in establishing a vast network of mega-dams and canals, reservoirs, weirs and hydropower projects is examined.

This approach to governance has been framed politically by the keen desire of the CCP to have the nation perceived as an international leader in economic, scientific and technological development. Yet, some decisions to construct water infrastructure have led to the displacement of many millions of people and the dislocation of their lives. These impacts are sufficiently widespread and well-known for some experts to suggest that the public-at-large will strive to limit the future exercise of state power and use of state instruments of governance in this way (Rogers and Crow-Miller 2017: 1239 'Approaches'; Miller *et al* 2017: 234). However, the power of the assemblage of corporate entities, ministries, departments, universities, foreign corporations and international organisations seems sufficient to this day to hold sway over current political leaders, particularly when they need to respond to water scarcity or severe flooding (Webber and Han 2017: 1451-1457).

Until very recently, economic development in China and the drive to provide energy and water for burgeoning cities and their industries have relied heavily on the environment to provide extensive natural resources, while also serving as a sink for agricultural, domestic and industrial emissions and waste. This pattern of development was unsustainable and led to grave water wastage and pollution, deforestation, loss of surface water and arable land. The political need to maintain governmental legitimacy and social order has been severely tested as these issues have become unifying foci for widespread community dissent and civil protest (Ball 2017: 308-312). These protests have been driven by various influences, including the scale of pollution, land and water alienation, social and economic disparities, and the failure of water management and infrastructure strategies to deliver visible improvements (Gill 2017: 'Domestic Challenges').

As a counter to the threat that such widespread damage and unrest poses for China's future environmental, social and economic goals, China's leaders have introduced major water, air and environmental reforms. But subsequent sections show that there have been insufficient systemic and institutional changes. Some commentators contend - and the substance of this chapter supports the proposition - that the way the nation deals with its water and related environmental problems will define the path of its future development (Ball 2017: 310-314).

China is an extremely diverse country in terms of geography, the spread of its natural resources and ethnic populations, its urban, agricultural and industrial strengths, and the distribution of wealth, life styles and culture. It is therefore unsurprising to find marked differences in the political priority accorded to the implementation of water policy and water regulations by county and local politicians and administrations. There are variations in local understandings in the implementation of national legislation, including differing interpretations by local courts (Ball 2017: 312). As well, there is the persistent problem of corruption that undermines policy implementation at all levels of governance in China – an issue which Xi has tackled very widely with great vigour. Some of the political leaders recognise that it is impractical to expect uniform implementation of centralised policies across the whole nation and that some local variations must arise (Stratfor 2016: 5). However, the counter view is that too much water policy and regulation has been 'reshaped by the interests of those who implement them' (Rogers and Crow-Miller 2017: 1239 'Hydropolitics').

In 2015, the World Bank (2015: 10) invited more than 500 of its stakeholders in China to list development priorities for the nation. It is notable that 42% rated government effectiveness and governance as the top priority issue by comparison with 18% for economic growth. This illustrates just how central these informed citizens viewed good governance to be in achieving key goals in contemporary China. This chapter shows that the leadership has an urgent and major role to play in reducing political and administrative limitations on the coherent management of water resources, environmental restoration and protection and sustainable development. All such changes have the potential to contribute to improved water security.

3.2 Administrative Structures

The CCP has over generations mediated political participation and channelled much public activity as a result of the way the state has laid down formal institutionalised, hierarchical structures and procedures. When faced with the need to carry through major reforms which necessarily alter the distribution of power in this complex system, the CCP has often found new ways of shoring up its influence. For example, it has built over some decades a hierarchy of organisations from village and neighbourhood levels to county, provincial and the central bodies in Beijing (Saich 2015: 85). Similarly, while villages and farmers are now able to manage more of their own affairs and operate more commercially in an increasingly market-driven economy, the Party has been able to maintain key elements of the rural political structure and advance its political interests through Party membership in branch and village committees and by exercising influence over key township officials (Chen 2007: 161, 170; Sun *et al* 2013: 733). The CCP has also placed government or Party officials in key positions in some of the myriad non-governmental organisations that economic reform has spawned (Nickum 2010: 540).

The administrative division of China, which is essentially hierarchical in dealing with day-to-day administrative tasks, is widely recognised as contributing to the complexity of administrative process and to spawning inefficiency and may contribute to corruption. Though President Xi continues to lead the sweeping anti-corruption campaign, localised corruption of legal, financial and public services and processes still casts a shadow over many land and water development outcomes. The nation is divided into provinces which in turn are subdivided administratively into prefectures, counties and cities, and counties are subdivided into townships and towns. There exist a number of further special administrative arrangements, largely under the control of the national government including some municipalities and large cities as well as autonomous regions, prefectures, counties and townships. When the term ‘autonomous’ is used in China, it is often viewed by the authorities as connoting a modest degree of ethnic autonomy.

This whole cumbersome system has been subject to intense pressure from within. Changes occurred as the drive towards a more market-oriented economy began and the state decentralised considerable policy implementation and economic management to the provincial level (Mertha 2005: 791-3). Where economic actors and private enterprises played a part in modernising the economy a higher degree of autonomous local action progressively emerged. For instance, private capital and public-private partnerships were introduced into water supply, wastewater treatment and major water infrastructure projects (Tan 2015b: 1). Over time these processes necessarily led to further changes in the legislative and administrative systems. Under Xi, the state has endorsed some private initiatives directed at the provision of advanced water services for the growing urban middle class - primarily because the state does not have the capacity to keep pace with demand (Wang 2017: 211). Despite these changes, the basic structure of major systems has remained intact, but they have become somewhat fragmented by market forces and processes of past devolution and decentralisation (Rogers and Crow-Miller 2017: ‘Hydropolitics’). These are features of what experts often describe as the ‘fragmented authoritarian state’.

There are many less formal administrative arrangements and pathways of influence in modern China. Chinese society continues to be built on strong networks of personal and family connections which operate across administrative barriers. That is especially useful when local resource allocation powers are linked to development projects (Nickum 2010: 544). There are many forms of 'democratic localism' particularly in the cities where grassroots community institutions mediate various stakeholder interests (Wang, Lieu *et al* 2018: 149). There is also more policy change pioneered at the local level, which ends up influencing economic, administrative and political realms, than the centralised, top-down institutionalised process might suggest or the President support (Kuhn 2018 378). Countless complex vertical and horizontal *informal* links exist between Party committees, ministries, inter-sectoral bureaucracies and leadership co-ordinating groups. These arrangements can be helpful but equally can interfere with policy implementation and regulation by creating additional bureaucratic hurdles and contradictory decision-making processes (Saich 2015: 118-9).

There are large numbers of informal groups and networks which advocate social change and challenge the established order, some of which do so without resisting the state while others actively foment dislocative social protest (Zhang 2017: 286; Gill 2017: 'Domestic Challenges'). In various sections of this chapter reference is made to local examples of successful and peaceful challenges to established systems in order to achieve improved environmental and water management outcomes. One such example is to be found in Baoding in Hebei, where existing hierarchical structures have been set aside as local government has shaped a clean energy technology hub and a low carbon city program (Shin 2017: 549-551). People in the local agencies have developed a professional circle that openly exchanges information, sets common goals and jointly solves problems. So productive bottom-up change is possible but is not commonplace. If others are to benefit and wider reform is to occur in entrenched systems, the state needs to offer more than one-off tacit support for such innovations.

China has played a significant role in establishing the UN blueprint '2030 Agenda' for global sustainable development and has prepared an ambitious implementation plan for the nation UN 2015; Ministry of Foreign Affairs [MFR] 2016). That has led to a series of new targets such as: 'by 2030 achieve universal and equitable access to safe and affordable drinking water for all … (as well as) … adequate and equitable sanitation and hygiene for all' (MFR 2016: 32). It not obvious that other even more ambitious goals are achievable, based on current programs, legislation and institutional frameworks. Examples of these goals include 'restore functions of water ecosystems' and 'enhance the role of comprehensive river basin management in water governance' (MFR 2016: 32-33). The plan as articulated reflects the inputs of many experts who doubtless aspire to see such changes occur. The exercise does show that some leaders recognise that stakeholders must be involved in setting and securing such goals and in monitoring implementation (Kuhn 2018: 384)

3.3 The Legal Framework and the Changing Law

Since ancient times, the Chinese state has taken a controlling role in the allocation of water resources, *inter alia*, to reduce loss of life and livelihood during floods and more recently to create infrastructure to mitigate floods, provide hydropower and safeguard irrigated agriculture and food production - as well as water resources during drought. Analysis in later sections reveals that present policies have produced quite variable results for water security.

In 2002 the People's Congress amended the 1988 Water Law. Under the provisions of that amended law, efforts were directed at more sustainable management of water resources. The previous approach had been heavily geared towards water engineering and development of water infrastructure to supply growing needs for water. The main foci of the amended law were water use efficiency and conservation; control and prevention of water pollution; an improved system for licensing water rights and allocating water resources; and, somewhat greater exercise of water management responsibilities by river basin authorities (China Information Center 2002: 1-3; Cheng and Hu 2012: 265). These issues and the challenges ahead are examined in subsequent sections together with assessments of program effectiveness. The law was given effect through local regulations, but it was recognised that provincial congresses could take account of local circumstances (Jiang 2017: 46).

As rapid industrialisation continued, water pollution and water scarcity grew more pervasive. Climate change has aggravated these problems. In the period 2008 to 2015 the state responded by revising the established *Law on the Prevention and Control of Water Pollution*. The Twelfth Five-Year Plan was promulgated, the 'Three Red Lines' policy was introduced and 'Guidelines on implementing the stringent water resources management system' were issued (GWP 2015: 6). In aggregate, these plans laws, policies and guidelines committed the nation to an urgent and coordinated effort to overcome water pollution; improve surface and groundwater quality; improve water conservation and water use efficiency in industry and agriculture; and curb water demand. Targets were set for 2020 that aimed to limit the increases in water usage and to improve water use efficiency and freshwater quality (Wang, Wan *et al* 2018: 419-420). In later sections it is shown that only some goals were achieved and that many of the targets did not reflect the seriousness of the challenges. In 2016, ADB

(2016: 26) showed that the major difference in national water security between China and Australia and Japan could be ascribed to less effective governance arrangements in China.

The Chinese authorities responded to the unintended consequences of rapid industrialisation by modifying the regulatory framework. That included efforts to secure effective and ‘stringent regulation of water resources management’ by assigning specific responsibilities to each province, autonomous region and municipality to control pollution, patterns of water use and efficiency in use (GWP 2015: 23). Each authority became responsible for reporting progress against targets and working plans developed by provincial governments (GWP 2015: 23). Each provincial government was, in turn, required to complete an annual evaluation of performance for appraisal by the (MWR) Ministry of Water Resources (GWP 2015: 23). A central agency group was also formed to make random inspections, check progress and examine the controls applied.

These represented early steps by the state under Xi to ensure that industry was complying with environmental standards. To 2017, thousands of facilities had been inspected, $130 million fines levied and numerous plants closed. Government incentives were provided for projects in areas that were performing well and approvals were withheld where performance was poor (Stratfor 2017: 1-6). While it is clear that air quality in many major cities is continuing to deteriorate, it is too early to judge the long-term contribution of these measures to water security, quality and quantity (Stratfor 2017: 4).

3.4 Role of State Actors

This section deals with the main state actors associated with water resources management and water policy development and implementation in China. It builds on the exploration in preceding sections which reveals how many political, administrative and legal actions can either support or interfere with attempts by the national government to drive comprehensive and effective water policy reform and its implementation. One focus lies on the consequences of poorly delineated, competing and at times conflicted responsibilities and goals of ministries of state. Another deals with the overlapping and complex shared relationships between levels of government. This bureaucratic complexity is the cause of frequent failure by the state to achieve its policy goals for water management in China.

Prior to 2018, the national ministries listed in Table 3.1 exercised some role in the management of China’s water resources, in ways that influenced national water security. In particular, there was overlap in responsibilities for water pollution control as well as water resource use, protection and management. (Huang and Xu 2017: 425; Zhao 2015: 69; Cheng and Hu 2012: 266). Other nations, including Australia, have complicated ministerial arrangements at several levels for water resource policy and management and experience difficulty in achieving both role differentiation and horizontal coordination. However, in China there is the added complexity that each ministry has hierarchical arrangements spanning central, provincial, county and municipal levels (Huang and Xu 2017: 425; Jiang 2015: 110). For instance, MWR has overseen an evolving but highly centralised system in which water usage rights have been allocated administratively through its hierarchical system to regions and enterprises, as elaborated further in Section 6.

Table 3.1 Ministerial Water-Oriented Responsibilities

Ministry (Bureau)	**Responsibilities**
Water Resources (MWR)	Resource allocation, governance, irrigation infrastructure, water use
Environment Protection (MEP)	Protection and conservation, discharge quality, pollution control
Health	Drinking water standards
Housing and Urban-Rural Development (MHURD)	Urban supply, use, distribution and disposal, river infrastructure
Agriculture (MOA)	Agricultural water allocation
Geology and Mines	Checking groundwater levels
Land and Resources (MLR)	Management and exploitation of natural resources, including land
State Price Bureau	Provincial water price guidelines
Ecological Environment (MEE) from 2018	All previous MEP, some MOA, MWR, MLR and other functions
National Resources (MNR) from 2018	All previous MLR, some MOA, MWR, MHURD and other functions

This has contributed to weak oversight by ministries of local implementation as well as inter-ministerial competition and conflict in the regulatory and administrative operations. Yao *et al*

(2017: 2339 ‘Introduction’) state that: ‘The administrative structure of China’s agricultural water management has grown into a vast and complex bureaucracy with overlapping competences and responsibilities’. Many other Chinese experts have examined and commented on these overlaps and the associated confusion and conflict. They point to the failure of the state to ensure that action is concerted in ways that resolve common problems of policy, role definition, oversight of implementation and post regulation monitoring and assessment (Zhao 2015: 68-71; Cheng and Hu 2012: 265-268).

During 2018, some of these institutional arrangements were changed dramatically. In China’s ‘Two Sessions’ most notable for making Xi ‘President for life’, the new constitution referred to an ‘ecological civilisation’ (Xu *et al* 2018: 2). As a result of deliberations in the Two Sessions new ‘supersized’ Ministries of Ecological Environment (MEE) and Natural Resources (MNR) were formed. A primary task of MEE is to manage the nation’s ecological systems and protect its natural environment, including fighting all forms of pollution and managing the effects of climate change (Xu and Chan 2018b: 4-5; Cheong 2018: 2-3). MNR is to map ecological red lines across the nation to protect natural resources. It will also approve and manage future resource developments, including by assessing environmental ‘carrying capacities’ (Xu and Chan 2018: 7). These are major reforms but they will not bear any fruit during the currency of this thesis.

While the state and its major ministries are powerful and controlling, there are many regions, prefectures and counties which have their own people’s congresses and governments which introduce regulations and legal orders. With the introduction of the amended Water Law, state ownership of water resources was retained but some devolution of administrative responsibilities occurred to the provinces, which then had the power to distribute water to end users (Cheng and Hu 2012: 264-265). In this way, responsibilities for water governance became shared at several levels of government. The situation has become more complex where government services have been converted to state-owned enterprises in urban settings and when there has been increased reliance on subcontracting and competitive procurement (Nickum 2010: 540; Bhullar 2013: 318).

The State Council and National People’s Congress are responsible for formulating coherent national policies, but provincial and local governments also have mandates spanning ‘water utilisation, conservation and protection, water planning, water disaster management, and water disputes resolution’ (Jiang 2017: 50). They have statutory roles for agricultural land use planning, water conservancy and environmental protection as well as for water that flows through their jurisdictions (Huang and Xu 2017: 425 – 431). Centrally promulgated rules, orders, plans and regulations are pre-eminent, but provincial, departmental, river basin and local level rules also exist, as well as adjustments to national policies to meet particular local needs (Webber and Han 2017: 1446). While there are many water resources authorities and bureaus with responsibilities for water use, water conservation and flood control, at various levels of government, none can override the exercise of authority by national ministries.

4.0 CONSERVING AND PROTECTING WATER

This section deals with water conservation and efficient water use, controlling pollution and improving water quality. While these four issues all interact in their impacts on water security, food security and the security of manufacturing industry, in China separate national policies, programs, laws and regulations have been developed to deal with each (CWR 2014a: 1; Tan 2014: 1).

As recently as 2015, only 5% of surface water existed in pristine condition, urban water supply interruptions and shortages were commonplace and 300 million rural dwellers faced significant health risks, including through lack of safe drinking water (Abbassi *et al* 2016: 15; Knowles 2016: 2-4; Hu 2018:8). In many places water quality continues to deteriorate because industrial and sewage treatment and disposal processes remain inadequate and efficiency in industrial and agricultural water use is inadequate (WEPA 2018: 44; WHO/UNICEF 2017a: 79). Weak laws and poor implementation, inadequate monitoring of discharges, low penalties and collusion between industry and environmental assessors have all been contributors to this situation.

The government's initial efforts were directed at stabilising and controlling water pollution, followed by an active legislative phase. This was founded on the Laws on Prevention and Control of Water Pollution and Environmental Protection, the Water Pollution Prevention and Control Action Plan (known as the 'Water Ten Plan') and the 13th Five Year Plan for Ecological and Environmental Protection. In the same time frame, work continued on improving drinking water quality through targeted reductions in untreated and poorly treated domestic, industrial and agricultural wastewater discharges and through enhanced monitoring (Tan 2015a: 1; 2015b: 1; Knowles 2016: 4-5). Later efforts to require large water consuming industry to use recycled water and to improve wastewater treatment were given an extended time-frame to 2040 (Dickey 2017: 8). That reflected the scale of the treatment challenge, rather than the urgency of the need to control and prevent pollution. All stationary sources of water pollution were to be licensed by 2020, with thermal power stations, pulp and paper, steel and cement the early targets (State Council 2016a, b:1; Li 2015: 8). The licences cover types of pollutant, amount and concentration, and accord with state emission goals.

These traditional control strategies have been complemented by the introduction of some new approaches to pollution control. In 2018 the Environmental Protection Tax Law took effect, under which a series of pollutants, including water pollutants, were to be taxed to drive the upgrading of treatment and shift industrial practice to 'cleaner production' (State Council 2016b: 1; Cicenia 2018: 1-2). The effectiveness of this measure will be undermined if provincial governments deliberately set low rates to attract or maintain a strong manufacturing base (Cicenia 2018: 3). In 2016 a new 'River Chief' mechanism was introduced with 900,000 chiefs having been designated by the end of 2018 (Hu 2017: 3; CWR 2018: 3-4). There are four levels of chief namely provincial, urban, county and township. Within the jurisdiction of each chief there are responsibilities for environmental and water quality performance in rivers and lakes, the state of which is to be made publicly known (Hu 2017: 3-5). Those who succeed are to be rewarded and promoted. A group of national and international experts have already indicated that the 'executive capacity of the river chief system' is not sufficient to solve major environmental issues (China Council for International Cooperation on Environment and Development [CCICED] 2019: 2).

In more traditional terms, the Supreme People's Court has set up a tribunal to review pollution episodes, which is empowered to punish severely corrupt officials, and to require government officials to report on their degree of success in achieving environmental targets (Tan 2015b: 2). The state has also shut down hundreds of heavy polluting small industries such as paper manufacturers (Jiang 2017: 72). More generally, violations for industrial and sewage pollution are being punished severely by fines, plant shut-downs and gaol, and industry is being required to monitor water pollution levels. (CWR 2017: 1-2; 2018: 3-4; Xinhuanet 2017a: 1-3).

Conservation of existing groundwater resources represents a major challenge because they are widely used by industry, agriculture and urban water utilities. That is one reason why so many national aquifers are severely contaminated by industrial, agricultural and domestic waste. In the period 2001 to 2015 national groundwater use increased by 3.1% nationally over the earlier period 1980 to 2000 (Yu *et al* 2018: 448). By today, there has been significant over-exploitation, particularly in the four major river basins of northern China, widespread aquifer depletion, 50 cities needing to deal with ground subsidence, coastal seawater intrusion and increasing and accelerating desertification in arid and semi-arid regions (Yu *et al* 2018: 449-453)

The coal industry is responsible for 20% of water withdrawals in China (Davies and Westgate 2018: 1). It uses water in mining, coal preparation, transportation and conversion, and for the disposal of wastes which can contain heavy metals and other chemicals (Jiang 2015: 120). The majority of coal deposits and coal-based enterprises are located in the north, frequently in places where water quality is poor, water shortages are severe and the environment is fragile (Xia 2017: 4). Some 60% of the nation's coal-fired thermal power capacity is also located in the north (Jiang 2015: 120). Since 2013 the Chinese authorities have issued many plans and documents directed at improving treatment and efficiency in use of water by the coal industry. Key documents issued by the Ministry of Water Resources and the National Energy Administration focus on avoiding further contamination of water sources, particularly groundwater, dramatic improvements in water reuse and high quality treatment of wastewater prior to discharge (Thieriot 2015: 1-3).

4.1 Results and Residual Problems

In 2015, a working group of ministries and commissions led by the MWR evaluated progress in achieving effective water management by examining compliance with the targets set in 2010 across the 31 provinces and the autonomous regions of China (Wang, Zhang *et al* 2018: 905-906). These targets recognised the need to start the long journey towards improving water use efficiency and water quality, notably by reducing pollution. Only in some zones of major rivers and lakes had water quality improved (Wang, Zhang *et al* 2018: 905-906; MWR 2017: 1-3). A study had previously found water quality across all sources in mainland provinces met only 55% of the minimal Chinese water quality standards applying in 2015 (Boren 2017: 2).

These results did not meet international standards, as demonstrated by an independent study led by the Hong Kong Productivity Council. It examined the performance of 36 highly polluting textile and leather, electronics and metal finishing industries at undisclosed locations across China. It found that 67% of water used by these industries could have been saved, that 60% of water necessary to production could have been recycled, and that wastewater pollution levels could have been reduced if waste streams had been treated separately and effectively (Ma 2017: 1-2). The authors of the study indicated that *provided that its recommendations were followed*, both production costs and water pollution would be greatly reduced, and the water supply of 57 million people in the Pearl River Delta region would be significantly improved (Ma 2017: 1-2).

During 2018 the new Ministry of Ecology and Environment (MEE) issued its ‘2017 Report on the State of the Ecology and Environment in China’ (MEE 2018). The report reflects more serious recent intent in monitoring and reporting on national water quality. The report shows that in the seven major river basins the Water Ten Plan target of 70% surface water reaching Grade III or better by 2020 would be met by the Yangtze and Pearl Rivers, but not by most major northern rivers. For example, in the case of the Yangtze there was an improvement from 82.3% in 2016 to 84.5% in 2017, whereas in the case of the Huai River the result deteriorated from 53.3% in 2016 to 46.1% in 2017 (MEE 2018: 18-26; CWR 2018: 7-8). Meanwhile water quality in groundwater and lake systems was also shown to have continued to deteriorate. That led the government to introduce prohibitions and limitations on some sources, to propose step-wise national reductions in use, and to encourage urban centres to seek alternative sources to groundwater (Yu *et al*, 2018: 456-458). Shen (2015: 61) favours major restructuring to overcome deep-seated problems caused by uncoordinated management and regulation at several levels and by the failure to focus collective effort on sustaining each aquifer.

In many catchments compensation schemes and arrangements have been developed in which the polluter is rewarded for improved water quality in a key reservoir for drinking water or is obliged to compensate those who have lost water quality. Compensation mechanisms have also been developed between upstream and downstream users and between levels of government, cities, farmers and industries. This approach has been examined in detail in the case of water quality in the Danjiangko reservoir serving Beijing residents and surrounds (Pohlner 2019). At the same time, pollution control policies have led to enterprise bans and closures and to replacement of some water-intensive crops. While the principles of compensation and polluter pays underlie these approaches, they have not been scaled up because the results are ‘limited and patchy’, not all actors have equal negotiating power and resources and the payment of compensation has been uneven (Pohlner 2018: 100023, ‘Conclusions’).

Despite stronger regulation of pollution and water use many coal industry enterprises, and other extractive users, still exhibit poor water conservation practices and inadequate wastewater treatment (Xia 2017: 2). The results have not met the authorities' expectations, in part because there are significant differences in the targets for reuse of mine water between those set by key central ministries and those adopted by several provinces (Thieriot 2015: 2). Yet, in 2013, MWR is reported to have set the ambitious standard of 100% reuse of mine water by 2020 in water scarce regions (Thieriot 2015: 2). A water risk assessment tool was developed in 2017 which allowed the water usage and wastewater discharge practices of 30 of the major coal companies in China to be assessed (Xia 2017: 2). The majority were found to have more than 100 violations of discharge regulations and to have failed to disclose violations, clean-up and environmental performance in annual reports (Xia 2017: 4). None of the companies provided feed-back on the trial or the results obtained (Xia 2017: 5). Unfortunately, the responsible provinces were also relatively unresponsive (Xia 2017: 4).

Of total water use in China, agriculture is the largest user, taking more than 60% of accessible water, chiefly for irrigation (Jiang 2017: 77; Hu 2018: 5). While productivity in use has improved over the decades, the overall efficiency of irrigated agriculture in water use and in processing wastes is poor compared with that of developed countries, as further explored in Section 7 (Wang, Zhang *et al* 2018: 902-903; World Bank 2017: 3-17). For example, in 2016, the ratio of water used productively on crops versus total water supplied was 0.55 in China compared with the superior results of 0.7-0.8 in most developed countries. One reason is that public investment has been directed into dams and flood mitigation rather than into aging agricultural infrastructure and water conservation in agriculture (General Office of the State Council [GOSC] 2016: 2; Yu *et al* 2015: 5776). Another is that farmers have too often been called on to save water, change crops and rehabilitate land at the same time as water has been taken from their traditional allocations to meet municipal and industrial shortfalls (Jiang 2017: 77).

The General Office of the State Council (GOSC 2016: 1-3) acknowledged that water infrastructure in agriculture had made only a weak contribution to water conservation. He advocated increased use of water markets and more effective water pricing as tools to improve future water conservation (see also sub-section 7.2). However, water price reform has tended to founder, in part because the costs of administration and fee collection from small dispersed farms are too high (Yao *et al* 2017: 2339, 'Regulation'). Water permits, issued through a variety of arrangements, determine the amount of water that can be used for crop production. Where farmers have concentrated on water-saving and higher value crops, that has had the perverse effect of increasing irrigated areas and water use (Yao *et al* 2017: 2339, 'Discussion'). At the same time, approximately half the water withdrawn for irrigation is being lost through evaporation and leakage (Jiang 2017: 16). All these issues have been further explored in Section 7.

One useful way forward was identified by the World Bank (2016: 1-3), through a series of projects in China's water scarce north. These studies identified problems in agricultural practice, water consumption in irrigated agriculture and evaporative losses that were all contributing to low water use efficiency. Project goals included helping farmers to increase their understanding of both contemporary farming practice and the law. The Bank instanced a village in Guantao County where the villagers developed their own water rights and sharing system, supported by the county administration. Local awards were given to those who reduced water consumption and prices were increased for those who over-used water (World Bank 2016: 2-3). Unfortunately, such projects and advances have not been widely replicated or supported.

In 2016/17 the Chinese government set out to further restructure its primary industries with water and food security in mind (State Council 2016d: 1; United States Department of Agriculture [USDA] 2017: 1-19). This involved establishing optimal growing regions for staple grain crops, identifying more appropriate areas for growing other commodity crops and moving towards best practice in animal husbandry and agriculture (State Council 2016d: 1). Direct controls were introduced to reduce the area of irrigated farmland, to restrict the cultivation of high water-using crops and introduce a water permit system for agricultural users (Yao *et al* 2017: 2339 'Discussion'). The initiative was also designed to reduce the impact of agricultural chemicals on water ways, return disused agricultural land to grassland and forests, conserve water and reduce soil pollution (USDA 2017: 1-9). Some pricing reforms were progressively introduced from 2016 to manage water demand, improve water monitoring and encourage water saving in irrigated agriculture (State Council 2016e: 1). Government funds were allocated to help overcome local government funding shortfalls and improve the rate of introduction of new agricultural technologies and infrastructure (Yao *et al* 2017: 2339 'Introduction').

Increasing public concern at lack of progress in reducing pollution, system failures and water scarcity has recently led the government to require public releases of pollution data, the introduction of procedures to facilitate citizen reporting of industry non-compliance, and other ‘government organised’ citizen participatory processes, *albeit* through the traditional, hierarchical political system (Knowles 2016: 6-11). In 2019, the president of a Japanese think tank observed: ‘China’s water crisis stems primarily from its inability to halt water pollution and waste’ (Funabashi 2019:1)

4.2 Consequences for Water Security

Throughout the 21st century, the Chinese state has drawn on its extensive powers to introduce major measures directed at overcoming water pollution, increasing water conservation and water use efficiency as well as advancing the treatment of sewage effluent and wastewater. The mix of command and control management measures, supported by some economic and market instruments and substantial public financing of water infrastructure and treatment, shows a high level of state commitment to improving water availability and source water quality. However, there are increasing signs that both the authorities and citizens are dissatisfied with the rate of reform and the lack of acceptable results. There are a number of causes, including the institutional constraints created by existing PRC systems; the unmanageable pace of policy and legislative change; variable local and regional policy implementation and enforcement; and, the failure of much industry to meet national standards. As a result, all these programs are making only a limited contribution to water security for the state and for future national preparedness.

An overarching objective has been to achieve water quality and quantity sufficient for human consumption, industry-at-large and food production, as demonstrated by the number of state reforms. Standards of human sanitation and the quality and reliability of drinking water and industrial water in cities have improved steadily over recent decades, with intermittent system failures. The situation in rural and agricultural regions is, however, progressing slowly from a very low base. There is a long way to go in efforts to achieve comprehensive water security for the welfare of all citizens.

Water security for the environment is elusive, despite the scope of the network of laws and regulations as well as the scale of efforts to curb pollution and conserve water. In all these initiatives, there appears to be little recognition by authorities that aquatic systems take time to recover from past insults – some systems may never recover. As observed throughout this chapter, there have been essentially no measures developed to advance water security through whole system management of complex water-based systems or to monitor present and future river basin health. Any prospects of near-term system recovery of critical groundwater systems and major surface waters in the north can only be viewed as unlikely aspirations.

The influence of this group of programs on the long term water security of many consumptive primary and secondary industry users remains uncertain. There are multiple institutional causes as well as the failures observed above of some industries to achieve even moderate national targets for water quality, water conservation and water efficiency in use. That has led the authorities to close polluting industrial plants, modify agricultural sites and practices and to use legal process to enforce its requirements. Corrective action depends on effective monitoring of the results of program implementation. At present that is so weak in many arenas, including those affecting water security, that the State Council has introduced new measures to advance state policy implementation, monitoring and enforcement. These Council requirements and wide-ranging coercive measures are too recent to have led to visible improvements in the four water security domains.

5.0 RIVER BASIN MANAGEMENT AND PLANNING

The future health and resilience of the major river basins systems of China is critical to its water security and represent a significant factor in determining the nation’s future economic prospects. There has been very considerable national and international research into various facets of river basin management and planning in the main river basins of China. In the 1990s river basin plans were developed for the seven major river basins and their important tributaries and early efforts were made to link river basin and land use planning, under the aegis of seven basin commissions. In accord with the Water Law of 2002, basin plans were revised, and a National Integrated Water Resources Plan as well as plans for flood control, water saving and reservoir reinforcement were introduced (Pegram *et al* 2013: 29-30).

While, in theory, the seven basin commissions exercise governance over the major river basins, in practice they have been subject to direction by MWR in policy, planning, water allocation and program implementation and must comply with many state directives and national laws (Huang and Xu 2017: 425, 431). They are not permitted to interfere with regional administrative actions or decisions or with major national water diversion projects (Nickum 2010: 543; Huang and Xu 2017: 425). Such constraints limit the capacity of the commissions to manage the rivers as whole systems. There are some similarities in the legislative and administrative constraints faced by the Murray-Darling Basin Commission in Australia, as explored in Chapter 2. However, the situation facing the Chinese basin commissions is more complex, in terms of overlaps in responsibilities and the scope of regulatory and administrative requirements. For example, overlaid on the role of river basin commissions are the intersecting interests and responsibilities of towns, cities, counties and provinces in relation to water management, agricultural land use planning, water conservancy and environmental protection (Huang and Xu 2017: 425 – 426).

The Changjiang Water Resources Commission (CWRC) with responsibilities in the Yangtze River Basin serves as an example of the roles actually discharged by basin commissions. It is a major public body, with 20,000 employees, two supporting bureaus dealing with the Yangtze River Basin and hydrology and the ASEM Scientific Research Institute (ASEM 2018: 1). Most staff are engaged in tasks such as flood control, drought relief, water quality monitoring, regulation and administration. They issue water permits, monitor water withdrawals, apply penalties and seek to assure the optimal use of water in industry, navigation and irrigation (Zhou 2010: 10-20). These roles have been reinforced by the State Council through a series of further directions spanning water saving, efficient use and distribution, flood and drought measures and improved water management (Pegram *et al* 2013: 30). The Commissions have further responsibilities for basin master plans, mediation of water disputes, reviewing storage and water inflow data, examining water quality and pollution levels and building, managing and operating significant water projects (Qian and Wang 2017: 138; OECD 2015b: 1; Zhou 2010: 10-20). Many of these latter roles are at best only partially discharged for the reasons adduced in the following section.

5.1 Results and Residual Problems

In 2016, the floods in China caused $US 38 billion damages and the loss of 800 lives, which represents the second most costly disaster of its kind in Chinese history (Osti 2017: 1-2). While, the Yangtze River Basin alone received 20% more than its average flood season rainfall in that period, the greatest impacts were on small and medium sized tributaries and sub-basins, as well as on reclaimed land around lakes (Cheng *et al* 2018: 307, 2; Osti 2017: 9). In these locations, there were thousands of breaches in dykes, serious flooding of cultivated land and large numbers of people evacuated. The pattern of investment in dykes and dams, many of which had been strengthened or increased in height since the floods of 1998, mitigated the effects of these 2016 floods on the infrastructure in the Yangtze River itself (Cheng *et al* 2018: 308-309).

Another major role of basin commissions is to deal with the aftermath of drought and to provide effective responses and relief. In that regard, China has been argued to have a ‘finely tuned’ disaster relief and response system (Zhang *et al* 2012: x). However, the challenge in both mitigating and ameliorating the worst impacts of drought runs much wider than the present remit of the basin commissions. For example, mitigation has largely been met through continuing reliance on heavy-engineering, supply-side construction of water storages and water pipelines, as examined in Section 6. One consequence is that when droughts are severe, serious secondary problems emerge such as the need to deal with extensive sedimentation in water storages, extensive drying up of some water sources and contamination of others.

China has a network of policies, programs and regulations aimed at curbing water demand, as examined and reviewed in Section 4. Because of weakness in implementation, these strategies are not making a significant contribution to overcoming water shortages and the effects of severe droughts (See sub-section 7.2). Causes include the failure of management strategies to deal with the scale and pace of urban, industrial and intensive agricultural development, and poorly contained water demand in areas of existing water shortage (Zhang *et al* 2012: x). In 2012, the Asian Development Bank raised the need for a more integrated and whole systems approach to planning and managing the impacts of significant droughts (Zhang *et al* 2012: ix - xi).

Since 2015 the role of basin commissions in controlling water pollutants, understanding the capacity of basins to cope with pollution and preventing deterioration in water quality has been strengthened somewhat (Huang and Xu 2017: 425). Under the Water Pollution Prevention and Control Plan, the management of pollution control has relied on a zoning strategy, which was also designed to help coordinate water management across levels of government (MEP 2017: 1; Deng, Lin *et al* 2017: 1374 ‘Introduction). Although the zoning process is supposed to take account of hydrology, type and distribution of pollutants, land use and administrative changes, the lack of a common focus by all state entities on the long-term welfare of the basin makes it unlikely that these requirements will be met (Deng, Lin *et al* 2017: 1374, ‘Conclusions’). While efforts to control pollution through zoning have been promoted as a sound response to pollution control, *no* significant improvements were reported in 2017 (Deng, Lin *et al* 2017: 1374, ‘Introduction’; Wang, Zhang *et al* 2018: 902-903).

There have been many projects and programs designed to reverse environmental degradation and recover floodplain land for flood storage. Some projects have been quite successful. For example, in 2002, in order to deal with periods of no-flow under drought conditions, the national government introduced controls on extractions in upstream provinces of the Yellow River - with monitoring which could trigger action, if needed (Connell 2013: 4). On the other hand, more intensive agricultural activity and greater economic development of reclaimed land has often aggravated flooding and exacerbated its impact (Osti 2017: 8; Cheng *et al* 2018: 307-308). Here again the commissions do not have the necessary authority to ensure that all instrumentalities focus on the health and security of the rivers, their ecosystems and their communities.

Between 1998 and 2015, $US 350 billion was invested in improving 620 million hectares of land, much of which fell within major river basins (Bryan *et al* 2018: 193-194). Some forest conservation, reafforestation and grassland restoration led to water quality improvement and reduced sedimentation, for example in the Yellow and Yangtze Rivers. However, in the water scarce north, there were cases where large scale afforestation actually increased evaporation and flooding; decreased run-off, stream flow and soil and groundwater retention; and, failed to provide native habitats for animals, birds and insects or to support the rebuilding of diverse ecosystems (Bryan *et al*, 2018: 194-202; Holz 2017: 4-8). Despite all this effort, 'the encroaching desert shows little sign of slowing' (Rechtschaffen 2017: 3).

The Chinese authorities have increasingly encouraged the concept of 'harmonious' development between people and nature, calling for a greater focus on river health in basins and the sustainable use of basin water resources (Qiting 2016: 255-256; Pegram *et al* 2013: 30). This has been accompanied by a number of significant programs, directed either by either international organisations or the Chinese authorities, which have been successful in restoring ecosystems by increasing water retention in soils, reducing sediment loads, protecting diversity and increasing carbon sequestration (Lu *et al* 2012: e31782; GWP 2013: 1-5). That has led to more wide-ranging multi-year programs costing China billions of dollars as a substantial effort to overcome loss of biodiversity and to rehabilitate and restore river basins (GWP 2013: 1). More recently, attention has turned to green financing of ecological rehabilitation, green corridors and green development projects (KPMG 2016: 47).

There has also been some study of social impacts in river basins and whether stakeholders are willing to pay for more holistic management of river basins. Aregay *et al* (2016: 970) carried out a comprehensive case study of the Shiyang River Basin, an inland basin with a semi-arid climate, in a region of rapid population growth, strong economic development and excessive water demand. The study examined the willingness of those in differing locations and engaged in a variety of occupations to pay for greater integration of river basin management in order to effect major basin restoration. A significant proportion of all residents and users were willing to pay for restoration of water quantity and quality in the lower basin, forest restoration in the upper reaches and landscape improvements throughout the basin. This lends weight to the argument, mounted by many researchers and international organisations, that a more-informed and empowered citizenry would support much more widespread and effective whole system management of water and land resources in the water basins of China.

All these policies, projects and programs have made some contribution to reducing the scale of threats to river basin health and management, though economic interests have usually trumped those concerning the health of rivers and river basins. However, Qiting *et al* (2016: 256) and Huang and Xu (2017: 425) point out that the commissions cannot make a significant contribution to improved and integrated water resources management (IWRM), primarily because they do not have sufficient authority to coordinate actions across the biophysical and socio-economic systems of river basins. Equally, the commissions are not able to deal with bureaucratic conflict in delivering flood mitigation because there is not 'an effective partnership and better co-ordination between multi-sectoral agencies and multi-tiers of government' (Cheng *et al* 2018: 311). Overcoming these challenges has been made more difficult because the Chinese authorities have placed the river basin commissions below provincial authorities in the Chinese administrative power hierarchy (Jiang 2017: 49-51).

5.2 Consequences for Water Security

China has developed a network of laws, regulations and directives aimed at improving river basin management in the nation. As a sub-set of this approach it has introduced many requirements and constructed much infrastructure designed to mitigate the effects of floods and droughts on citizens, the environment and the economy. These measures have delivered benefits for many citizens but have not collectively achieved water security for the state.

Political determination is evident in the many plans, programs and projects but the water security of many actors and the environment has been diminished because the basin commissions are not able to engage in whole system basin management. The commissions have no option but to deal with the consequences of the exercise of administrative, water and environmental powers by an array of ministerial, provincial and local instrumentalities. These collective efforts have not secured good governance.

Human welfare has been a key objective in national approaches in river basins. That has entailed efforts to control pollution, improve water quality and accessibility by constructing storages and pipelines, and by mitigating flooding, water shortages and drought. Flooding in main river reaches has been reduced and water security for domestic, industrial and agricultural users has improved. Key decisions that impact on basin aquatic systems and riparian lands have not been taken in concert with the management and planning roles of basin commissions. As a result, prospects of improved water security for many other users continue to be limited.

Projects and programs directed at environmental restoration, generally guided by major ministries and prefectures rather than basin commissions, have led to varying degrees of restoration in regions, as a result of the creation of reserves, reafforestation, recovery of flood plains and repair of alienated or disused land. Where the health of local aquatic, riparian and estuarine systems has improved, there have been commensurate gains in water security for the environment. There are, however, many situations where sustainable development has not materialised and environmental water security has not been achieved.

Pollution control has received the priority attention of the State Council and the seven River Basin Commissions. However, the results of national efforts to contain and control pollution, explored in Section 4 above, parallel the generally weak results in river basins, given that the basin commissions lack the tools and power to discharge this role fully. There has been some progress in containing new sources of pollution but little tangible contribution to enhanced water security for the environment resulting from the collective pollution control programs.

As a result of the various programs water security for some has advanced but for others the situation remains unchanged or has actually diminished. On the other hand, improved modelling has helped basin commissions and the Chinese authorities gain a better understanding of the differential impacts of climate change at specific locations and in the construction and design of many substantial and newer water infrastructure projects (see Sections 2 and 6).

6.0 WATER INFRASTRUCTURE

For most of this century, the Chinese state has recognised the importance of demand-side water management in its legal instruments, water pricing and policies directed at efficiency in domestic, industrial and agricultural use as well as in conserving water more generally. At the same time the state has continued to invest in supply-side construction and extensions of large-scale, heavy-engineering-based water infrastructure. In these latter endeavours, the authorities have tried to overcome water scarcity through storage and transfer, while seeking to reduce the impacts of flooding and to increase national power generation. The authorities have encouraged trade in water transferred to user locations through major infrastructure, in an effort to improve national water use efficiency (Jiang *et al* 2020: 251-252). Two major examples of water infrastructure are explored in this section, namely the Three Gorges Dam and the South-to-North Water Diversion Project (SNWDP). The analysis deals with some of the benefits, problems and challenges associated with the construction and operation of substantial water infrastructure in China. Water-based irrigation infrastructure is examined separately in Section 7.

Water resources in China are managed through some 100,000 reservoirs, the majority of which can be found in the east, particularly in the lower reaches of the Yangtze and Pearl river basins, leaving only 6% of the nation's major rivers free flowing (Yang and Lu 2014: 6041, 'Introduction'). This result alone has serious consequences for the way these river systems are managed, now and in the future. These reservoirs are of such capacity that 20% of national river basin storages retain more than the annual flows in the river systems in which they have been built (Yang and Lu 2014: 6041, 'Introduction'; see also Section 2).

The Three Gorges Dam is the world's largest dam in terms of water displacement. It has the capacity to generate 22,500 megawatts of non-greenhouse gas generating power, creates a reservoir that is more than 1000 square kilometres in area, and is designed to withstand more than a one in 10,000 year flood (Deng 2012: 1; Primary Facts 2013: 2). The impact of the dam on water discharge is modest because the dam's storage capacity is only about 5% of the Yangtze River's annual discharge (Yang and Lu 2014: 6041, 'Reservoir Distribution'). The second example is the massive water diversions project, SNWDP, which is designed to meet the needs of the water scarce north and support major urban and industrial development. It serves a major region of China by connecting four river basins, three mega-cities and six provinces and in so doing transfers water for hundreds of millions of water users (Crow-Miller 2017: 241).

6.1 Results and Residual Problems

One of the main reasons for constructing the Three Gorges Dam was to advance industrial and economic growth (Grey and Sadoff 2007: 550-551). This was part of a program of heavy investment in reservoirs, transfer schemes, hydroelectricity projects, canals, water treatment and irrigation infrastructure and the acceleration of major projects, involving expenditure of $US 163 billion in 2011-2013 alone (Tortajada 2016: 183; China Daily: 2011b: 1). In 2011, President Hu Jintao stated that water stress in China was exerting an ‘evident impact on China’s economic security, ecological security and national security’ (China Daily 2011a: 1). That led the national leadership of the time to elevate water resource management and water conservation to a higher national priority.

More recently, President Xi (2018: 1) adopted a different position in focusing on achieving ‘high-quality growth’ in the economic belt along the Yangtze River and turning the river into a ‘multimodal transport corridor’. In that context, there are reports referring to significant plans to construct further dams on the Yangtze, in order to increase hydropower generation (Environmental Assessment Agency [EAA] 2018: 56). The President’s views are at variance with those of various experts. In May 2019, a group of eminent Chinese and international researchers, supported by expert advisers, mostly from MEE and ADB, called for institutional reform to link the current pattern of economic development in the Yangtze River basin better to basin restoration and green development (CCICED 2019: 1-18). The group commended the way many prefectures were working to mobilise public funds in efforts to achieve improved pollution control, water quality improvement and some aspects of environmental restoration.

The Three Gorges Dam has become important ideologically, as a Chinese icon, a major tourist attraction, a tribute to the Party’s legitimacy and the virtues of the Chinese socialist system in the Technological Age (Crow-Miller 2017: 240-241; Ball 2017: 244, 251). It also serves as a showcase for Chinese skills and planning. In 2011, the government claimed that the project had benefited Chinese society through ‘flood prevention, power generation, river transportation and water resource utilization’ (Bosshard 2011:1). The dam was designed to generate massive quantities of hydropower as green energy for economic growth, and in so doing to deliver more than 10% of the nation’s power needs (Ball 2017: 252). Today, the central authorities hold that 50 million people in northern China have benefited, through transferred water supplying 70% of Beijing’s needs, improved agricultural production and reduced pressure on other sources (China Daily 2017: 1). River navigability, transportation and trade involving sizeable shipping have improved through the operations of various subsidiary dams, reservoirs and locks.

The negative social impacts of the project have been extensive. The construction of the dam involved submerging nearly 2,000 cities, towns and villages, many manufacturing plants and important cultural sites as well as the building of more than a dozen replacement cities. Though $US 10 billion was allocated, the process of rehousing and providing alternate jobs and lifestyles has been slow and often affected by bureaucratic corruption and insufficient compensation - leading to very mixed results in terms of effectiveness and equity (Ball 2017: 246-249; International Rivers 2009:1). It is estimated that fertile land used in growing 40% of China’s grain and 70% of its rice could ultimately be adversely affected by the project (Hays 2011: 7). It is also noteworthy that China’s commitment to reducing greenhouse gas emissions could have been secured by harnessing alternate sources of renewable energy rather than by construction of this and other major dams (International Rivers 2014: 1).

The extent to which local populations have benefitted from flood mitigation varies with the specific river location, agricultural, industrial and settlement patterns and the intensity of rainfall. In the last decade, some efforts have been made to improve the management of water, land and catchments, to deal better with the needs of communities severely impacted by water and land use decisions. The Three Gorges dam forms only part of a network of reservoirs and flood-diversion areas along the length of the Yangtze and its tributaries. Weng (2012: 3) argues that building a comprehensive flood mitigation strategy for the whole river basin and its inhabitants requires a new strategy to be agreed and followed by all state actors.

Early in its life, construction of the dam was shown to have led to fish and river animal species becoming endangered, loss of biodiversity, erosion of coastal wetlands, destabilisation of hundreds of kilometres of river slopes and banks (caused by fluctuating water levels) and multiple serious landslides (Bosshard 2011: 1). The wisdom of building the dam in in an earthquake zone was also seriously questioned (Ball 2017: 244-245; Bosshard 2011:1). Widespread siltation of water canals and the main reservoir has become a major problem, as has extensive pollution from poorly treated sewage and agricultural and manufacturing wastes flowing into the dam (Yang and Lu 2014: 6041, 11; International

Rivers 2009: 2-3). Many of these problems have now been acknowledged by the Chinese government, including the need to increase spending on landslide and pollution amelioration and to better support relocation of more residents (Bosshard 2011:1; Hays 2011: 14).

In the case of the SNWDP, there is contest over the economic benefits of the project. While the costs were in the order of $US 80 billion to 2017, Wilson *et al* (2017: 1489) showed that the economic benefits claimed in several studies were highly dependent on the assumptions made, including water use efficiency, the value of transferred water and projected patterns of economic growth and water allocation. Further major assumptions centred on there being no alternate water sources or ways of providing supply and meeting demand. The Wilson study established that the environmental costs of the project had been borne by those depending on water in the offtake areas of the Han and Yangtze Rivers, where seasonal flows had diminished and water quality had been reduced.

There continues today to be a powerful political and ideological debate about mega-water infrastructure projects in China, especially revolving around the SNWDP. Those defending the project offer the following sorts of defences:

- The Chinese people are accustomed to powerful forces reshaping the landscape, so they can deal with the interplay of major water infrastructure, flood control and the changed environment (Lin 2017: 383-385).
- The SNWDP is an apolitical project designed to help redress the national water imbalance between north and south and is providing hundreds of millions of users with safer and more secure drinking water.
- The project has made a significant contribution to the agrarian heritage of China, to economic stimulus, technological change and national integration (Lin 2017: 384-385).
- The development of major hydroelectric power as ‘green energy’ is making an important contribution to combatting climate change.

There are many Chinese and experts and academicians, as well as international experts and international bodies, who have offered counter-views, such as:

- The Chinese authorities have not focused on alternative ways of overcoming inefficient use of water and poor water conservation.

- Building the SNWDP has actually masked government inaction in dealing with multiple sources of anthropogenic water stress (Webber *et al* 2017: 373-375).
- In the construction of the SNWDP, the authorities closed factories, farms and fisheries and forced the resettlement of hundreds of thousands of people (Funabashi 2019: 2).
- Projects such as the SNWDP are largely influenced by engineering feasibility and political framing and advantage, rather than by cost-benefit analysis, risk assessment and environmental impact (Crow-Miller *et al* 2017: 234).
- Water pollution has been diverted elsewhere in order to improve the quality of the water delivered and increased availability of water has stimulated some water demand, leading to increased localised water scarcity (Rogers *et al* 2020: 60-61).
- The operations of the system are highly energy intensive and generate significant greenhouse gas emissions (Rogers *et al* 2020: 61).

Crow-Miller and colleagues (2017: 245) conclude that in the process of modernisation and nation building 'any critical perspective on the role of big infrastructure in water management is likely to be marginalised, if it can develop at all'. The text of the 13th Five-Year Plan for Economic and Social Development in China supports that proposition. The plan, notably Chapter 31 entitled 'Water Security', focuses heavily on the positive role water infrastructure must continue to play in providing water for irrigation and urban supply as well as flood mitigation (Central Committee 2016). There is a similar heavy-engineering Japanese culture which has been examined in Chapter 4 of this thesis. However, in Japan, there are more signs of the role of water infrastructure and its impacts being assessed and questioned publicly, leading to some changes in project plans and several existing reservoirs being dismantled.

Presently, the pattern of infrastructure construction has left only 6% of the nation's major rivers free-flowing, threatening healthy ecosystems and aquatic life (Yang and Lu 2014: 1-7). Fertile land has been alienated, fish stocks depleted, biodiversity diminished, coastal wetlands eroded and many river slopes and banks destabilised. Water siltation of canals and reservoirs is commonplace and extensive pollution persists as a result of poorly treated sewage and agricultural and manufacturing wastes (Bosshard 2011: 1). As dams have filled agricultural land has been lost, environmentally and culturally significant sites have been submerged and hundreds of millions of people have been uprooted.

6.2 Consequences for Water Security

The net economic and social benefits that flow from this pattern of construction are highly contestable and the water security outcomes for the state are very mixed. Through its program of construction of large scale water infrastructure, the state has sought to anchor its political legitimacy and to advance China's modernisation. In constructing myriad reservoirs of varying size, the state has also sought to mitigate the effects of floods, store water to overcome shortages, increase green power generation, improve river transportation and alleviate regional disparities. Water security for many urban dwellers and key primary and secondary industries has improved markedly, but that has come at a cost. The fortunate have derived multiple benefits, but many others have lost economic and lifestyle choices associated with previous levels of water security.

Recent major expenditure has been directed at moderating the environmental effects of the construction of water infrastructure. However, the overall impact of the extensive construction program on water security for the environment continues to have long-lasting effects. Many impacts are now impossible to overcome, given the adverse consequences for river and environmental health and water security. The impact of climate change on vulnerable regions, industries and populations is playing a significant part in the planning and design of recent water infrastructure projects.

The absence of efforts to manage the interplay between proposed major water infrastructure and the modifications to complex aquatic and socio-economic systems in major river basins has had considerable negative implications for water security. Further, at the highest level, strategies are not evident that would link water, environmental and energy security planning to proposed infrastructure development.

7.0 MARKET-ORIENTED WATER REFORMS

The Chinese authorities recognise that formalised mechanisms for water allocation, water markets and water trading are useful tools in efforts to improve water use efficiency and moderate water demand and water scarcity - as well as in moving water use to higher value-added users. The state has controlled the way all these mechanisms have been developed, at the same time as continuing existing supply-oriented approaches to meeting contemporary water demands. In many Western countries, water markets, water pricing and cost recovery have been introduced to aid improved water governance, management and planning and encourage a greater appreciation by users of the value of water. The following sub-sections deal with progress in introducing market-oriented water reforms as a new element in the Chinese socialist market system.

7.1 Water Permits and Water Trading

Before 1980, water allocation and water rights were largely the responsibility of the state and were centrally administered. The opening of the economy and the associated competition for scarce water resources led to a heavy demand by many governmental and private interests for well understood ways of defining, controlling and assigning water rights and water entitlements. Under the system developed in response the state continues to define water rights, control water allocation and reallocation, the granting of water permits and water distribution. These processes are managed by state actors at several levels who can exercise parallel decision-making powers (Wang, Wan *et al* 2018: 422).

7.1.1 Results and Residual Problems

The provincial authorities licence major water users as Water Use Permit holders, while designated local authorities issue permits to individuals, collectives and industry at large (Moore 2014: 3-4; CWR 2014b: 2). The permits include a defined purpose for which water is to be used, the maximum quantity that can be taken in a nominated period and may prescribe locations where water infrastructure can be built (OECD 2015b: 4; Moore 2014: 4). The assessment process takes into account the water resources available in the local or regional resource pool and is supposed to have regard to environmental flows and ecosystem health (Moore 2014: 4; CWR 2014b: 1). Under the system, defined quantities of water are allocated to specified users under a regional water cap, with the quantum determined according to security of supply conditions that vary with the season and climate change. The whole process is designed to help drive water conservation and water use efficiency. Water can be reallocated to give access to a new ‘priority user’ or because changes in allocations are required under national or regional water plans (CWR 2014b: 2). These adjustments are determined administratively, to accord with state directives (Wang, Wan *et al* 2018: 422). Some traditional water rights have proven to be difficult to manage in this system because of uncertainties about their past legal foundations and duration.

In 2016, China established a China Water Exchange, as a national water rights trading platform (Jiang 2017: 62-64). Following a pilot scheme to test various forms of trade in water rights, MWR released provisional regulatory measures to allow trade between holders of regional water rights, water abstraction rights and irrigation water rights, subject to state oversight of trading activity and regulation of the market (Jiang 2017: 62-64; Jiang *et al* 2020: 251). The majority of trades to date have involved government bodies and state-owned enterprises with prices managed administratively (Jiang *et al* 2020: 251; Wang and Yang 2018: 01233, 'Introduction'). In this system there is heavy competition between provinces, prefectures and water administration departments for available water resources.

There are many current water diversion projects where the authorities are encouraging trading in assigned water rights in efforts to improve water use efficiency and smooth water allocations (Jiang *et al* 2020: 250-251). For example, quotas for water provided by the SNWP have been traded within Henan province (Jiang *et al* 2020: 251). City to city trading has also been permitted where one city has been able to provide funding to support supply augmentation in a neighbouring city in exchange for water entitlements to increased drinking water supplies (Moore 2016: 5).

Industrial users and water supply utilities needing supplementary water face difficulties in trading because the necessary involvement of regulatory and planning authorities represents a significant, additional burden in complexity and cost (Wang, Wan *et al* 2018: 425-428). Too frequently, this has led urban water utilities to resort to high cost water augmentation strategies through transfers and desalination, while nearby rural water was available at much lower cost (European Union [EU] SME 2013: 6). Early in the development of a trading regime, small numbers of trades occurred, where the needs of industrial and urban regions for more water were met through the transfer of water entitlements from irrigation areas, in exchange for the funding of major projects designed to conserve irrigation water and reduce farming costs (Moore 2014: 5-6). Such trades have continued to encounter difficulties in operating under the formal state allocative and trading apparatus.

National efforts aimed at water conservation have been impeded by the fact that water allocations to farmers are handled differently from those of other users (Moore 2016: 8-9). Jiang (2017: 95-96) found some farmers felt their rights were ill-defined and equity was not adequately considered in water allocations and transfers. Most farmers now pay volume-based water fees and receive their water from irrigation management organisations, through canals and channels (Wang, Wan *et al* 2018: 425-426). Any water trading in the farming communities tends to be 'one-on-one' and short term, primarily because the institutional complexities render broader scale trading very difficult. In the Shiyang River Basin something more akin to Western trading has taken place through the creation of agricultural water exchanges (Moore 2014: 6-8). These schemes have been backed by metering and monitoring, local participation, the recording of trades and have local governmental support - though the initial volumes traded have been small.

In China, an idiosyncratic system governing water markets and water trading has emerged beside the established supply-side, command and control approach to water governance and management. In its current form the system is limited in what it can accomplish by the involvement of the state in water allocations, permits, markets and trading and by the focus on state entities. These constraints have reduced opportunities to improve water use efficiency, water conservation, recycling and the movement of water use from less productive users to those delivering higher productivity and value-added products.

7.2 Water Pricing and Water Taxes

Leading Chinese professor of environmental economics Ma Zhong (2014: 1-6) argued that that water discharge standards and discharge fees had been set too low, while ineffective wastewater collection had been widely tolerated. As a result, industry historically found it more advantageous and less costly to discharge polluted wastewater than to improve water treatment, or conserve or recycle water. In partial recognition of this situation, the government announced ‘a comprehensive, systematic and advanced water pricing policy and framework’ (Shen and Wu 2017: 227). The objectives of water pricing reform as stated under this policy are: to promote water conservation and help reduce water shortages; to encourage migration of water use to higher value added processes; to improve wastewater treatment; to ensure that a greater proportion of public costs are recouped from water treatment, transfer and storage; and, to invest any modest profits in public water treatment and infrastructure. Many such objectives have underpinned other water reforms but as shown elsewhere in this chapter have proven to be difficult to achieve.

Following the introduction of the 2003 Regulation on Administration of Water Supply Prices for Water Conservancy Projects water charges shifted from subsidised administrative fees to ‘government-set or government-guided prices’ (Jiang 2017: 80). This process led to the progressive introduction of varying tariffs and charges. As a result, costs differ for permit holders, those using pumped or stored water, urban domestic, commercial and industrial users, and for polluting and wastewater discharges (Shen and Wu 2017: 199-219). The pricing framework and these differing tariff arrangements have added further to the complexity of administrative arrangements in China. The next section reveals that, in practice, pricing has frequently been most influenced by political and socio-economic considerations.

In 2016, China imposed a water resource tax on heavy users of surface water and on those drawing on over-used groundwater systems. Formally the tax represented an extension of an older and broader resource tax system (Xinhuanet 2017: 2). The water resource tax was piloted in Hebei, a seriously water-stressed province. The tax replaced an existing fee for water extracted from surface and groundwater systems which was charged by the government but collected by local government.

7.2.1 Results and Residual Problems

Irrigated agriculture in China traditionally has involved family-based operations, accustomed to water charges determined by the area utilised rather than by volumetric charging. That approach to charging has favoured farming techniques like flood irrigation, that do not require metering and are not sensitive to water conservation goals (Jiang 2017: 81). A recent review of three large-scale irrigation districts in China, differing physically and socio-economically, revealed that while government policy since 2004 has favoured cost recovery for water used in irrigation that has not occurred in practice (GOSC 2016: 2). One significant reason is that while prices for irrigation water may be low relative to the supply costs, the prices are high relative to farm returns. It seems that where water prices have been increased at the district level, grain production and farm returns have diminished, inequities increased and groundwater resources have been exploited rather than conserved (Liao *et al* 2017: 60).

While cost recovery remains an important goal, the above study also reveals that there has been relatively little emphasis in China on low-cost irrigation technology, reforming canal and farm based irrigation practices, improved groundwater management, and use of non-price incentives for farmers and irrigation districts to adopt water saving measures (Liao *et al* 2017: vii). This has continued to be the case, despite the policy directives of government and the level of available funding for improved metering, irrigation infrastructure, optimised plantings and crop selection and water management reforms at the local level (GOSC 2016: 1-6).

As in other arenas of water policy, implementation of the tariffs and charges has been uneven and mired in systemic problems. The complexity of the hierarchical delivery and regulatory systems is one significant cause, as described in Section 3. Other factors include the differing interests and levels of commitment of myriad actors in implementing centrally imposed criteria and standards. Weaknesses in fee collection and supervisory processes and inconsistencies in the ways industry, agriculture and domestic consumers are treated are further significant contributors to these problems (Zuo *et al* 2016: 257).

In a comprehensive review Shen and Wu (2017: 222-227) have shown that water pricing reform has not led to the benefits sought by government. Instead pricing has been far more influenced by considerations related to national socio-economic development. Shifts in national political direction and priorities have affected the direction of reform, consistency, public understanding and efficiency. One consequence of failure to consider water scarcity in setting prices is that opportunities have been missed to drive water conservation harder. Where water tariffs have been increased in urban surrounds, water utilities have generally done so to cover maintenance costs and investment in infrastructure. Such proposals for price hikes are reviewed by prefectural authorities that may initiate public hearings (Jiang *et al* 2019: 9). In fact, these authorities often face social and political predicaments, as was the case for Beijing, where water was already costly for households, but the costs of transporting water to Beijing via the SNWDP were enormous (Fan *et al* 2015: 572-573).Shen and Wu (2017: 227) conclude their review of the national situation by stating that there is ‘a massive gap between water pricing policy and implementation in China’.

On the other hand, the introduction of the water resource tax led to far more encouraging results. The trial in Hebei proved to be very effective in reducing water use by heavy users such as in the steel, cement and chemical industries. It led to greater efficiency in water use, notably the introduction of water saving devices and the replacement of some extracted fresh water by seawater and recycled wastewater (Xu 2018: 2). In 2017 the trial was expanded to comprise nine provinces including Beijing and Tianjin (Xu 2018: 3-4). The new water resource tax was formally recognised when the PRC Resource Tax law came into effect in August 2019. The tax rate is determined by local government and varies from 1% to 20% per cubic metre of water (Standaert 2019: 2).

7.3 Consequences for Water Security

Regulatory and administrative reforms reflect increased state intent to entrench an efficient and consistent system for allocating water and issuing permits. The value of water markets, water trading and cost recovery have been recognised by Chinese authorities, but the implementation framework has been narrowly cast. The complexity of water management and delivery systems and the pursuit of short-term political and economic goals have contributed to missed opportunities to tackle water scarcity and recover some public costs. These issues have undermined progress towards water security for the state.

Good governance through the effective application of administrative and market-oriented instruments has been impeded to a greater extent than in either Australia or Japan. The benefits in introducing water markets and water trading have been limited by the pervasive role of the state in shaping, controlling and narrowing participation in the system. System complexities, agency shortcomings and cost have also reduced the contribution good governance could make to water security. The outlook for recent Chinese reforms to water pricing is promising given the gains already evident in Hebei province in terms of water saved, industry efficiency and revenue gained through the piloting of a water resource tax. In several provinces this water resource tax now replaces earlier governmental fees for water extraction from natural systems.

The introduction of regional water caps and security of supply conditions that vary with the season and climate change are making a positive contribution to human and environmental welfare. However, market-oriented reforms have made only a very modest improvement in national water conservation, water use efficiency and recycling. Water security for the environment would be improved in climate affected regions if the impact of current water permits and water allocations on river, lake and groundwater health were reviewed – a matter also deserving of early attention in the Murray-Darling system in Australia.

The Chinese systems of water pricing and water trading have not made a material contribution to water security for human welfare. Nor has water security for consumptive users in industry and agriculture benefited greatly from the introduction of water markets and trading. That has resulted largely because institutional complexity and high administrative costs are affecting take up. Where some gains have been made in the quality and quantity of accessible water, that has made a minor but positive contribution to water security.

8.0 URBAN WATER SUPPLY AND SANITATION

The 2002 *Water Law* and the 1984 *Pollution Prevention and Control Law* provide the foundations under which water supply and sanitation responsibilities are exercised. Prior to the creation of the two new super-ministries, namely MEE and MWR, responsibilities for urban supply, sewage and drainage as well as associated construction and management of water infrastructure were discharged by MHURD. Quality standards and controls on supply and discharge were the province of MOE (see Table 3.1). There are, however, many other legal, regulatory and administrative measures, which impact on water supply, water savings and wastewater, sewage and drainage treatment functions. These matters now have to be taken into account by MEE and MWR, as well as other state authorities, departments and bureaus at all levels of government (Cheng And Hu 2012: 268; Zhao 2015: 69).

While the priority focus in China is on urban arenas, there is a substantial backlog in water supply and sanitation services in rural regions, with some regions suffering more than others. Research suggests that the strength of linkages between the government and ethnic minority villages and communities and 'the relative ease of implementing policy in (Han) majority areas' is an important influence on such outcomes (Pizzi 2015: 131-132). For example, two decades after a water project was begun in 1995, one of two million rural dwellers still lacked clean drinking water in Hotan Prefecture in the Xinjiang Uyghur Autonomous Region (Radio Free Asia [RFA] 2015: 1-2).

8.1 Results and Residual Problems

Demand for improved urban drinking water supply and wastewater treatment continues to outstrip available governmental resources largely because of the rapid rate of urbanisation. As described in Section 2, virtually all Chinese cities suffer from water shortages or supply interruptions or both and many citizens face the need to boil or treat the water before use (Knowles 2016: 2). Scarcity and contamination of source water have led to the pumping of water of improved quality from distant sources (Hafner-Cai 2014: 1). In 2015, water was supplied by city pipeline infrastructure to 90% of urban premises and 62% of rural premises, whereas, as noted in Section 4, 74% of urban premises and only 9% of rural premises were connected to the sewer (WHO/UNICEF 2017a: 61, 79). These data highlight the significant disparities between urban populations and rural dwellers in respect of water security.

The scale of the problem faced by Chinese authorities is evident from China National Bureau of Statistics (CNBS) data which reveal that Beijing residents had only 40% of the national average available water while Tianjin had even less at 38% (CNBS 2016: #8-12). Additionally, the Chinese national consumption figure of 439 cubic metres of water per person is considerably lower than that of Japan at 624 and Australia 703, respectively (Statista 2019: 1). In 2016 alone, the Chinese government spent $US 54 billion on water supply and sanitation, though this still did not meet 50% of its national targets of the time for water supply and reticulated sewage (WHO 2017: 9, 11).

At the level of major cities, there has been heavy private sector investment in the construction and delivery of water supply, wastewater treatment facilities and more recently desalination plants - that are costly and energy intensive to build and operate (Tortajada 2016: 183). By 2017 there were more than 130 seawater desalination plants operating in China with two thirds of the desalinated water produced serving industry needs and the other third used for residential domestic purposes (Water and Wastewater International [WWI] 2017: 1-2). In the largest cities, water bureaus sell and transport water to the city.

Water and sanitation services are usually provided by water and wastewater bureaus that operate independently of each other. Wastewater services may be further differentiated by district, collection and treatment. The scale of the wastewater challenge can be seen in Table 3.2, which shows 2015 data for the three major cities, cited as examples in this chapter. The Chinese authorities continue to acknowledge the need for heavy further investment in sewage treatment. In recent years China has also been testing the concept of ‘sponge cities’ by creating networks of permeable surfaces through roof-gardens, wetlands and stormwater re-use systems (E2Designlab 2017: 1-3). These are designed to help mitigate the adverse effects of drainage, stormwater runoff and minor flooding.

The search for higher quality drinking water for major cities is well demonstrated in the case of the city of Shanghai, where the major water source intake has varied considerably over the past 50 years from various river and lake locations and has involved the construction of numbers of reservoirs and pipelines (Huang and Xu 2017: 424). Such water transfers have been authorised by the State Council, MWR or water basin commission or by arrangement between jurisdictions. For example, two neighbouring provinces were required by MWR administrative order to provide water for Beijing. There was no financial benefit or compensation for those parties, even though the arrangement put considerable strain on their water supply systems (Jiang 2017: 74). In other cases, negotiations between neighbouring jurisdictions have met long term needs through more mutually beneficial, but binding agreements between the parties.

Table 3.2 Annual City Wastewater Discharges (CNBS 2016: #8-14)

City	Industrial wastewater discharged (million tons)	Domestic wastewater discharged (million tons)
Beijing	90	1426
Tianjin	190	740
Shanghai	469	1768

In China, the fragmentation of responsibilities at the urban level has created considerable problems in the delivery of urban water supply and sanitation. The failure to integrate management of various elements of the urban water cycle is an issue confronting some other countries, though not of the same order as those created by the hierarchical administrative system (see Section 3). Several Chinese research groups have argued for better integration of water resource management, service delivery and regulation in Beijing; for a unified approach to water management by cities, river basin commissions and local government administration (Fan *et al* 2015: 570; Cheng and Hu 2012: 266-268). They have also called for new mechanisms to resolve conflicts and to share information.

This issue has been at least partially addressed in some urban situations. In Zhejiang province the government has introduced a program that aims to improve coordination and integration across pollution, drainage, flooding, water supply and water saving, which it has promoted as a guide for its counties, cities and towns (Xu *et al* 2016: 37). At the level of city government, Shenzhen has led efforts to integrate service delivery by combining all water-related functions, including water supply, wastewater and sewage treatment and drainage, in one agency since 2001 (ADB 2010: 7). This led to creation of the Shenzhen Water Group, approved by the Ministry of Commerce, which has been successful as a contractor in improving water supply and sewage and wastewater treatment elsewhere in China.

8.2 Consequences for Water Security

Oversight and regulation of urban water supply and sanitation is guided by complex arrangements involving ministries, provinces, counties and cities as well as a comprehensive legislative and regulatory base. The political will to drive dramatic improvements, notably in urban surrounds, is evident in the multiple programs, comprehensive legislation and heavy expenditure pattern over decades. However, water security for the state is undermined by the institutional complexities, the failure of cities and provinces to integrate management of water supply, sewage and industrial wastewater treatment in most cities, and by the enormous backlogs in provision of key urban and rural services. Good governance and improved water quality are also being significantly impeded by the conflicting mandates and interests of many governmental actors. There are, however, some encouraging signs where localised efforts in cities and provinces have led to improved coordination of the actions of public entities, resulting in water service and security benefits.

Human water security through safe and consistent water supply and wastewater and sewage treatment and disposal have been long term, high priority and heavily funded targets in China. However, water security to support welfare for all urban residents remains a continuing challenge. It is still an elusive goal for rural residents. Problems for urban residents continue because of the widely prevailing water scarcity and water pollution of sources as well as inadequate treatment or system breakdowns in water supply and wastewater treatment. The heavy costs, and significant environmental and social externalities, associated with the construction of major water storages and pipelines have not been publicly assessed against alternate means of overcoming water scarcity and water contamination and improving water security.

The water security of industrial consumers in urban environs is closely tied to water security for human welfare. Improving water use efficiency, water saving and wastewater treatment by major industrial users requires that they meet more stringent requirements. Comparable metropolitan-based major industries world-wide have saved and recycled water, complied with tighter regulations, and demonstrated the resulting economic benefits, leading to enhanced water security. It is only in some cities and provinces that modest efforts have been made to integrate the delivery of urban water and sanitation services. There is little evidence that cities are trying to advance water security by considering the linkages between population growth, city form, social and economic development and the sustainability and resilience of aquatic systems.

The sites, scale and level of treatment of domestic wastewater, industrial and sewage discharges have a heavy bearing on the receiving waterways, their rates of recovery and the water security of the urban and riparian surrounds. As identified above this varies considerably from well-managed high quality outcomes to much poorer results. The way water infrastructure, system leakages, drainage and recycling are managed affects the results for the environment and its water security. Climate change has been recognised as a further significant influence on water availability for domestic, industrial and agricultural users in urban surrounds. But, given the scale of the problems described above it represents just another critical factor to be considered in integrated city water management and future water security for users and the environment.

9.0 TRANSNATIONAL RIVER BASINS

China regards those stretches of transnational rivers flowing across its land mass similarly to the way it views the water resources in major domestic rivers (Li and Wu 2016: 8). Yet, every shared river basin is different not only in terms of geography, hydrology and environmental characteristics but because each water-sharing nation, its industries and peoples vary in their needs. These neighbouring nations have different economic, environmental and management capacities, as well as legal frameworks, governance regimes and levels of commitment to use tools to create efficiencies in use of water and energy and to curb demand (Zhang and Li 2017: 7). There are serious implications for nearly three billion people in 14 downstream countries resulting from the political and governance decisions China takes in relation to the 16 major transboundary river systems that flow through the nation (Li and Wu 2016: 1-2). In practice, national political interests tend to occupy centre stage, whether the issue is infrastructure construction, economic development, the sharing of water resources, or joint water management and basin custodianship.

9.1 Results and Residual Problems

There are a number of factors which affect China's approach to each transnational water basin (Zhang and Li 2017: 6-15). The convoluted interplay between Chinese instrumentalities at several levels and the way their differing mandates impact on river outcomes is one such factor. The Chinese position also changes markedly according to the extent of existing agreements and arrangements, political relations with neighbours and important sub-national relationships. China responds cooperatively where the nation has good bilateral relationships, leading to fruitful dialogue and some joint decision-making. In the northeast, China shares water with North Korea, Russia and Mongolia where significant rivers form international boundaries between the states. China has entered into a number of bilateral treaties with these countries and has agreed that development leading to major diversions or water infrastructure construction must be a shared decision (Li and Wu 2016: 4).

That is not the approach taken in the northwest and southwest. For example, there are three major river systems flowing through China with their sources in the Himalayan and Hengduan mountains. As early as 2011, China signalled its intent, under the provisions of its 12th Five-Year Plan, to build many major hydro-power stations and water diversion projects on these rivers (China Direct 2011). This position was adopted, despite these rivers being at risk from the same environmental problems as identified in Sections 5 and 6, and despite the Chinese approach having been heavily contested by downstream Southeast Asian countries and environmental groups. Examples of the consequences of these and later similar decisions are described in succeeding paragraphs.

China plans to build about 60 hydropower dams on the Lancang river and its tributaries (known elsewhere as the Mekong river system) which traverses several Chinese provinces and five Southeast Asian countries. Since the construction of 7 hydro dams, with 11 or more underway, the hydrology of the river system has changed in many ways including sediment load, water temperature, bank erosion, natural ecosystems and fish stock (International Rivers 2014: 1; Bernstein 2017: 5). Some 60 million people have been affected to varying degrees as the projects have impacted on water availability in rich agricultural regions in the Mekong delta and as a consequence of reduced fish stock in one of the world's greatest freshwater fisheries (Bernstein 2017: 1-2). Critics hold that the river system in progressively turning into a series of lakes and canals for the benefit of Chinese shipping and hydropower users, at the cost of overall river health and farmers and fishermen in downstream countries (Bernstein 2017: 3).

In recent years the position has changed somewhat. The Mekong River Commission (MRC) comprises five Southeast Asian countries working together to integrate management of the water resources of the Mekong, while aiming to protect people and the environment and to support sustainable development (MRC 2018: 1-2). China has responded to the overtures of the Commission by providing hydrological data and has worked to reduce some impacts of several dam structures on downstream people and environs (International Rivers 2014: 1). The nation is also reported to have committed to operating its various projects in ways that maintain downstream river flows (Wang 2018: 6). Recently, China has taken the initiative in promoting a Lancang-Mekong Cooperation process. The leaders of the 6 cooperating countries have agreed to focus in the years 2018-2019 on ‘medium-sized’ projects (GWF 2018: 3; China Daily 2018: 1-2). After that, it seems possible that discussion of water related matters will include cooperation in water resource management, dealing with climate change, some technical matters and joint assessment of flood control and drought relief (China Daily 2018: 7-8).

At the same time as China has expended money and effort in the Lancang River, its domestic efforts have been directed at expanding its control over this important river system (Bernstein 2017: 3). That is a matter of no small concern to the wider international community. Since about 2000, the US, Japan, South Korea and Australia have all been involved in promoting enhanced multilateral governance and cooperation in the Mekong basin (Li and Wu 2016: 7). The US and Japan have focused on the politics and the management of the Mekong, by providing substantial tranches of funding to the South East Asian countries to help bolster their positions in joint actions and decision-making (Li and Wu 2016:7). The Australian Government has recently provided additional funds directed at strengthening government-to-government relations, standards of governance of the Mekong and ‘holistic management’ of the water resources (Australian Water Partnership 2019: 2-3).

In the case of the Yaluzangbu River (known in India as the Brahmaputra River) China has claimed absolute sovereignty over the more than 50% which lies within its territory (Li and Wu 2016: 4). China has already built one hydro-power station on the main stream which has had significant impacts on downstream countries and their peoples, and, could aggravate difficult China-India relations by increasing water scarcity in an economically important region of India (Zhang 2015: 1). In fact, both India and China have major hydropower projects completed or underway and within China debate continues over further possible water diversion projects (Li and Wu 2016: 6). This waterway has been the subject of dialogue between the leaders of the two nations with a view to easing tensions (Zhang 2016: 157). Experts suggest that if confrontation or conflict is to be avoided in future, an effective trans-border water agreement is needed, as well as a mechanism to deal with contested issues (Zhang 2016: 163-4; Zhang and Li 2017: 8).

Li and Wu (2016: 8) argue that China should designate a single government ministry or agency to coordinate the nation’s collaboration with neighbouring states in the management and regulation of transnational river basins and their water resources. Failing that, they favour the introduction of an overarching mechanism for governmental coordination, because the government ministries and instrumentalities have vastly different foci, spanning hydroelectricity, irrigated agriculture, fisheries and resources management and development. On the other hand, overlaid on questions of governance are key political considerations relating to each river and each neighbour, at any given time. The final approach adopted by China for individual rivers and river reaches seems destined to continue to be largely influenced by current Chinese approaches to international relations, national economic and regional development and by the outcome of bilateral or multilateral political negotiations.

9.2 Consequences for Water Security

In transnational water basins, the Chinese position is built on the nation's political interests supported by the application of the extensive network of Chinese laws and procedures. China's approach to basin management and governance in major rivers that flow through its territory and that of neighbouring countries is similar to its approach to those river basins which lie solely within Chinese borders. The exception occurs where Chinese approaches to water governance, management and use are guided by obligations under regional treaties and agreements. On the other hand, there remain many transnational basins where the impacts of Chinese priorities and the interests of the Chinese state tend to trump those of downstream neighbouring states, the water security of their citizens and their economies. Some ongoing disputes over land, resources or coastal and shipping rights, have been further heightened by actions of the Chinese state. In these various respects it can be concluded that the perceived water security and interests of the Chinese state dominate - as opposed to the security of all those who depend on the river system in neighbouring countries.

Even in developing a national position on each basin there is little coordination of the policies and actions of major governmental participants, leading to delays and contestation. Neither has priority been accorded to whole system management of basins and their resources, basin sustainability or the health and resilience of the aquatic systems. In the majority of cases, collective management of the river basin itself and the use of its water resources have not been the prime focus of shared governance arrangements. Poor water security is frequently the result for many users and the environment.

In transnational water basins, the water security of consumptive users engaged in hydroelectricity and major river-based shipping and commercial trade has been enhanced by the Chinese approach to management and use of shared waters. The construction of much water infrastructure has helped in countering flood mitigation and hydropower generation has delivered direct benefits to major urban and regional populations. On the other hand, the water security and welfare of tens of millions of people, in China as well as neighbouring countries, has been compromised. For the fortunate ones that has been a short term problem but countless peoples remain disadvantaged in the long term.

From the perspective of the environment, the construction by China of hundreds of water storages and other water infrastructure on major transboundary rivers has frequently led to increased sediment in some locations in China. Perversely, sediment deposition has diminished in the estuaries of other states where it is so vital in replenishing nutrients and maintaining fertile soils. In addition, water levels, temperatures and flows have changed, banks have been eroded and fish stocks and natural ecosystems have been depleted, in similar ways to national waterways, as reviewed in Section 6. Overall, environmental water security in China has frequently been diminished as it has in neighbouring regions and countries. While the Chinese authorities recognise that climate change impacts on the severity of droughts, floods and storm events in some river basins as well as the stability and safety of some water infrastructure, this issue does not appear to be a major influence on the course of most negotiations over transnational river systems.

10.0 CURRENT WATER SECURITY

The conclusions in this section draw on examinations of data, findings, reports and research in all the preceding sections and are presented within the framework for assessment developed in Chapter 1. Sub-sections 10.1 to 10.4 focus on the influence and impact of politics, governance, management and climate change on national water security. Sub-sections 10.5 to 10.8 also build on the analyses in this chapter but focus on the four specified water security domains of the state, human welfare, the environment and consumptive users. Where the conclusions could be positioned under more than one item, they have been presented in more detail in one primary location. Shortcomings and deficiencies in policies and programs as they impact on water security have been examined, as well as the likely contribution of current national reforms and initiatives to water security in the near term. All these conclusions have been considered in making the country comparisons of national water security and in examining future positioning and prospects in the final chapter.

10.1 Impacts of Politics

Throughout this century the Chinese leadership has developed legal instruments, programs and directives which have given water use and water resources management considerable political impetus. The will to achieve dramatic improvements is obvious in the pattern of legislative development, programs and heavy expenditure focused on urban water supply and sanitation and many other programs dealing with water quality, water pollution and water conservation. Despite this level of effort there has been widespread failure to meet expectations. Under President Xi economic development and national prosperity continue to dominate, while the role of the state has been reinforced along with centralised control and top-down governance. Some centrally controlled and experimental projects have continued where the state could benefit directly and financially, as in the refinement of new models for national water trading. On the other hand, bottom-up reforms, with the ability to cut through bureaucratic systems and institutional barriers may lack sufficient support to benefit local and regional water security.

Political framing and the search for political legitimacy and political advantage have been extremely influential, particularly in the extensive program of supply-side construction of water infrastructure. Water security for all actors and the environment has been much diminished in the absence of political decisions to restructure the river basin commissions, to curb the power of other actors in river basins and to provide commissions with the power to exercise whole system management (see also 10.3 below). In the case of transnational basins, politics and political actions that advance the national interest have usually dominated in the approach of the Chinese leadership to water sharing and use. Politics have often also dislocated efforts to allocate and share national water resources efficiently and fairly. Water trading reforms have often been retarded by the perception that their application could affect local political positions and social stability.

10.2 Impacts of Governance

The contribution of the comprehensive legislative and regulatory framework and expenditure of substantial public funds to water governance is not commensurate with the level of national effort expended. For example, the need to entrench an efficient and consistent system for allocating water and issuing permits has been recognised but has only partially been realised. Decisions to construct water infrastructure in major river basins have changed dramatically the nature and modes of operation of these major Chinese river systems with frequent serious negative consequences. Good governance and water security have both often been compromised in the absence of public assessments of social and environmental impacts, cost-benefits of major water projects and efforts to assess alternate strategies.

Good governance has been impeded by the interplay of the differing roles and outlooks of many governmental actors, by the disruptive effects of national and local politics and corruption and by the complexity of institutional and hierarchical arrangements. As a result, regulatory oversight and program implementation have often fallen short of expectations. These institutional factors represent major hurdles for the Chinese authorities to overcome in improving governance and water security outcomes.

10.3 Impacts of Management

In China, the authorities have accorded very understandable priority to implementing policies that target the scale, extent and impacts of pollution, water contamination and water wastage. There are, however, considerable adverse implications associated with piecemeal application of these measures in the absence of a framework focused on sustainable resource management. Differences in the agendas of various governmental actors, partial conformity with national standards and weak monitoring and auditing of program outcomes have all contributed to patchy program implementation and outcomes.

It is only in some cities and provinces that modest efforts have been made to integrate the management of urban water and sanitation services in order to gain efficiencies and improve standards and productivity. The ability of urban water managers to introduce effective demand management and improve water security has been hampered by regulatory and administrative complexity. The impacts of the urbanisation process on the health of neighbouring aquatic systems have not generally received serious attention.

There is substantial contestation over the net benefits of the pattern of infrastructure development in China versus the economic, social and environmental benefits of alternate strategies. In river basins, water resource development and associated modification of the river systems have usually been accorded top priority. The impacts of such proposals on citizens and their well-being and the sustainability of the aquatic systems have frequently received far less official attention. The existing approach does not involve whole system management of river basins, freshwater lakes and groundwater systems. It has led to some actors gaining improved water and energy security while others have lost water, environmental and economic security as well as opportunities and lifestyle choices. In many instances, important national aquatic and riparian environments are continuing to be degraded.

10.4 Impacts of Climate Change

China has introduced regulations, set targets and changed administrative arrangements in order to deal with the regional impacts of climate change, which have already increased the severity of droughts, floods and storms with major impacts on people, their lives and industries. Water scarcity represents a massive national problem which climate change is making even more intractable, as the nation continues to try to meet the needs of domestic, industrial and agricultural users. In river basins, it is clear that climate change is making even more challenging the tasks of governance and management, particularly as the authorities continue to favour the construction and operation of new water infrastructure.

China has many programs and policies that aim to address climate change and has ratified both the Kyoto Protocol and the Paris Agreement on climate change. As the world's greatest producer of greenhouse gases, it faces a massive national as well as international challenge. The nation is already a world leader in adopting and introducing renewable energy - but continues to be the major global consumer of coal. Arguably, China has more at stake than any other state in the international effort to control rising ambient temperatures, given the projected effects on patterns of flooding, droughts and national disasters as well as the implications for national water security.

10.5 Water Security for the State

The term 'water security' is virtually absent from state literature. While 'integrated' and 'sustainable' are often used in official documents that is not in the context of whole system management of water resources or river basins. The state owns these water resources and exercises very considerable control over them through a substantial network of laws, regulations and directives. State actions have created thousands of storages and pipelines, modified rivers and surrounding land, determined future usage of the land by agriculture and industry and led to the relocation of tens of millions of people. In these ways considerable state power has been directed at reducing water insecurity, largely through efforts to overcome widespread urban water scarcity and to improve water availability and quality. However, the improvements in water security for the state are modest when set beside the level of effort and expenditure. The ability to exercise sweeping powers accentuates the challenge for the state in securing a better balance between economic exploitation of water and land resources and their sustainable management.

10.6 Water Security for Human Welfare

Over decades, China has committed to progressive improvements in human water security by assigning a high priority and massive funding to efforts to provide safe and consistent water supply, particularly in urban centres. Both storages and pipelines have contributed to greater water availability and water security for many urban and some regional and agricultural populations. It has also meant that millions of people have borne the collateral human costs, social and environmental dislocation, lost amenity and loss of the previous spiritual links to significant water sources.

Water security for urban residents has improved each year in terms of continuity of supply and water quality. Those improvements have been diminished by a lack of cohesive management, water scarcity in some regions, widespread water pollution and breakdowns in water supply and wastewater systems. China faces an enormous challenge still in clearing the backlogs in provision of human sanitation and drinking water in some urban and most rural and agricultural regions. In transnational water basins, the welfare of tens of millions of people in neighbouring countries, who are dependent on river access, water quality and river flows, has been compromised, largely as a result of China's approach to resource exploitation and development.

10.7 Water Security for the Environment

Water security for the environment is in most instances a distant target. Pollution control has received national priority attention through a comprehensive network of laws and regulations. In major river basins extensive programs have been launched to control pollution and restore some regional environments. However, aside from reduced pollution from new factories and plants and recent plant closures, only very modest results have been reported. In China the quality of urban treatment of domestic wastewater, industrial and sewage discharges varies in cities and towns from well-managed high quality outcomes to very poor. The effectiveness of this treatment is an important determinant of the health of the receiving aquatic system and that of the surrounding environment. Even healthy and resilient groundwater and surface water systems take time to recover from and respond to the impacts of pollution of various kinds. The introduction of regional water caps and security of supply conditions that vary with the season and climate change have made some contribution to improved environmental welfare.

The patterns of growth, traditional approaches to agriculture and timber harvesting and climate change have all played a part in the loss of land and water habitats essential for indigenous plants and wildlife. The loss of rivers, wetlands, lakes, biodiversity and increasing desertification have led China to mount region-wide programs directed at reforestation, grassland restoration and halting desertification. In some cases, water quality has improved, sedimentation been reduced and flood plain and alienated land have been stabilised. However, in the north, flooding tends to have increased and reforestation has not provided the necessary habitats for various native species. As a consequence, while some land and aquatic systems have improved, others have not and the water security gains therefore vary.

The massive development of hydroelectric power on most major river systems has provided power for industrial and domestic users but has had major negative implications for rivers and for the lifestyles and locations of many citizens. Frequently a primary reason given for construction has been the significant contribution that hydropower will make to the generation of ‘green power’, as a significant contributor to the Chinese campaign against climate change. Major water infrastructure on both national and transnational rivers has frequently increased sediment in storages, while actually reducing its deposition in flood plains, where it is vital for agriculture mostly in neighbouring states. This infrastructure has also altered water levels, temperatures and flows, banks have become eroded and fish stocks and natural ecosystems have been depleted. As a consequence, water security for the environment in China has often diminished, as it has in some neighbouring states.

10.8 Water Security for Consumptive Users

Many consumptive primary and secondary industry users face long-term water insecurity, because that is dependent on the degree of success in implementation of the nation’s legislative and regulatory efforts to improve water quality and access. There are some positive results associated with current initiatives. For example, in irrigated agriculture, measures to curb wastage, improve water use efficiency, restrict the cultivation of high water-using crops and set water quotas to accord with river basin management plans are showing some promise in terms of future water security. In many of the main rivers, but not necessarily their tributaries, the security of consumptive users has improved as a consequence of reductions in the severity of flooding. In the major transnational waterways, users have benefited from Chinese efforts, through increased availability of hydropower and from structural improvements for shipping and major river-based commercial trade.

State entities have been able to use trading as a tool in meeting some water needs and in managing the sharing of available water. But, water pricing, water markets, water permits and water allocation have contributed only in minor ways to advancing water security for consumptive users at large. This has occurred because of limitations on market access and water trading as well as institutional problems and the high public administrative costs of water transactions. Where key development decisions impacting on basin aquatic systems and riparian lands have not been taken in concert with the management and planning roles of basin commissions the prospect of improved water security for many has actually diminished. Only when management strategies can adapt to economic, social and climatic change and work to control demand on available water supply, can the water security of these users be better assured. Major primary and secondary industry users could contribute far more to their own water security were they to comply fully with water efficiency, water saving and wastewater treatment requirements set by the state. That is critical, because while agriculture uses the majority of accessible water in China, its efficiency in use, in processing wastes and in fixing structural leakages are all very low by world standards. Some major industries such as textiles, electronics and coal fired thermal power are also poor managers of water use, water conservation and wastewater treatment.

CHAPTER 4

A CRITIQUE OF WATER SECURITY IN JAPAN

1.0 INTRODUCTION

The challenges in achieving water security in Japan differ from those in either Australia or China. The early sections of this chapter identify factors specific to Japan which create the framework within which water security is advanced or retarded. Section 2 of this chapter deals with the changing water context in Japan. Much of the nation benefits from abundant snow and rainfall which at times is sufficient to cause serious flooding, although the nation also experiences periods of drought. This section examines some of the challenges facing the government and the people if water security is to be improved. In Section 3, the dominant position of the Liberal Democratic Party (LDP) post war is reviewed along with the pivotal role played by groups of senior politicians, officials and industry leaders in determining key aspects of national policy. The interplay between the national government and local government is explored in Sections 3 and 4, particularly in the context within which water management is conducted and water security influenced. The situation is dissimilar from that in both Australia and China, especially in situations where it is local government which plays the leading role in Japan. As in previous chapters, activities have been assessed which have made a significant contribution to national water security, whether through the efforts of local government or through projects led by industrial or other groups.

Japan has a sophisticated network of broadly based laws spanning many facets of water resources and environmental management. When confronted by specific problems such as deteriorating water quality in lakes, the authorities have responded by introducing additional narrowly-focused pieces of legislation rather than amending and extending existing laws. The Japanese legal and administrative systems are characterised by stability over time with many of the major laws having remained in place over some decades. On the other hand, the hierarchy of plans continues to be broadened and extended, with the main statutorily based plans being regularly revised. Section 4 provides an assessment of the nature and importance of planning at various levels and sectors in Japan. All three nations have institutional blockages to effective water management and reform as well as to improving water security - issues specific to Japan are examined in Section 5.

The majority of the chapter is taken up with an examination of the way major national programs have advanced or influenced water security outcomes to the end of 2019. These programs are strongly rooted in the network of laws and major statutory plans. As was the case in Australia and China the programs and sectors examined have spanned topics as diverse as river management, water planning and water conservation. Each has been assessed in terms of the basic approach, the results achieved and the challenges ahead, with a final section dealing with ‘Consequences for Water Security’.

There are three primary sources of data and analysis referenced in this Chapter, including extensive material deriving from government, senior government officials and government supported bodies in Japan. A second major source is international organisations which have developed documents focused on water policy, management and planning often by drawing on data deriving from Japanese government sources. The latter international organisations include the Global Water Partnership (GWP), the Asian River Restoration Network (ARRN), the Organisation for Economic Co-operation and Development (OECD) and the Global Development Research Centre (GDRC). The third source of data, information and critical commentary derives from the work of a number of individual or groups of researchers. Takao (2018) charts the phases through which environmental policy and governance have progressed, leading to the most recent foci on sustainable development and climate change, while Noda (2018) focuses on governance and water resources development. Kagawa-Fox (2010) has examined in considerable detail the political and industrial influences over Japanese environmental policy formation which have important ramifications for the allied arena of water management. Adachi *et al* (2015) have identified various institutional blocks to major water reforms and their causes, while Noda *et al* (2018) have explored problems associated with dam construction and removal in Japan.

The stability of the Japanese system is such that policy documents and official reporting developed and presented in the first decade of this century, particularly by Japan Commission on Large Dams (JCOLD) and the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), still serve as prime references today in major official documents. This position contrasts markedly with the continuous change that has characterised the development of legislation and policy making in China over recent years. The Japan International Cooperation Agency (JICA 2017) has issued a report, based on the inputs of academic, governmental and consultant experts, which provides a comprehensive review of the Japanese approach to water supply and water management, supported by many case studies.

It reveals the breadth and depth of the requirements that must be met by both public utilities and private industry in managing water resources. In that regard, the document tends to advocate the 'Japanese way' as part of the marketing of Japanese technology to the world. Okada (2016) provides a comprehensive view of water policy, water management, its role in economic development and water conservation and efficiencies, albeit again with MLIT overtones. The heavy focus on both technology, engineering and economic development is very evident in these papers.

2.0 THE CHANGING WATER CONTEXT

Water continues to play an important part in religious and cultural traditions and aesthetic sensibilities, in Japan, as well as in Japanese arts and daily life (Dix 2017: 48-51). Today's national water context is strongly influenced by the period beginning in the early 1950s when national economic development was the highest priority, living standards rose and demand for water increased significantly. In that phase of post-war development, the nation came to face many adverse water-related issues including spread of waterborne diseases, high water leakage from storages, land subsidence due to excessive groundwater pumping, industrial water pollution, significant flooding and droughts (JICA 2017a: 5). Massive pollution not only left river reaches, lakes and large tracts of land devastated but affected the health and destinies of thousands of people. During the period 1950 to 1970 water, air and land environmental regulation was weak (Kagawa-Fox 2010: 3). However, between 1970 and 2000 the legislative and regulatory base was greatly strengthened through a network of environmental management and pollution control legislation (see Section 4). By the conclusion of that period Japan was viewed by some experts as a leader in its environmental policies amongst developed nations (Kagawa-Fox 2010: 4-5; Takao 2016: 3-4).

There are 16 major river basins in Japan with about half the population living on their alluvial plains, which together cover 10% of the nation's land mass (Water Environmental Partnership in Asia [WEPA] 2015: 2). This is a consequence of the majority of the country being mountainous and forested. Heavy rainfall occurs from spring to early autumn, including the period of monsoonal rains and typhoons, with major snowfalls in some regions during winter. This has led to Japan being described as the 'Land of Water' (Niponica 2015). Flooding generally occurs when the snow melts and early summer rains and typhoons all coincide over the same time period (JCOLD 2009: 91). Today, climate change has led to increasing temperatures and evaporation, diminished precipitation and snowfall, and to greater fluctuations in the extremes of rainfall events (Japan Times 2018: 1-3: Climate Reality 2019: 3-5).

The intensity of the flooding has been a major influence on dam building in Japan over many centuries, given that dams and reservoirs can serve as major instruments in mitigating the effects of floods. Because about 75% of Japan is rugged and mountainous, the rivers tend to be steep in gradient and relatively short in length, with small river basins. As a consequence, water and melting snow flow rapidly to the sea, with only some of the flows intercepted by dams of modest scale or extracted by Japanese people and industries direct from the rivers (Okada 2016: 71). During flooding the water level rises rapidly at peak flows but also falls away quickly after the event (MLIT 2012). The summer climate confers a benefit on the nation by nurturing considerable natural diversity in animal, insect and plant ecosystems as well as the forests that cover about two-thirds of the land mass (Iinuma 2013a:1). The rain, summer humidity and relatively high ocean temperatures provide a good climatic environment for paddy rice agriculture, which over centuries has supported a dense Japanese population (JCOLD 2009: 13).

As a nation, Japan receives 60% more in annual mean average rainfall than the rest of the world. However, when the Japanese population density is taken into account, the average per capita rainfall is only 25% (5000 m^3/year) of the world average. The water actually available per person is even less, standing at 3,400 m^3/year compared with the world average of about 7,500 m^3/year (WEPA 2018: 54). In 2016 Japan as a nation received about 1772 mm of precipitation, some 35% of which was estimated to have evaporated (WEPA 2018: 54; Okada 2016: 72). The principal consumers of water in Japan in 2012 were agriculture 67%, industry 14% and domestic users 19% (Okada 2016: 73). Unlike industry in China and Australia, Japanese industry recycles large quantities of water, so industry actually uses almost five times this amount when recycling is taken into account. In 2014, 19% of water consumed in Japan derived from groundwater (JWWA 2016: 5).

Despite the rain, snow and monsoons affecting parts of Japan, there are regions in drought in most years (Tembata and Takeuchi 2018). Since the 1900s there has been a pattern of steadily diminishing rainfall, punctuated by a series of significant droughts about once every ten years, which may increase in frequency and severity with climate change (Okada 2016: 71-72; Tembata and Takeuchi 2018: 20). The areas most vulnerable to drought lie in the nation's central and western regions and affect Tokyo and other heavily populated cities. During past localised severe droughts, domestic and industrial users in the centre and west of Japan experienced water restrictions, notably in the major cities where mandatory restrictions often lasted for some months (Tembata and Takeuchi 2018: 20). In the distant past, water users did not rely on government oversight or measures, but instead self-managed available water and flows in many river basins through collective efforts to share available water and impose water restrictions.

3.0 SOURCES OF POLITICAL POWER

There are a number of important sources of political power in Japan which can constrain or advance national water security outcomes. There are critical cultural forces and norms within Japan which, while not representing a single source of power, do collectively influence events and outcomes. For example, the government in striving for ‘futuristic’ national goals, consciously relies not only on the technical and engineering skills of the nation but also the respect of the Japanese people for authority, social goals, legislation and plans (Hayes 2018: 237). In that regard the Prime Minister recently called for a return to the pre-war values of national duty, deference and hierarchy (Stockwin 2018: 142). The analysis in this text shows that the specification of detailed legal requirements, administrative measures and standards and the orderly implementation of laws and plans are all significant influences on water security and water resource management outcomes.

Since 1952, the dominant party has been the LDP which has shown the capacity to mobilise key centres of national power to work with it over long periods in government. That includes politicians and senior public servants, business communities and other interest groups (Stockwin 2018: 138). Following the return of the LDP in 2012, the LDP government under Shinzō Abe has focused on economic growth, relaxing regulation to promote productivity and efficiency, international competitiveness and maintaining national security and political stability (Hayes 2018: 230-233; Takao 2019: 1-2). In this period, power has increasingly become concentrated around the Prime Minister, who has shown a preference for a presidential style of government (Stockwin 2018: 142-145; Vosse 2019: 277-278).

On the other hand, Rohlen (1989: 12-17) argues that the Japanese government is less engaged as a central national authority than is the case in many developed economies. He perceives the government as an agent building linkages, interacting with others, mediating and effecting compromise and in so doing helping to sustain the social fabric. In keeping with this model, the Japanese government is seen as determining the boundaries of the national legislated policy framework, while allowing others considerable administrative latitude to make situational judgments (Rohlen 1989: 12; Takao 2018: 308). Hayes (2018: 48) highlights the role of the bureaucracy in shaping public policy and argues that decisions are often ‘made through an extensive, and time-consuming, process of consultations and negotiations among government agencies and interest groups.’ She argues that the considerable power of the senior officials in Japan resides in: the resilience of the bureaucracy; the weakening of government following electoral and ministerial change; the continued importance of previously issued ordinances; and, the enduring strength of the bureaucracy’s linkages to supportive client and interest groups (Hayes 2018: 48-49). In the absence of more open, transparent water policy development and decision making this approach is readily enough molded to advancing selected interests.

Business and industry wield considerable political power. There is great strength in Japan in the bonds between business and government as well as business links to senior officials. In the context of this thesis it is notable that the private sector plays a major role in Japan’s economic, environmental and water resource policies, programs and activities. The current government recently stated that this sector is responsible for advancing more environmentally-friendly services, aiding pollution prevention and working to achieve efficient use of natural resources (Japanese Government 2018a: 23-25). The research here and elsewhere suggests that industry plays a more limited role in protecting the environment than the government suggests. A recent industry survey revealed that many Japanese companies will go so far as to seek efficiency in water use, but few if any perceive a wider role in fostering good water management or in reducing water-related risks (CDP 2019: 10).

At the domestic level, Takao (2018: 286) found that the coalition of big business interests and economic ministries is sufficiently powerful to override or emasculate progressive environmental and water policy proposals and reforms in Japan. Similarly, detailed analysis by Kagawa-Fox (2010: 249-252) reveals that the LDP has reshaped Japanese environmental and resource management policies to meet the political expectations and the demands of vested commercial interests. For example, in the implementation of sustainable development in Japan, the short-term political goals of the LDP and these commercial interests are argued to have overridden long-term national needs, equity considerations and the interests of the wider community (Kagawa-Fox 2010: 149-152). That contrasts with calls by the World Commission on Environment and Development (WCED 1987) for sustainable development to ensure that the needs of future generations are respected and not compromised or limited by today's decisions.

At the international level, interlocking networks created by major industrial and trading businesses have led to much public environmental and natural resource policy being shaped in ways that advance business and commercial interests (Kagawa-Fox 2010: 149 -152). It is therefore unsurprising to find independent Japanese experts criticise the way the so-called Iron Triangles comprising senior representatives of business, the LDP and the senior public servants (even in positions of influence post retirement from the service) continue to influence critical environmental and resource policies (Kagawa-Fox 2010: 249-252; Takao 2018: 286; Hosono 2015: 36). Very often the strength of the relationship is sufficient to ensure the approval of large public works projects, both national and international, which provide contracts for firms supporting the government (Hays 2012: 5). The Japanese expression 'Amakudari' describes the way former senior officials often use influential, post retirement positions in related companies, NGOs and local government to promote specific legislation, guide funding to preferred contactors or to support 'dubious' construction projects (Buruma 2011: 2; Moriyama 2019: 1-4). Recent efforts have been made to create a transition to a system where politicians and the prime minister's office take the lead in key policy decisions.

There is considerable interplay between central and local government in Japan, in part because local government is engaged in spending about 75% of public funds. The Constitution, reinforced by the *Local Autonomy Law* of 1947, confers powers on local government to self-govern, manage local affairs and property, to carry out administrative functions, set goals and establish policies and issue rules and regulations (Hori 2016: Sections 6-8). In 2000 the Law was amended to improve efficiency and equip local government better to deal with local and fiscal challenges of the time (Hays 2013: 2). However, in practice these changes have done little to affect the discharge of administrative power by central government. Local government has two tiers, namely prefectures and municipalities. Each of the 47 prefectures has an elected assembly and governor who is the chief executive, and all prefectures have core administrative responsibilities. Municipalities consist of cities, towns, and villages which fall within the boundaries of the prefectures (GDRC 2019: 1).

In some respects, the actions and authority of local government are more circumscribed than suggested above, because it is largely obliged to operate within the boundaries and rules set be central government (Hayes 2018: 51). National legislation frequently creates the operational context for local government to give effect to national policies and plans and to manage expenditure of public funds (Matsui 2017: 40-41; Hays 2013: 2-3). The government views local government as the regional coordinator of relevant actors and interests in the implementation of many measures in each region of the country (Japanese Government 2018a). It was local government that took the political lead in the early introduction of strict pollution controls and emission regulations in Japan and in developing environmental impact measures (Takao 2016: 46-48, 120). Today, local government continues to play a key role in securing national environmental, water and land resource and conservation goals (Takao 2016: 54-56). In advancing climate change policy, the central government has relied heavily on local government to implement its measures (Takao 2018: 137, 301).

The environmental movement of the last century was active and influential in effecting policy changes in Japan. The present government claims that non-government organisations (NGOs) continue to have legitimate roles in advancing conservation, offering policy advice, informing the public and furthering international cooperation (Japanese Government 2018a: 23-24). That is a contestable claim. Clearly, the same government did not welcome the powerful voices for change very evident in those social movements calling for accountability and action at the time of the Fukushima disaster (see Section 5). Some experts argue that position of citizen movements and pressure groups in other countries is more powerful and influential because in Japan government takes on the role of ‘promoting public interest’ (Ozawa *et* al 2019: 2). Takao’s research (2016: 286) shows that community groups are invited to participate in government advisory councils ‘if they take a pro-government stance or not engage in contentious politics.’

4.0 THE LEGAL AND PLANNING FRAMEWORKS

Japan’s water law and water planning are examined in the following two sections. The country’s post-war Constitution makes the national government responsible for both formulating national policies and for the laws, cabinet orders ministerial ordinances and notices which give effect to those policies, including for water resources management, water infrastructure and water quality. In contemporary terms the Japanese Government (2018: 23-24) defines its role as establishing the national framework, within which the goals, directions and roles for all actors are played out.

The Japanese planning system is extensive and complex, with major planning strongly inter-linked with the legal network. Statutory planning has played a central part in determining the direction of national, regional and local development as well as patterns of economic growth, land use and urbanisation. The five Comprehensive National Development Plans of last century were focused on regional and city planning, changed demographics, projected patterns of land use and measures to achieve plan goals (MLIT 1998; OECD 2017: 1). The latest successor National Spatial Strategy Plan of 2015 continues to emphasise economic growth and to deal with national spatial structure and land use. However, it also covers sustainable use of the nation's natural resources, comprehensive and integrated river management, improved water cycles and conservation of both groundwater and water quality (MLIT 2015: 48-49; Mugishima 2017: 4).

The national government approves plans developed by prefectures and establishes regulations and standards that must be followed. In regional planning there is a heavy focus on regional economies, strategic policies and projects for infrastructure and industry in built up areas (Srinivas 1997a: 2-3). Rural development is most heavily influenced by 'agricultural protection policies and legislation' (Srinivas 1997b: 1).

4.1 Water Law

Centuries ago, customary rules were forged within and between villages to govern water sharing. These sharing rules tended to favour 'first in first served', villages with significant local power and influence and upstream users over downstream users (Noda 2018: 191). The rules were negotiated between the users of a region and could be adjusted if mutually agreed to meet changed flow conditions or the needs of a new entrant (JCOLD 2009: 113). An early preoccupation of post-war Japanese Governments was how to overcome all constraints, including customary rules, on use of water for irrigation, power generation and more broadly for economic growth. In the period 1950 to 1964 the central government introduced a number of laws to guide and structure future progress towards cohesive development in the use and conservation of water resources.[7] This also provided the framework and the level of funding needed to mitigate the worst effects of droughts and floods.

[7] These include the *Water Resources Development Promotion Law*, the *Water Resources Development Public Corporation Law*, the *Comprehensive National Land Development Law*, the *Electric Power Development Promotion Law*, and the *Disaster Countermeasures Basic Law.*

Another objective in introducing this suite of legislation was to begin centralising administrative control over Japan's surface waters and to modify the impact of customary law and rights and local water use rules (Noda 2018: 190 -192). There followed the *1964 New River Law*, which removed control over rivers from local government and reduced some of the problems for the central government created by customary rights. It also served to moderate contestation between upstream dam organisations and downstream users, to overcome the lack of development rights, and to override the opposition of some ministries to loss of sector-based control (Noda 2018: 193; JCOLD 2009: 114). Under these statutes, the Ministry of Construction had the power to control rivers and lakes, construct storages and allocate dam use rights (MLIT 2008a: 1; Sawano 2011: 2-3).

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is the successor to the Ministry of Construction. It has extensive powers and a broad mandate and serves as the prime arm of government implementing land and water oriented legislation and coordinating water supply and construction and operation of reservoirs (Noda 2018: 192).[8] Through its Water Resources Department it has responsibilities for water resources policy, management and planning; its Water and Disaster Management Bureau (replacing the River Bureau) for flood control, river water utilisation and dam construction; and, its Sewerage and Water Waste Department for those critical matters. The complexity of relationships with other government ministries and bodies and the constraints on policy reform are teased out in the following paragraphs, and are amplified in the analysis of Section 5.

There is a wide network of laws in Japan governing various other aspects of water resources policies, management, planning and supply.[9] Many ministries, agencies, departments and bureaus have defined responsibilities under this network along with prefectural and municipal instrumentalities. The Ministry of Health, Labour and Welfare (MHLW) has specific responsibility for water supply for domestic use, particularly water quality. The Ministry of Agriculture, Forestry and Fisheries (MAFF) deals with water supply for agriculture and the conservation of river headwaters in the discharge of its forestry role. The Ministry of

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[8] In the discharge of these roles MLIT gives effect to the provisions of the *Water Development Promotion Law*, the *Japan Water Agency Law*, the *Law Concerning Special Measures for Reservoir Areas*, the *River Law* and the *Law on Specially Designated Multipurpose Dams* and the *Special Measures Concerning Upstream Area Development Law*.

[9] These include the *Water Supply Law*, the *Land Improvement Law*, the *Forest Law*, the *Industrial Water Law* and the *Industrial Water Supply Business Law*.

Economy, Trade and Industry (METI) focuses on water supply for industry and hydroelectric power generation. The Japan Water Agency (2016) is another agency that reports to several ministers and is engaged in building, renovating and managing dams and coordinating these activities across prefectures. It has been the major developer of water infrastructure in the seven rivers systems and is funded by a series of governmental, irrigator and industrial sources. These agencies tend to guard their own domains which at times limits cooperation.

The nature of environmental management, conservation and security has implications for many facets of the management of water resources, water systems and water security. After the era in which Japanese industry was accused of exporting pollution and waste to other countries and engaging in resource exploitation, the Japanese government introduced strict water and environmental regulations to be followed by Japanese firms, domestically and internationally. By the turn of this century there were many environmental laws designed to protect and conserve the natural environment including aquatic regimes (Takao 2018: 1-3).[10] Of these, the *Basic Environment Law* defines the responsibilities of central and local government, corporations and citizens. It calls for cooperation between national actors, respect for the environmental rights of future generations and establishes the basis for a Basic Environment Plan (Ministry of Environment [MOE] 2019: 1).

It is MOE which has regulatory authority for much legislation impacting on the management and use of water resources including environmental protection and conservation, environmental pollution, waste disposal and environmental impact. Matters relating to water supply and water emission permits are examined in Section 8. Amongst the major projects requiring Environmental Impact Assessments (EIAs) are dams, which largely fall within the purview of MLIT (see following sections), and a variety of construction and development projects. Local government ordinances serve similar functions to EIS legislation in dealing with some specific projects and those with local important impacts (Ozawa *et al*, 2019: 7). In recent decades, the government has been able to promote Japanese technological advances and harness ‘clean’ technology in the environmental and water resource management arena

[10] The primary laws are the *Basic Law for Environmental Pollution Control*, the *Nature Conservation Law*, the *Water Pollution Control Law*, the *Environmental Impact Assessment Law*, the *Soil Contamination Countermeasures Law*, the *Waste Disposal and Public Cleansing Law*, the *Pollutant Release and Transfer Registers Law* and the *Law Concerning Special Measures of Lake Water Quality*. In 1993 the *Basic Environment Law* replaced the environmental pollution law and major parts of the conservation law.

(JICA 2017a: 6). This has underpinned both Japanese international aid and leadership of international development programs (Takao 2018: 49-50).

At a number of points in this chapter reference is made to the importance of joint stewardship and tangible cooperation in dealing with major water management challenges and water scarcity. It follows that the above substantial network of laws has not been devised with autocratic implementation in mind. Rather frequent ‘partnership’ between national authorities, local government and water utilities has played a significant part, as the national government sets the framework while much implementation and management occur through coordinated efforts at local levels, as examined in Section 3. In addition, administrative instruments, such as internal notes (*tsutatsu)* and administrative guidance (*gyosei shido*), help guide stakeholders in interpreting and implementing laws. While the approach has some shortcomings as revealed by Kagawa-Fox (2010) and because of the institutional complexities considered in Section 5, it has been beneficial in improving water management outcomes and advancing some aspects of water security in Japan.

4.2 Water Planning

The government is responsible for developing and implementing water resources policies of national significance. In 1999, the government introduced the Comprehensive National Water Resources Plan (known as Plan 21) and the Basic Environment Plan which focused on water conservation and water quality. Plan 21 created a national planning framework for development, based on the river resources and projected patterns of water supply and demand for the period 1999-2015 (Okada 2016: 77). The focus was strongly oriented to completing planned and ongoing construction of water infrastructure and continuing the pattern of development of water sources of the time. MLIT (2008d: 2) claimed that the national water system would be assured by 2015 and that it would be stable enough to meet foreseeable demands, including in years of water scarcity. The Plan also set out to promote a ‘regional consensus’ around reliable targets for water supply, foster community involvement in improving water environments, secure water for the environment and maintain water quality (MLIT 2008d: 1).

In 2008 the responsible Minister for MLIT designated seven major rivers for comprehensive development to meet increases in urban population and industrial demands. In 2016, these basins supported 52% of the national population and 46% of the national output of manufactured products (Okada 2016: 77). For each of the seven rivers water resources basic plans exist:

- Forecasting water demand and targets which have been set according to end use
- Identifying facilities that need to be constructed to achieve the supply targets
- Addressing factors impinging on the development of the riverine resources and the rationalisation of water use

If the Minister determines that a plan should be changed, consultation must take place with the Cabinet, relevant Ministers, agency heads, prefectural governors and the National Land Development Council (MLIT 2008d: 2).

In the years following the 1992 Rio Earth Summit, Japan focused heavily on sustainable development and adopted the national Basic Environment Plan and the *Environmental Impact Assessment Law* (Takao 2018: 4). The Fifth Environment Plan (Japanese Government 2018) continues the emphasis of other plans on sustainable production, consumption and development in the use of Japan's natural, human and economic resources (MOE 2018a: 5-12). It asserts that climate change must be dealt with effectively and that lifestyles must accord with sound management of the environment. While the plan does not list the overcoming of water scarcity or improving water security as key challenges, it does:

- Advocate a precautionary and risk-based approach to environmental management (Japanese Government 2018a: 17).
- Acknowledge that the interaction of economic, environmental and social factors has led to complex problems requiring integrated solutions, such as 'integrated watershed management' (Japanese Government 2018a: 14, 41).
- Require pollutant loads to be reduced, wastewater treatment to be improved and groundwater extractions to be controlled, often pursuant to existing regulations (Japanese Government 2018a: 75).
- List indicators that must be monitored dealing, *inter alia*, with water quality, watershed circulation, pollutant levels and groundwater health (Japanese Government 2018a: 76).

In this list, the latter two requirements relate to current approaches by MLIT and other ministries to managing and safeguarding water quality. On the other hand, the next section points to major impediments to the adoption in Japan of approaches likely to advance the former two issues in the list, namely integrated watershed management and a precautionary approach to environmental management.

5.0 INSTITUTIONAL CONSTRAINTS

Better and more integrated management of water resources and respect for the consequences of that management on the hydrological cycle is impeded by complex institutional and administrative arrangements in Japan, just as it is in Australia and China. Sections 2 and 4 reveal the number and breadth of major national ministries, agencies and bureaus with jurisdiction over some aspect of water resource management with direct consequences for water security outcomes. For example, the national legal and planning frameworks have created considerable overlaps between jurisdictions in relation to rivers, headwaters and estuaries, the environment, health and welfare as well as in the management of the impacts of farming, agriculture, domestic sanitation and industry on surface and groundwater systems (Umeda 2014: 1; The Japan Times 2014a: 1).

In the book *Policy Analysis in Japan*, Adachi *et al* (2015) point to institutional blockages that prevent the introduction of transformative policy and the effective analysis of existing policy. While this phenomenon parallels that in China (see Chapter 3, Section 3) the causes are quite different in Japan. For instance, the Ministers of State, who collectively comprise the Cabinet, exercise executive power but arrive at most decisions by consensus. That tends to favour incremental policy development and reform rather than major or systemic reform. Adachi *et al* (2015) have pointed to the cautious way policy is changed in Japan and the tendency of leadership to avoid provoking public contestation. Examples include seeking to moderate existing debates outside the arena of public scrutiny and procrastinating or actively delaying data-gathering and public dissemination of information in order to reduce contestation prior to decision making (Hosono 2015: 34; Rohlen 1989: 34; Hays 2012: 3).

Another factor is the dominant part played by elite public officials in ministries, parliamentary supporting agencies and bureaus in crafting legislation, shaping budgets and coordinating inputs, as raised in Section 3 (Kagawa-Fox 2010: 249-252; Iio 2015a: 24; Stockwin 2018: 138). Through regular contact with interest groups and local government, these officials can and do narrow the focus of what is introduced into governmental process by selecting matters of concern to powerful interests or politicians (Iio 2015b: 92-95). The political influence of power brokers in the LDP and industry groups in shaping policy and determining outcomes is equally important (See Section 3).

Japan has legislation and industry codes of conduct directed at reducing corruption, but these various alliances continue to favour specific interests (Global Legal Insights 2020: 1). In the instance of the Fukushima disaster the government acceded to public pressure by conducting a more open review of nuclear energy policy than ever before. Yet, it was clear that neither the government nor the people were fully informed because as Buruma (2011: 2) observed 'the tight-knit cliques of bureaucrats and corporate officials made sure that a utility company vital for economic growth would never be hindered by strict regulation or political oversight'. Even though there were mass public protests, largely supporting nuclear power phase down, a conjunction of change in government and the exercise of countervailing power by the nuclear energy sector was sufficient to derail this publicly desired outcome (White 2015). The process and its outcome were much different in contemporary Germany.

In sum, there is significant emphasis in government on coordination, compromise and accommodating vested interests rather than on institutional reform and policy development. That has weakened the formation of public policy, which could be significantly strengthened if dialogue and consultation by the government with the Japanese people were more substantial and effective (Iio 2015a:27; Hosono 2015: 36; Adachi 2015: 290)

6.0 TOWARDS NEW WATER MANAGEMENT PARADIGMS

In recent years, the Japanese government and its lead agencies have produced laws, plans and policies which link climate change, integrated management of water and land resources, improved management of critical ecosystems and water cycles. These have the potential to improve national water security significantly. In response, there have been attempts to fashion some policies and programs that advance these concepts and recognise the linkages (Japan International Cooperation Agency [JICA] 2017a: 12). By contrast, the governments and ministers of Australia and China have not generally fostered IWRM. This section examines some of the programs initiated, the challenges, the strengths and the weaknesses. The subsequent sections show that these goals have only partially been achieved, in part because of the way the Japanese authorities and ministries envisage and discharge their roles.

In Japan, published material emanating from government, ministerial and lead agency sources has focused on the importance of IWRM since the turn of this century. In practice, however, the application of integrative approaches is limited. This has occurred because decisions have frequently already been taken involving substantial changes in major surface water sources in order to achieve economic-oriented water development, secure water supply and ameliorate flooding. In these circumstances integrative management can only occur, after the event and in considerably modified systems. As a result, many natural river characteristics have irreversibly been changed and river environments and ecosystems have seriously deteriorated.

In 2009 the Japanese government established ‘Team Water Japan’ to focus on sustainable water management across sectors, including at the river basin level, by drawing widely on expertise from agencies, local government, the private sector and NGOs (Oki and Musiake 2009: 575-578; Team Water Japan 2013: 1-2). It also formed a ‘Water Security Council of Japan’ to provide policy advice to the Prime Minister, formulate policies across bureaucratic boundaries and to assist Team Water. This Council also comprises leaders, drawn from the Japanese Diet, academe, business and other arenas, supported by sectoral action teams.

In the *Basic Law on Water Cycle Policy* of 2014, integrated river basin management is again identified as an important element. The central thesis of this act is that ‘proper water circulation is important for the environment, people’s daily lives and industrial production, and that water is a valuable property of the nation’ (Umeda 2014: 1). The act is not focused on the full hydrological cycle which links evaporation, rainfall and the needs of aquatic systems in a continuing cycle. Rather, it requires the nation’s public instrumentalities to manage forests, farm lands and cityscapes so that water is better conserved and retained (Umeda 2014: 1; The Japan Times 2014a: 1-2). It also seeks to reduce water shortages, declining water quality, excessive exploitation of water sources, particularly groundwater, and to better manage climatic events (The Headquarters of Water Cycle Policy [HWCP] 2017: 1; The Japan Times 2014a: 1-2). Following this legislative step, the Japanese Cabinet adopted the Basic Plan on Water Cycle Policy in 2015, on which the Water Security Council is currently working (HWCP 2017: 8-9; Ohmura 2014: 2-3; World Water Forum 2017: 1-2; 2019: 1-2).

The Japanese authorities have accorded a very high priority to understanding, predicting and mitigating the effects of climate change. While, the mean annual national temperature rose by about 1°C during the 20th century, Japan is now experiencing increasingly extreme climatic events each year (See Section 3). Early projections envisaged a rise of 2-4°C during the 21st century with increased incidence of 1 in 100-year floods, landslides and sediment movements through rivers and reservoirs (MLIT 2008g: 15-17; 22). Recent reports envisage the temperature rise to be in the order of 2°C, with the potential to expose 50 million people to flooding and inundation by seawater (Boyd and Baird 2018: 2). The risks associated with increasing temperature are greatest from winter to spring in northern Japan. As early as 2008, the Japanese authorities envisaged that managers needed to be better positioned to adapt existing operational procedures in rivers and to engage in more effective whole system responses to climate change (MLIT 2008g: 13). That included improved flood and drought planning, modelling and mapping, enhanced river and dam safety provisions, and increased community information and awareness (MLIT 2008g: 33-39).

In 2018 the government introduced the *Climate Change Adaptation Act* which focuses on many sectors of the economy and life as well as water resources and the water environment. In those areas, adaptation plans are to be developed as well as a national climate change impact assessment to be made every five years (Japanese Government 2018b). In responding to the UN ‘2030 Agenda’ for sustainable development Japan formed a Cabinet body known as the ‘Sustainable Development Goals (SDGs) Promotion Headquarters’ (Japanese Government 2017: 4). That entity has established a national framework, national priorities and more than one hundred measures to be implemented. The primary goals for water involve restoring ‘sound’ water cycles, improving river basin management, conserving water, preserving ecosystems and reducing the risks and impacts of natural disasters (Japanese Government 2017: 32). Prior to this international agenda, Japan asserted that the nation had been ‘implementing measures in an integrated manner to build a sustainable society through environmental, economic and social improvements’ (Japanese Government 2017: 4).

6.1 Results and Challenges

The prime Japanese agency responsible for water management and development decisions, MLIT (2008f: 2; 2011: 1) views IWRM as if it were a series of steps covering legal, financial, construction and operational matters, all focused on providing efficient water and energy use and overcoming disaster risk. Similar values underpin the MLIT (2008f: 2) assertion that ‘Water Plan 21 identifies long-term water supply and demand prospects and means of improving water use stability through efficiency measures and effective use of existing infrastructure’. These issues are further explored in the case of the city of Nagoya below and the Tsurumi River Basin in Section 7.

Asayama (2016) developed a case study to show how IWRM and water cycle management have been applied to the city of Nagoya and its regional surrounds. Nagoya is situated near the mouths of the three rivers that flow through the Nōbi alluvial plain from mountainous headwaters to a receiving bay. The whole region includes many major dams, barrages, canals as well as more than forty urban centres of varying size and all the associated water, drainage and sanitation facilities. The study shows that IWRM has been applied as a series of separate processes rather than as one superordinate, integrative procedure (Asayama 2016). Issues such as the health and resilience of the water sources, resource conservation and biodiversity have received little attention. Instead, the process has focused on:

- efficient operation of existing water infrastructure, its maintenance and restoration and its protection against earthquakes (Asayama 2016: 3).
- controlling flooding, including the construction of ninety-six stormwater reservoirs, associated channels and pumping stations (Asayama 2016: 11-12).
- cooperation between basin municipalities, to advance collective regional interests and the development of new river-based businesses, with some provision for cooperation on environmental matters and river circulation (Asayama 2016: 14).
- reducing the impacts of infrastructure and extractions through forestry management and sediment control (Asayama 2016: 8-10).

Recent legal, policy and planning documentation refers to the restoration of healthy water cycles. In practice, most major rivers have been extensively modified through the construction of water infrastructure and heavy water use. As a result, restoration has usually entailed some aspect of river and environmental repair rather than attention to water cycles (See Sections 7 and 8). To achieve improved basin management and healthy hydrological cycles would also involve overcoming the challenges created by the number of governmental bodies with some responsibility for aspects of water resource management. That represents a significant institutional hurdle to achieving a healthy hydrological cycle - as is the case in Australia and China (See Sections 2 and 5; Umeda 2014: 1; The Japan Times 2014a: 1). So, the task of reconciling river management policies and plans with new basin and hydrological cycle policies and plans is destined to take time, resolve and significant policy, planning and institutional change.

Japan has adopted a multifaceted approach to climate change, elements of which are linked to water resource management and national water security. Traditionally, high priority national efforts have been directed towards controlling and alleviating flooding, especially through river management and water infrastructure programs (see succeeding Sections 7 and 8). Major flooding and frequent land-slides are recurrent problems as severe rainfall events feed the short, rapidly flowing rivers and undermine the surrounding land, affecting millions of Japanese people living in coastal districts, particularly on alluvial plains. For example, in 2018 and 2019 torrential rainfall and typhoons caused unprecedented flooding, mudslides and surging seas in many regions of Japan, leading to the evacuation of millions of people, loss of hundreds of lives and inundation of homes, services and heritage sites (Wilson 2018: 1; Reuters 2019:1-2; Climate Reality 2019: 1-3). Rebuilding infrastructure alone after the 2018 floods has been estimated at $US 2.3billion, before taking account of the costs to be borne by government and the community in restoring farmland, housing, property and small business (Nikkei Asian Review 2018: 1).

A continuing role for major agencies has involved programs designed to assure physical dam security, while also containing and controlling sediment and refuse flows and adapting approaches in the light of new knowledge about climate change (MLIT 2008g). For example, over the past 30 years water temperatures in rivers, lakes and marshes have been found to be warming with the potential to increase suspended sediments and lower Biochemical Oxygen Demand (BOD), a good indicator of water source health (Central Environment Council 2015: 36-37). While some Japanese cities have worked progressively to counter the impacts of flooding, the projections of greater rainfall in some regions associated with climate change, have led to further government and city action. In the case of Tokyo, the world's largest underground floodwater diversion tunnel and cavern has been constructed over 13 years at a cost of $US 2 billion, as one example of the government's emphasis on 'adaptation' projects (Ortiz 2018: 3-8).

Japan has developed a series of risk-based services and warning systems to inform water resource managers throughout the nation of impending extreme weather events and their actual progression. By 2010, the Japan Meteorological Agency (JMA) had harnessed advanced information and communications technologies to create a series of integrated networks and high-resolution models of global patterns of weather circulation (MLIT 2008f: 1-2). The JMA is able to support domestic and international research and alert water supply authorities, river managers and emergency services to major climatic events in real time (MLIT 2008f: 2; World Bank GFDRR 2016).

Thousands of disaster base stations and warning stations have been established in municipalities and, as early as 2003, Japan had laid 27, 000 km of high-speed optical fibre to monitor water movements. By 2009, river and channel flows and river bed-load discharges were being measured, monitored and evaluated and the reliability of technology assessed to better manage the impact of flooding and drought (National Institute for Land and Infrastructure Management 2009: 1). Technology is also widely applied at times of water scarcity, when major dams in river basins are utilised in synchronised ways to maximize water availability for domestic and consumer use (MLIT 2008f: 1). Japan has invested very heavily in protecting this water infrastructure and in training its managers. Some of this strategic investment has positioned the country to face the vulnerability of water infrastructure and 'soft' water targets to attack. When it comes to threats to cybersecurity, the nation has a *Basic Act on Cybersecurity*, 2014 and a Cabinet directed Cybersecurity Strategy (Japanese Government 2015; Arie 2017). That has led to a more open public process in developing national approaches to the protection of critical infrastructure to cyberattack than has been the case in dealing with other covert physical threats to water supply, treatment and distribution.

The world faces grave pressure on available water resources if future populations are to be sustained. It is reported that the Japanese Water Security Council has joined other nations in examining how to devise a water system that can cope with a global population of 10 billion people (Building Research Institute [BRI] 2011: 38-39). In searching for solutions, Japanese authorities are conscious that the nation is a net importer of agricultural and livestock products. The quantity of water used in the production of these imported goods, known as 'virtual' water, actually exceeds annual water consumption by domestic Japanese agriculture (BRI 2011: 40).

It is difficult to reconcile this global concern and the sophistication of physical preparedness to deal with the impacts of climate change with the country's position on greenhouse gas production – with all of its implications for water, human and national security. After all, rises in climate-induced global temperatures are already exposing a major proportion of the dense population of Japan in coastal locations to serious threats of severe flooding and inundation associated with rising sea levels. Japan's most recent commitment is to cut emissions to 26% of 2013 levels by 2030, a somewhat more demanding target than that set by Australian authorities. Both these targets fail to cut emissions to 45% of 2010 levels by 2030, as recommended by the Intergovernmental Panel on Climate Change (Boyd and Baird 2018: 1-3).

6.2 Consequences for Water Security

Some of the initiatives described above offer promise for future water security but it is too early to assess whether they will make tangible contributions. IWRM as currently applied in Japan represents a disciplined, but only partially integrated, approach to the management of water resources, rivers and reservoirs. The utility of the approach and its contribution to wide-ranging water security is limited by several factors. IWRM is viewed as involving management of major aquatic systems *after* overriding national economic goals for rivers have been established and patterns of development have largely been determined. That includes the introduction of many dams and other forms of water infrastructure into these systems. In such processes, rivers, their environs and ecosystems are significantly modified and future water security impaired. Under this Japanese approach to IWRM, there is very considerable time, effort and resources needed to arrive at agreed management strategies and operational plans, particularly in bringing all parties together. Some of these limiting factors apply equally to restoring ecosystems and water cycles as well as to securing sustainable development in Japan.

The Japanese approach to handling the impacts of climate change on the management of water resources and water security is risk-oriented and sophisticated in dealing with the aquatic systems in Japan as they exist today. However, environmental water security and the impacts of climate change on water resources would benefit from being accorded a higher national priority. Japan harnesses advanced technology, widespread modelling and monitoring to mitigate the effects of the floods and droughts and has developed an extensive and adaptive approach to public safety, infrastructure security and coping with natural disasters. However, people and national water security are at increasing risk as a result of global warming. That argues for tougher targets to be set for national emissions in Japan – and other wealthy countries including Australia and the USA.

7.0 RIVER MANAGEMENT AND PLANNING

All rivers in Japan are public property and are separated in their management by class. Overall, there are tens of thousands of rivers in Japan, with only about one hundred regarded as being nationally significant in size (Brasor 2010: 2). In fact, there are 109 Class A rivers that are principal sources of water for major cities that are managed centrally by the national government, with more distant reaches managed by prefectures. There are 2723 rivers designated as Class B which are smaller with an average river basin area of about 40km^2.

They are managed by prefectures which can delegate river improvement work to their municipalities (JCOLD 2009: 177; 2017: 177). There are other small rivers which lie outside the ambit of the River Law (Sawano 2011: 6).

Prior to post-war industrialisation, Japan's rivers were an abundant source of aquatic life, with vast numbers of fish visible swimming upstream in many rivers during spawning periods (Kiguchi 2013: 1). While significant dam building to meet local needs does date back to the late 19th century, from the middle of the 20th century the government took over control of construction. That led to the building of dams to control flooding, provide water and hydropower supply and to meet the demands of economic development. That has been accompanied by water shortages caused by rapid urbanisation, industrialization and rising living standards (Takahashi and Uitto 2004: 69).

Today river management is founded on the 1997 revised River Law. The task of managing rivers now includes promoting public safety, moderating the impact of floods and storm surges, overseeing and managing water usage, conserving key elements of the natural environment, and engaging riverine communities in planning and water sharing. Revisions to the River Law have occurred often in response to pressure by the Japanese people who had over some years decried the excessive impacts of water infrastructure and associated works on the national rivers as well as the unquestioned power of government and technocrats to build water infrastructure (Takahashi and Uitto 2004: 69). Currently, the River Law is administered by MLIT, which must also take account of other laws, ordinances and orders, including those dealing with administrative and structural standards for river water infrastructure and facilities (JCOLD 2017: 175-176).

The management of rivers and who uses their waters is guided by river administrators, otherwise known as river managers, under the provisions of the *New River Law*. There is a hierarchy of administrators, depending on the class of river water and socioeconomic importance, from MLIT ministers and senior officials to prefectural governors and municipal mayors (OECD 2015c: 1). The river administrators have to monitor drought conditions and when necessary oversee the establishing of mechanisms to share and conserve available water. Some sophisticated approaches involving joint custodianship through drought coordination councils are examined in sub-section 10.2.1.

Under the provisions of the Basic Plan on Water Cycle Policy, each river basin has to establish a River Basin Water Cycle Council which in turn is required to produce a River

Basin Water Cycle Plan (HWCP 2017: 8-9). It was not envisaged that this process be controlled by a single administrator but through the collaborative efforts of national and regional public bodies and local stakeholders and communities. The act envisages that local communities will 'lead the way in promoting river basin management' (HWCP 2017: 8). This draws on the idea of collective basin stewardship reviewed in Chapter 1 and in Section 2 above. The government will however give guidance to the new process through a headquarters located in central government. That headquarters will broadly shape future water cycle policy, provide guidelines to river councils and identify commendable examples drawn from existing approaches to river basin management and planning (HWCP 2017:8-9; The Japan Times 2014a: 1-2).

7.1 Results and Challenges

'The excessive development of rivers with flood control works, dams and barrages' in the 20th century led to virtually all Japanese rivers losing amenities and deteriorating markedly in ecological health and water quality (Takahashi and Uitto 2004: 69). Since the turn of the century new laws and guidelines have been introduced which call for improved river environments in Japan[11]. Collectively they have created the framework within which some habitat conservation, channel and river restoration has occurred, as well as the formation of fish passages (MLIT 2017: 306). For example, in the case of the Kushiro River, which supports Japan's largest wetland, sediment inflow has been checked, the profile of meandering tributaries restored and trees replanted on degraded land (Asian River Restoration Network [ARRN] 2012: 50). As a result of these efforts some fish and birds have returned. Overall, however, in 51 Class A river restoration projects carried out to 2012, less than 10% of the projects accorded priority to restoration of critical river properties such as river flows and water quality (ARRN 2012:20).

The revised River Law requires the development of a River Management Policy for each river as well as a River Improvement Plan (JCOLD 2009: 177). In principle, river improvement plans should provide for water flows to be sufficient to meet the basic needs of river plants, animals and their habitats as well as ambient water quality standards. On the other hand, the plan formulators must also take account of the views of governors of prefectures, mayors and local residents in plan development (Sawano 2011: 19). In practice,

[11] These included the *Law for the Promotion of Nature Restoration*, the Basic Guideline for Nature-Oriented River Management and the Basic Guideline for Rich River Development.

it is the MLIT river administrator who is empowered to approve construction of dams and levees, the dredging of rivers, the design of water infrastructure to control the impact of floods and who authorises any works activity proposed by another entity (JCOLD 2009: 177). Concern over the extent of unnecessary river modification was one of the factors underlying law revisions.

The construction of extensive dams and other water infrastructure on all the nation's significant rivers has led to considerable and unnecessary levels of dislocation to river flows, riverine land, ecosystems and the natural hydrological cycle, as further reviewed in Section 8. All this has serious implications for the new water cycle councils. Above all there are many existing issues relating to the deterioration of land, water and ecosystems which need to be overcome if water cycles are to be improved markedly. Managing changes in groundwater is an added difficulty, because there is no national law dealing with groundwater. Under Civil Law groundwater is not a public resource even though, in theory, government is legally able to restrict its use in designated public areas (See sub-section 9.4). Another hurdle is created by customary water rights, because the law does not restrict the exercise of those rights, even if they are found to impact adversely on the water cycle (Umeda 2014: 1). Finally, as shown in this chapter, harnessing rivers and their resources to maximise economic growth continues to be an over-riding goal in national development. The councils do have one advantage which lies in the natural characteristics of Japanese rivers, because the impact of dams on water cycles is often much less than the impact of such structures on most rivers in Australia and many in China.

There is no standard prescription for how to apply IWRM. The case of the Tsurumi River Basin which has direct connections to the suburbs of Tokyo provides an excellent example of the time and resources needed to implement and benefit from the Japanese approach to IWRM. The basin and the river changed dramatically as the urbanised area in the basin grew from 10% in 1958 to 84% in 2000 (GWP 2013: 1). Problems resulting from this rapid urbanisation included reduced river flows; increased flood risk, water contamination and environmental degradation; and poorer river access and recreational opportunities (GWP 2013: 1). That led to efforts to achieve more integrated whole basin management in this much modified system, through 'Revitalization of a Sound Water Cycle' (GWP 2013: 1).

In fact, it took 6 years to complete the Tsurumi River Basin Water Master Plan, involving river committees, a river commission, council and administrative conference (GWP 2013: 2-

3). Targets, implementation strategies and timelines under the emerging plan were progressively developed through the interactions of citizens, civic groups, enterprises, experts, NGOs and multiple administrative agencies at central and municipal level. Even so, the Global Water Partnership (GWP 2013: 4) held that the project lacked measurable targets and therefore the capacity to adapt strategies in response to feedback or to cope with major change. In considering the relationship between the planning process and the effective implementation of IWRM, the Partnership observed that:

> 'The formulation of a comprehensive and integrated master plan, with the aim to revitalize a sound water cycle that is lost in the process of rapid urbanization, is an extremely time and effort consuming process.' (GWP 2013: 4).

7.2 Consequences for Water Security

Water security for the state is robustly based on a network of laws and high order plans. Extensive and effective implementation of these laws, notices and plans has positioned the state to manage the nation's rivers to achieve some national priorities. However, the objective of improving the water security of the state, as a result of recently announced concepts and strategies, continues to be retarded by the modifying influence of water infrastructure in each major river basin.

Human and consumer water security have played a pivotal part in the Japanese approach to managing rivers and water resources. So, amongst the key considerations post-war have been support for industrial development, power generation, the physical security of water infrastructure and security of supply for urban dwellers. That has entailed providing safe, reliable sources of water of high quality and adequate quantity, in part by engaging in dam building to both mitigate flooding and lessen the impacts of drought.

Water security for the environment has improved in some respects and deteriorated in others. In Japan's river systems there were marked improvements when the state overcame the widespread water pollution of fifty years ago. The standards, controls and targets progressively introduced and refined since then have created effective barriers against future contamination of surface waters, but have not been as successful in controlling sedimentation, contamination and eutrophication in enclosed systems such as lakes and reservoirs. The continuing heavy emphasis on introducing water infrastructure into the nation's rivers has led to significant major systemic modifications, loss of river-based fauna and flora, important natural river characteristics and social amenity. These changes have had a deleterious impact on environmental water security. In addition, the physical and water security of groundwater systems is not fully assured, in part because the water resource does not lie in state ownership.

8.0 WATER INFRASTRUCTURE

The issues facing Japan in deciding whether or not to construct major storages differ from those facing either Australia or China. The rivers of Japan are short and steep in gradient and the quantities of water stored in the nation's reservoirs are generally less than in the dams of many other developed nations. In periods of severe flooding, river flow is not significantly impeded by dams along the river courses because of the volumes of water in the systems as well as administrative decisions to safeguard the water infrastructure by allowing water to pass.

In post-war Japan, the processes of economic and land development were strongly linked to the benefits derived from constructing dams (JCOLD 2009: 10-11). The Water Resources Development Basic Plan of the early 1960s provided early impetus and contributed to the percentage of water supplied from water infrastructure increasing by more than three-fold from 11.6% in 1965 to 38.5% in 1999 (JCOLD 2009: 73). In a similar timeframe, the revised River Law of 1964, required river administrators and dam operators to establish a 'normal' flow regime to meet the needs of downstream water users, conserve habitat, fauna and flora and protect groundwater levels during dry periods. (JCOLD 2009: 117). The examples in the next sub-section explore the extent to which these requirements were implemented.

Many of the nation's dams were built prior to the introduction of the *Environmental Impact Assessment* (EIA) *Law* of 1999. Projects passed through an administrative EIA process, guided by the standards extant at the time which largely limited costs and delays for the proponent and public scrutiny (Barrett and Therivel 1991: 3, 155-157). By 2009, about 3,000 dams, weirs, canals, tunnels and aqueducts had been built on major systems as well as more than 200,000 irrigation ponds and minor dams (JCOLD 2009: 26). Irrigation channels were frequently constructed as public works, while small irrigation reservoirs were locally built and managed. These reservoirs are filled from local rivers and the irrigation process is managed by 7,000 Land Improvement Districts (LIDs) comprising groups of farmers (Mogi 2011: 1, 9).

In 2003, MLIT reviewed the effectiveness, in terms of cost and mitigation of flooding, of 93 dams under MLIT management during the period 1987-2001 (JCOLD 2009: 91). It found that 3.7 trillion yen (2001) had been expended in dam construction but estimated the monetary value of reductions in flood damage exceeded that figure by 0.5 trillion yen (2001 prices). The review took account of potential damage to flood levees, river systems and bridges but did not explore the social and environmental costs associated with dam construction and operations, including adverse changes to rivers, land, ecosystems and basin communities or the costs of land-slides and sediment build-up in dams. While the review relates to this past era, the analysis helps to explain the origins of the outlook of some in government and MLIT today.

Hydropower has been locally generated in Japan since the 1890s but post-war the focus changed from small storages and power plants to larger dams built along the length of rivers, including some located upstream in difficult terrain. In 1988, the responsible authority for hydropower, METI, found it necessary to issue a notification because in that year 9,600 km of Class A river beds had dried up below hydroelectricity dams - with improved river flows reported thereafter (JCOLD 2009: 118). By the turn of the century, pumped-storage power utilised the gradient drop between an upper and lower storage in the generation process. One such major system built between the years 1960 and 2000, comprised six major dams on the Kurobe River with associated hydropower plants. The whole project took advantage of the head-drop of some 1300 metres from the Kurobe Dam to the Otozawa Plant (JCOLD 2009: 86-87).

The fact that this whole pattern of dam construction changed little as Japan entered the 20th century, may explain the dominance of the available, somewhat dated governmental-sourced documentation dealing with water infrastructure construction policy and planning. The commentary in the next section, dealing with 'results and challenges', has sought to redress this balance by drawing on contemporary and independent appraisals by international organisations, experts and the media as well as brief examinations of several specific projects.

8.1 Results and Challenges

In practice, many dam and irrigation structures in Japan are in significant need of maintenance, renewal or demolition. The OECD (2011: 14) assessed that the Japanese authorities would need to increase its spending on water infrastructure by 20-40% to cope with urgent upgrading and rehabilitation. For example, in 2014, 38,000 km of municipal water pipelines were more than 40 years old and assessed as costing more than US $1 million per km to replace (Japan for Sustainability [JFS] 2014a: 2).

Public debate has sharpened in this century over the scale of infrastructure expenditure, the negative impacts of new dam proposals and the need to remove some dams. In the years 2009-2012 the newly governing Democratic Party of Japan (DPJ) responded by examining the cloistered formation of infrastructure budgets, the failure of major projects to meet public expectations, serious cost overruns, underpricing and wastage (Hays 2012: 10-15). A particular focus lay on the influence of Iron Triangles and the ‘Amakudari’ in selection of priority works and modes of construction, as reviewed in Section 3. Water infrastructure contracting and development was not immune from the many adverse findings in these DPJ reviews. They revealed that much public infrastructure was both unprofitable and unnecessary (Hays 2012: 5, 10; The Japan Times 2014b: 2).

The 1999 law explicitly provided for EIAs to be prepared for major dams, weirs and reservoirs that would impact on large tracts of land (MOE 2018b: 3). Other projects of lesser scale were also subject to full assessment if the authorising agency deemed that to be necessary. The law did not require an assessment to take account of traditional lifestyles or to protect endangered species (Kiguchi 2013: 1). The strong orientation of MLIT and its processes in favour of development tended to determine the outcomes. The law was strengthened and revised in 2012 (MOE 2018b: 2). As a result, implementation now involves several steps which allow public, municipal, prefectural and governmental commentary, with the views of responsible Ministers and the authorising agency being taken into account in the last phase. The final environmental impact statement (EIS) must deal with the feasibility of the project and evaluate environmental impacts. Once the proponent is formally authorised to proceed, generally by MLIT, it must meet all the provisions of the EIS and, after construction, must provide a post project survey report (MOE 2018b: 14).

The Japanese authorities have harnessed the capacities of water storages very widely to mitigate the impacts of floods and droughts on people, agriculture and water supply and to meet new demands (Okada 2016: 77). By 2015, government entities at various levels had constructed, operated and maintained 556 dams capable of delivering flood mitigation (Okada 2016: 78). The river administrator, within the MLIT structure, is called on to take account of the condition of each reach of a river system in determining the proportion of flood discharge that can be intercepted and stored in an existing dam, as well as the volume of water that moves downstream (JCOLD 2009: 91). Each dam has a control plan under which its storage limits and later discharge pattern are determined, as well as provisions to deal with any crisis caused if the scale of a flood exceeds expectations (JCOLD 2009: 99).

In 2009, the Dam Commission of Japan provided renewed guidance on dam building and operations. That led to many small-scale reservoirs being constructed on tributaries of major rivers with the objective of allowing river flows to be replenished in the main river trunks (JCOLD 2009: 16). River reorientation, channelling and the building of bank revetments in major rivers began to diminish as a consequence, the height of some dam walls was reduced and some fish-ways were introduced (JCOLD 2009: 107, 164). This led the Commission to claim that these approaches had ‘mitigated’ and ‘minimized’ the impacts of dam construction and operations on the living environment (JCOLD 2009: 16, 143). That is a contestable claim, as demonstrated by later examples in this Section and by the clear need described above for the government to strengthen the EIA process.

In the rapid national development post-war, public and private land, property and dwellings were submerged; river flow regimes, water temperatures and turbidity levels were changed; and, sedimentation was transported downstream from upstream storages (JCOLD 2009: 101). Many citizens were aggrieved at their loss of land, businesses, amenity and lifestyle while others suffered as the new dams surcharged, creating even greater flood events and causing more extensive damage than previously (The Japan Times 2014b: 2). That resulted in the introduction of provisions to compensate individuals for material losses and to support them in relocation, new employment and ‘livelihood reconstruction’ - but not to compensate them for cultural, spiritual, lifestyle and environmental losses (Noda 2018: 193; JCOLD 2009: 103-105).

Another window on dam building and its consequences in Japan can be provided by examining the outcomes of a number of specific projects. Some have achieved positive results for urban water users, while not dealing with earlier social, environmental and economic losses. For example, providing a stable water supply for Tokyo was a specific and major challenge. From the early 1960s many dams, weirs, barrages, canals and aqueducts were built on Tone and Ara River systems (JCOLD 2009: 76-77). That water infrastructure was designed to make a major contribution to a lasting and stable water source for the capital’s growing population and industries. The system performed well in 2004 when the city was confronted by intense heat and low rainfall. (JCOLD 2009: 77-78). Similarly, in Kyushu, the most southerly main island of Japan, two adjacent river systems were connected to improve water access and reduce regional dependency on groundwater supplies. The project was devised to alleviate the impacts of drought and flooding and enable substantial river flows to be captured in order to generate pumped hydroelectricity. It involved expenditure of about $1billion and took more than 30 years to complete – it too is seen as having met the desired, specific goals (Okada 2016: 78-80).

Another perspective can be obtained by examining proposals and projects involving demolition of dams by the Japanese government. Noda *et al* (2018: 446-451) found that the majority of such dams were constructed to deliver hydropower and that demolition was often fiercely contested by industrial interests. The major reason given in favour of removal of dams in Japan lies in their impacts on rivers and their environments (Noda 2018: 448-450). The final decision in 2012 to remove the Arase Dam on the Kuma River provides a good example of just how significant the social and environmental impacts can be - as well as the level of community pressure necessary before removal actually occurs.

Prior to completion of the Arase Dam in 1955, the river was productive and ecologically rich in fish, eels, crabs, clams and estuarine prawns (Iinuma 2013b: 1-2). These aquatic species supported a local fishing industry, anglers, inns, restaurants and a community lifestyle. The adverse impacts of dam construction were quickly evident. Native aquatic species disappeared; the movement of sediment, sludge and sand changed dramatically; downstream water quality deteriorated; flooding, dam noise and vibration increased (Iinuma 2013b: 2). Following a long local campaign, decisions were taken to open the gates of the dam on a regular basis, leading to noticeable improvements. Careful dam dismantling began in 2012, after which water quality improved, tidal flats were restored and whelk, clams and eels returned (Iinuma 2013b: 3-4). On the other hand, the Yamba Dam on the Agatsuma River was built after generations of contestation despite its known impacts on the giant salamander, local scenic beauty and hot springs (Kiguchi 2013: 1-2). This project was described as a good example of the 'big-money projects' favoured by LDP governments (Japan Today 2015: 1).

The Japanese authorities continue to face the critical problem of rendering water infrastructure more robust in order that it cope better with natural disasters. The nation has encountered many very costly restorations where land-slides in earthquake prone regions have inundated rivers and dams leading to loss of property and lives and requiring restoration projects that lasted for many years and cost tens of billions of yen (Atsuko 2010: 1-11; Kiguchi 2013: 1-2). The World Bank (2018: vii-viii) argues that past knowledge now informs Japanese reforms to dam management and planning and to the construction, repair and operation of storages. The LDP has announced a new phase of much increased expenditure on public works, including restoration of aging water infrastructure, to stimulate the economy and reduce recessionary pressures (Business Times 2018: 1-2). It remains to be seen whether new water infrastructure projects and the restoration of existing structures will take account of social and environmental impacts better than in the past.

As long ago as the year 2000, the World Commission on Dams (WCD 2000: 203-211) argued that nations should search for alternative ways of meeting water and energy needs. Such new approaches would be designed to impact less on the environment and citizens and be more equitable in sharing risks and benefits. In carrying out a detailed statistical analysis of major hydropower dams world-wide Ansar *et al* (2014: 43) concluded that in most cases they are too costly and take too long to build to deliver a positive return – not to mention the social and environmental costs. Nonetheless, Japan has added new capacity to the national storages each year. While there has been some reduction in the adverse impacts over those previously experienced, the construction program has centrally been designed to meet the requirements of the extensive network of long-term development plans (Noda *et al* 2018: 446). Japanese academics argue that this whole process is leading to rapid, overdevelopment of the nation's water resources (Noda 2018: 199).

8.2 Consequences for Water Security

Water security for the state is strongly oriented towards providing reliable water supplies, hydropower and reducing the threat and impacts of flooding. This approach is well founded in national law, planning and institutional arrangements. On the other hand, the continuing pattern of high cost construction of water infrastructure with serious deleterious impacts on the nation's natural water resources, has undermined the state's capacity to lead in water management, in improving water security and in restoring hydrological systems.

Human water security has been a dominant theme, particularly in relation to urban water supply, including in periods of drought, and in alleviating flooding in cities and on alluvial plains. Yet, in the furtherance of national goals, many citizens have suffered loss of homes, amenity, business, cultural and lifestyle rights as well as water security. Some of these losses have been recognised and compensated for by the state.

Environmental water security has frequently been limited to reducing the impact of new water infrastructure or moderating the more obvious impacts of existing infrastructure. This has led to limited benefits in some locations and for some species, while many aspects of the natural environment, central to river and water resource health, have been seriously compromised. The water security of many consumers engaged in industrial, power generation and agricultural practice has been advanced through current policies and operations, but too often at the cost and dislocation of others.

9.0 WATER RIGHTS, PERMITS AND PRICING

In Japan the state plays a central role in issuing permits for water use and controlling water prices. This section shows the interplay between many processes and programs as they collectively influence water security. It explores the consequences of political, administrative and financial decisions on water prices and their implications for the various actors and the environment.

9.1 Water Rights and Water Permits

Each river administrator, at the various levels described in Section 6, has responsibility for trying to achieve river flows that allow all holders of 'permitted water rights' to extract water while meeting various commercial, and some environmental and social demands (Nakai 2003: 13). Surface waters are in public ownership and management and water rights or permits are issued by the state, but there is no direct regulation of groundwater rights (see sub-section 9.4). Water rights are often regarded as property rights in Japan, whereas they actually represent a right to water use and to profit through that use (Noda 2018: 194). In fact, river water is public property and the state determines river controls and has responsibility for safeguarding the public interest (Nakai 2003: 4; Noda 2018: 194-195). This situation is somewhat analogous to that in Australia, as explored in Chapter 2.

9.1.1 Results and Challenges

General water rights are accorded to industrial organisations, local waterworks bureaus, and power companies while agricultural water rights are usually assigned to farmers' associations, land improvement groups and regional agricultural administrative offices (Noda *et al* 2018: 449). Permitted water rights specify the amount of water, intake location, the way the water is to be extracted and the purpose of use (Nakai 2003: 5). The river administrator keeps a register of river and reservoir conditions and lists of users in order to oversee use and determine the public interest, particularly when assessing new permit applications (Nakai 2003: 8). Permitted water rights are usually of 10 years duration. Each entitlement stays in place even if the right has not been exercised for a given season. Water rights for power generators entitle users to extract water from a specified reservoir in accordance with permit conditions. The permit may attract prefectural fees and generally lasts for 30 years (Nakai 2003: 6, 13).

Before a new permit application is approved consultation takes place with authorities at various levels, as well as concerned users; some financial and environmental impacts are assessed; and, the applicant must accept that records of usage will be checked (OECD 2015c: 1). Existing permits have precedence over those granted to new entrants who cannot through their actions infringe on existing rights (Noda 2018: 194). If the manager deems that an existing right holder would incur a loss as a result of a permit being granted, compensation may be required to be paid prior to a permit being issued (Nakai 2003: 8). If there is insufficient river water, under normal operating conditions for new hydropower or other major industrial users, the administrator often requires the new applicants to contribute to the cost of dam construction before issuing a water permit (Nakai 2003: 13). This has been an important vehicle in the water development process in Japan.

Transfer of an existing right can be approved by the river administrator if water is to be used for the same purpose but it cannot be sold or traded (Nakai 2003: 7). While provisions exist for transfer of water from irrigation to domestic use, the system is not flexible and the demand has been modest given overall declining national usage of water (Nickum and Ogura 2010:7). Water use coordination meetings determine water use restrictions during times of scarcity; water sharing is negotiated on a case by case basis (Noda 2018: 194). Administrators can approve adjustments to water extractions and sharing if faced with extreme drought (Nakai 2003: 17).

The river administrator has the power to control water usage and assign water rights, except in the case of customary water rights. Customary water rights are traditional and inalienable and almost all cover water for use in irrigation. These rights precede the first version of the *River Law* of 1896 but do carry with them modern responsibilities. In exercising these rights, the holder must identify the river from which water is extracted, the name of the right holder, the use and conditions under which water is used, the water intake and the wastewater outlet, the facilities used and a brief description of the whole project (Nakai 2003: 15). In practice, it is commonplace for the water intakes associated with these rights to be uncertain and for monitoring and data recovered to be inadequate for effective oversight (Nakai 2003: 17). When existing water infrastructure is reconstructed it is usual for the administrator to recommend the conversion of a traditional right into a permitted right (Noda *et al* 2018: 449). Under the suite of environmental protection and conservation laws, governors of prefectures can accept applications, issue permits or orders allowing the release of wastewater and emissions into public waters (Ozawa *et al*, 2019: 1- 3). Governors may delegate this authority to heads of municipalities including cities, towns and villages. Japanese local government, both prefectures and municipalities, can also establish regulations in keeping with state legislation (Ozawa *et al*, 2019: 1). A local government notification process also exists which may either complement or replace the permit requirement. Where a violation against the terms of a permit is identified, regulatory guidance may be provided, orders issued, rectification and clean-up required, compensation determined, fines imposed or for severe breaches imprisonment can result (Ozawa *et al*, 2019: 1 - 3). This system will be bolstered as a result of the recent decision to mount joint patrols using MOE and local government staff to examine patterns of water use and the receiving water environment (Ozawa *et al*, 2019: 1).

9.2 Water Pricing

In Europe, the USA and in Australia, as reviewed in Chapter 2, independent bodies regulate and oversee price setting by public utilities, many of which have been corporatised. The claimed benefits include greater fiscal discipline in utility pricing, reduced public sector costs, less pressure on government to engage in cost-sharing, subsidies or grants and removal of water pricing from the political and electoral domain. No matter the perceived benefits, the situation in Japan is quite different, because central and local government remain ‘heavily and directly’ involved in price setting (Shintani *et al* 2016: 1). In that regard, the government has provided guidelines on water accounting, water tariff setting and how to carry out periodic water tariff reviews (JICA 2017b: C5-5).

9.2.1 Results and Challenges

The process determining public utility prices in Japan could be viewed as more democratic than in Australia, Europe and USA, because it involves negotiations with many parties over prices, cost-sharing and utility profitability (Shintani *et al* 2016: 5). Fiscal plans are prepared that deal with costs of supplying water to meet demand as well as various operational and maintenance issues, plan duration, and the time interval until a further review (JICA 2017b: C 5-10; Brasor and Tsubuku 2015: 1-3). There are other localised factors that may be taken into account, for example in Tokyo water supply charges depend on diameter of water piping and usage, while sewer charges involve a basic rate combined with an actual usage charge (Bureau of Waterworks 2019: 1). It is not surprising to find pricing structures and urban water and wastewater rates that differ from one municipality to another. But, in 2004-2007, Marques *et al* (2011: 9) found the cost of water to consumers to be ten times greater from the most expensive source to the least expensive nationally, while the whole sector relied on government subsidies. Despite these price differentials, over the period 2000 to 2015 water utility prices remained relatively stable in Japan, while they rose by more than 40% in Europe and the USA (Shintani *et al* 2016: 2).

This stability has come at a price! Because water prices have failed to keep pace with distribution, maintenance and pipeline replacement costs in Japan, many municipalities, waterworks agencies and bureaus are now in financial difficulty (Brasor and Tsubuku 2019: 2). Their responses to these circumstances include drawing on municipal general accounts or seeking supplementary finance or subsidies from the Japanese government (Brasor and Tsubuku 2019: 2; Shintani *et al* 2016: 5-7). Some municipal water agencies have tried to contain water demand and the costs of augmentation by introducing tiered rates that increase with use (Okada 2016: 81). Others have taken the more usual international route of raising water use fees by as much by 30%, even though the cost of new connections to existing urban systems is already relatively high internationally (Brasor and Tsubuku 2015: 1-2; 2019: 1-3). Given the scale of this problem, it seems inevitable that urban water rates will rise more generally to deal with financial pressures on municipal government and utilities and to help cover costs.

Early in this century the whole agricultural sector was in decline with a backlog in replacement and repair of irrigation infrastructure and an impoverished small farm sector (Nickum and Ogura 2010: 29). In 2019, the OECD (2019: 76, 88) reported a decline in national investment in irrigation facilities since 1995; this was contributing to more than 20% of core irrigation facilities and structures having exceeded their expected lifetime. The cost of the major infrastructure associated with irrigation schemes, including dams, headworks and canals, is largely borne by government, with the capital costs variously distributed between central, prefectural, municipal government and semi-autonomous land irrigation districts (LIDs), depending on the scale of the infrastructure (OECD 2019: 28; Nickum and Ogura

2010: 8, 13). The process varies in outcomes at individual sites and in the way costs and benefits are shared (OECD 2019: 28).

LIDs are paid by all irrigation farmers for operations, maintenance and drainage in delivering water and removing wastewater. The LIDs may set additional significant fees to cover capital costs and pumping needed by some irrigation schemes (Nickum and Ogura 2010: 7-8). Changes in the registered use of land require the approval of local agricultural committees and, when approved, incur significant further fees from the relevant LID (Nickum and Ogura 2010: 8). The government does not subsidise LIDs for their recurrent operational and maintenance expenses, but it does subsidise and provide concessional loans to LIDs to moderate the impact of their share of the costs of major projects (Nickum and Ogura 2010: 16). Irrigation district fees for agriculture are more than 90% based on farm area rather than volume of water used and take no account of the nature of the crop or whether fields are fallow (Nickum and Ogura 2010: 7-8, 15).

It is rare for any LID to charge by volume even though volume-based charging is very helpful in conserving water. OECD (2019: 88) views the current system as providing little incentive for producers to economise on water use, while it also impedes necessary structural reform in Japanese agriculture. Based on 2013 data, the ADB (2016: 99-100) assessed water security to support agriculture via a composite index based on water productivity and water self-sufficiency. According to this index Japan fell well short of the positions in both Australia and China. Overall, it is clear that further reforms are needed, including rises in water prices, though that will be difficult to achieve given the political and social cost entailed.

9.3 Consequences for Water Security

The state interest in water security is well established in relation to water rights and water pricing. The state owns the surface water, controls water use and wastewater return and has an entrenched system of permits, regulations and sanctions. The situation is less secure in some cases of groundwater use and where customary rights are able to be exercised.

The permit structure and the nation’s approach to water pricing have provided human water security in the medium term. However, the financial pressures being faced by water utilities as a result of a period of stable water pricing presages considerable change ahead.

Permits granted by river administrators take account of some issues related to environmental water security. However, given the national priorities accorded to land and water resource development as well as human and consumer safeguards and welfare, the security of water for the environment continues often to be compromised.

The water security of the consumer has been assured in terms of state permit arrangements, associated regulation and the central role of the state in water pricing. In the absence of independent price regulation considerable differences in prices have emerged, utility costs have not been recovered and some consumer costs have effectively been subsidised. This is not a stable situation for either utilities or consumers. In the process of reforming rural agriculture, deteriorating local irrigation infrastructure, national and municipal debt, and cost pressures on LIDs are contributing to the water security of agricultural users remaining at risk.

10.0 WATER QUALITY AND WATER CONSERVATION

The number and extent of the standards set for drinking water, ambient water sources and sewage and industrial wastewater discharge reflect the serious intent of the central government and prefectures to keep improving water quality and to render water safe to drink and use. This campaign began in the 1970s and has seen many standards and requirements progressively increased over the ensuing years. This has been followed by efforts of utilities, industry and households and to a lesser extent agriculture to improve water use efficiency and find ways to conserve and recycle water. These initiatives are shown below to be making a notable contribution to some aspects of national water security.

10.1 Water Quality

The 1958 *Waterworks Law* requires the nation's utilities to monitor tap water regularly to meet national standards. All utilities must develop a Water Quality Safety Plan to identify hazards throughout the supply system as well as potential risks. Under these plans they need not only to monitor tap water quality, but to maintain standards at critical control points and work with others to improve quality of water sources in river basins (MLIT 2013: 4-5). The top tier of national drinking water standards, spanning more than 50 items, is legally binding on utilities and is effective in protecting human health and user needs (MLIT 2013; JWWA 2014: 7). Utilities are encouraged to monitor a second tier list regularly and to meet the standards it recommends. In Japan pesticides are not listed under the first tier standards, though some are included under the second tier provisions. Monitoring authorities are required to assess the concentration of pesticides post water treatment and to assess risks associated with daily consumer intakes (Kentaro *et al* 2014: 114-115).

Under the *Basic Environment Law* two kinds of ambient water quality standards have been established, namely quality standards to protect human health and standards to help conserve the living environment (WEPA 2018: 54). These national standards apply to all public water bodies including rivers, lakes, reservoirs and groundwater and require action by many public entities (MOE 2015a: 1-4). In all, Japan uses more than 30 biological, chemical and physical indicators to detect the ambient water quality (WEPA 2018: 14). In earlier times, groundwater was a high quality water source, but because it progressively became contaminated groundwater standards were tightened (MOE 2014b: 1-2; WEPA 2018: 59). Under the *Water Pollution Control Law,* uniform effluent standards have also been set for release of any contaminated wastewater to surface waters that could present risks to human or environmental health (WEPA 2018: 56). Governors of prefectures and mayors of designated cities can set stricter standards than the national uniform standards, introduce additional rules, require reports and issue orders (WEPA 2018: 57).

10.1.1 Results and Challenges

In 2004, the majority of drinking water samples from rivers met standards of the time, but that was not the case for water in lakes and marshes (MLIT 2008c: 5). In 2016, indicators for ambient health and the living environment quality were monitored for about 5000 Japanese rivers, lakes and reservoirs in order to assess performance against national environmental quality standards; about 2000 were also monitored against biodiversity standards (WEPA 2018: 15). The percentage of rivers complying with the environmental health-oriented BOD indicator reached 95.2%. On the other hand, the BOD compliance level for the assessed lakes and reservoirs remained much lower at 56.7% (WEPA 2018: 54). The Japanese government (2018: 9) sees the nutrient induced eutrophication of enclosed water areas as a continuing problem. Over 3,000 groundwater wells were also tested, of which 200 did not meet groundwater environmental quality standards - often because of contamination by fertilizer, livestock or human effluent (WEPA 2018: 55). In the same year, in most ambient freshwater sources, the quality standards for human health reached 99% (WEPA 2018:54).

Under the *Water Pollution Prevention Law* strict regulation of industrial and domestic wastewater discharge occurs and national, prefectural and industry standards exist for potentially hazardous pollutants (WEPA 2018: 25). Under this law continuous monitoring of water quality occurs and total pollutant load is specified and controlled. Between 2010 and 2014, about 15% of the establishments producing wastewater were inspected annually by government and a further 13% were required to meet new monitoring requirements (WEPA 2018: 28).

10.2 Water Conservation and Water Efficiency

Japan has fostered an array of approaches to water conservation, reuse, recycling and efficiency in domestic, agricultural and industrial use over many decades. The major approaches have included leakage control in treatment and distribution systems; wastewater recycling; rainwater harvesting; water saving innovations, equipment and techniques; demand management; application of financial instruments; and, support for local involvement, coordination and management in conserving and seeking system efficiencies.

10.2.1 Results and Challenges

In Japan withdrawal of water from all sources by all actors decreased from 1992 to 2016 by about 12%, with similar falls in individual consumption over that period (WEPA 2018: 20; Okada 2016: 74). These reductions represent a response to water conservation and efficiency campaigns, some decreases in population, and changes in behavior by citizens and industry faced with increasing water scarcity, increasingly brought on by climate change (see also sub-section 6.1). Japanese citizens have been supported by local government subsidies and by industry in introducing water-saving washing machines and toilets (Okada 2016: 82 – 84).

Over the decades, there has been a tendency in Japan to focus on food security at the expense of water conservation. In agricultural districts, LIDs have set charges and fees that help recoup some LID costs as opposed to encouraging water conservation (Nickum and Ogura 2010: 7-8). Nonetheless, water use in primary industry peaked in 1996 and fell away by 8% to 2012 [12] (Okada 2016: 75). The Japanese agricultural sector is small, fragmented and labour-intensive. It has been subsidised and protected over decades. The primary water users are, in order of importance, rice paddies, other irrigated crops and livestock husbandry. Rice production remains essential to Japanese food security and is historically, socially and culturally important but is recognised as a major contributor to national water consumption and wastewater production. Water usually enters the paddy fields through gravity-fed, irrigation ditches, often concrete-lined and constructed as public works projects (Nickum and

[12] These results are estimates because most agricultural water use is not measured

Ogura 2010: 7-8; Ricepedia 2019: 4-5). The primary source of irrigation water is river flows followed by hundreds of thousands of small reservoirs owned and managed by local hamlets (Mogi 2011: 1-2). Most rice cultivation does not require water to be pumped or drawn from groundwater sources.

Since 1995, rice production has steadily diminished and rice paddy and crop fields have decreased in area since 1975. (Ricepedia 2019: 4-5). Today, the rice industry is facing greater exposure to international competition, caused in part by free trade agreements, leading the area dedicated to rice cultivation to shrink by nearly 50% in the period 1962-2010 (Nickum and Ogura 2010: 7). Domestic consumption of rice has also fallen by 33%, leaving the aging farmers on small holdings with increased costs that threaten the viability of the industry (Ricepedia 2019: 5). As a consequence, the farming workforce continues to contract numerically and much of its irrigation infrastructure is in need of replacement or restoration (See also sub-section 9.2.1).

Drought represents a major challenge for Japanese authorities. In 1994, some 16 million people had water supply restricted or suspended because of drought, leading to a loss in agricultural production of 140 billion yen (MLIT 2008c: 1). Water shortages have become rarer in recent years, but droughts aggravated by climate change still occur, as outlined in Section 2. The river and dam administrators monitor river runoff and reservoir levels in real-time, enabling them to determine when drought conditions are setting in.

Chapter 1 of this thesis explores briefly concepts of stewardship and custodianship in which water users have organised themselves in ways that lead to effective management of a common resource pool and by so doing have been able to avoid the risks of overuse or pool exhaustion. In Japan, users in river basins form drought coordination councils which comprise domestic, utility, industrial and power user groups, farmers, MLIT, prefecture and municipal river administrators and other affected public entities. The role of these councils is to share river and reservoir information, forecasts and possible impacts on users and to become the forum in which major collective decisions are taken (Tembata and Takeuchi 2018: 21: Okada 2016: 85). The councils agree on progressive restrictions on withdrawals in a collective effort to save water and contain drought impacts, though the priority order is determined by the order in which rights were granted (Okada 2016: 85). Once drought is declared, ministerial and prefectural basin-level coordination arrangements are also established. This allows high order decisions to be taken such as diverting reservoir water from hydropower generation to water supply, curtailing the operation of swimming pools and mounting major campaigns to conserve water.

In times of water shortage farmers during last century reduced their demands on available water by joint management of local reservoirs and by taking turns in drawing water at designated times (MLIT 2008c: 1; Mogi 2011: 1,9). Since that time there has been very significant institutional change leading to water management for irrigation by groups of farmers in LIDs, who manage projects, planning and assessment and collection of fees (JCOLD 2009: 26-27; Yamaoka 2016: 12). Cooperative water management in the Ryoso LID provides a good example of some of the complexities (Koyosu 2013). The management task spans several cities, towns and villages, a variety of businesses and large tracts of land, including rice paddy fields. Decisions are taken by a general assembly, supported by an executive board, secretariat and audit committee. The role of the large assembly is to coordinate supply, operations and maintenance in a collective effort to generate equitable and efficient water use outcomes. At a technical level there are pumping stations and a hierarchy of canals, water intake volumes, timetables and water quality issues to manage. At the community level a variety of groups and interests have to be consulted and the public-at-large to be kept well informed.

In studying 165 cases of regional droughts in Japan, Tembata and Takeuchi (2018: 30) found that when stakeholder groups interacted and cooperated well the drought relief strategy was more effective, leaving the councils better positioned to deal with future droughts and climate change. This contrasts with Australian experience, where emphasis on a mix of individual rights and interests and electoral and economic interests does not lead to a focus on joint custodianship and equitable sharing of the common water resource.

In 2012, industries of all scales recycled an average of 79.1% of the water they used, while increasingly meeting wastewater discharge standards (Okada 2016: 75). Japanese membrane technology has aided this process by removing contaminants. That has led to purified wastewater, making it available for use in restoring river flows and some limited human applications (MLIT 2008f: 3) The level of recycling has represented a valuable contribution towards containing water demand. The best water recovery rate by major industry has been delivered by the chemical and steel industries that recycled 80 to 90% and the weakest by pulp and paper which recycled 40 to 50% (Okada 2016: 75). Some of the several thousand sewage treatment facilities in Japan treat and then recycle wastewater for use in toilet flushing, environmental projects, agriculture and industry (Okada 2016: 82-83).

Rainwater harvesting has been practised in Japan since the mid-1970s, with about 2000 municipalities having ordinances or guidelines in 2013 that promoted rainwater harvesting (Okada 2016: 81 - 82). Many buildings have collected rainwater and used it for toilet flushing, air conditioning and outside in gardens. Residents have installed rainwater tanks to cope with emergencies. In 2014, the *Law to Advance the Utilization of Stormwater* was introduced to reduce water consumption, moderate post-disaster scarcity and prevent sewer surcharges during flooding (JFS 2014b: 1-2). This process has been sufficiently successful to encourage government to introduce further measures that have strengthened the hand of local government.

10.3 Water Security Consequences

Water security for the state is firmly anchored in a legal, planning and regulatory regime that delivers high levels of water quality in water supplies, in discharges from water and wastewater treatment plants and in most river systems. The situation for the state has been enhanced by the levels of industrial conservation and recycling and domestic conservation but has been eroded by the failure to contain agricultural water and groundwater demand.

Human water security is provided through the delivery of high quality, world standard tap water to the vast majority of urban and rural residents, the tight regulation of many potential contaminants, water quality and system reliability. Most water consumers benefit from the high standards of quality, treatment, performance and reliability.

The laws, plans and ambient standards applied in Japan have contributed to environmental water security by protecting the nation’s rivers, their ecosystems and environs against pollution from agricultural, industrial and domestic sources. Those gains are substantial, but need to considered in the context of the losses in water security for the environment and rivers explored in Section 8. Enclosed water bodies such as lakes, marshes, groundwater systems and reservoirs have proven more difficult to protect to the same levels as river sources. Water conservation and water recovery are reducing demand pressures on vulnerable sources to a greater extent than in China and Australia.

11.0 WATER SUPPLY AND SANITATION

To keep pace with the rate of development post-war, water utilities were called on to find new water sources, on which dams could be built to provide water for industry and cities (World Bank 2018: 4). In 1965 the nation's rivers were the principal water source providing 55.5% of municipal supply, with dams providing only 11.6%. By 2015, supply from rivers, river beds and lakes had dropped to 33% while 47% of the needs of the substantial urban populations were being met from single purpose storages or multi-purpose dams (JCOLD 2009: 40; JWWA 2016: 3,5). To manage these storages and reservoirs, there are now more than 15,000 water utilities in Japan, many of which are small in scale. The majority have needed state support in the construction phase via long-term municipal bonds or limited subsidies.

The Japanese authorities have nurtured high professional and technical standards as the nation has progressively built a quality water supply network. Several ministries have contributed by laying down requirements for the nation's water and sewerage utilities, almost all of which are publicly owned (World Bank 2018: 5). Japan has also sought to build system resilience into its water supply systems and sanitation infrastructure in order to cope better with earthquakes and other natural disasters. The 1958 *Sewerage Law* (Japanese Government 1958; JSWA 2014) creates the planning framework for sewerage utilities, by stipulating standards for design, building and operation of sewage systems. Municipal governments are responsible for much oversight of utilities and for ensuring that municipal plans are harmonised with national and prefectural plans (JSWA 2014: 7-8).

The management of groundwater and its contributions to national water supply create special challenges. There is considerable complexity in the way the laws, guidelines and local common law, rules and ordinances determine the outcome for each particular groundwater source (Hori 2016: Section 1). The nation draws heavily on groundwater to support industry, agriculture and domestic uses and when normal supplies are interrupted by national disasters such as earthquakes. In 2014, rivers, lakes and reservoirs provided about 79 % of water to meet national needs, while groundwater met about 19% of national requirements (JWWA 2016: 5). The management of groundwater has commanded greater attention in recent decades because both community and government have become concerned by the extent of over-extraction, that has led to severe land subsidence and to significant contamination of some sites.

11.1 Results and Challenges

There are many standards, requirements and guidelines which govern water supply, treatment and distribution in Japan. Drinking water is safe to drink from a tap throughout the country (JICA I1-2). Water supply networks have been expanded so that 97.8 % of the population now receives its water through a reticulated system, including in rural surrounds (JWWA 2016: 4; JICA 2017a: 5). Municipal authorities must meet design, construction, treatment and operational requirements for water utilities (JICA 2017b: A-1). Each utility is required to comply with technical, health, environmental, operational and service standards and to develop a master plan spanning its business environment and future goals. (JICA 2017b: I1-19; I1-10, 11, 17; Ueda and Benouahi 2009: 132). These efforts have led to reductions in system leakage in supply systems to a national average of 4.7% (JICA 2017b: I1-2). This is a good result by international standards.

There are some private-public partnerships which deal with facility development and construction, operations and maintenance. In recent years, municipal small-scale operators have been encouraged to merge, link or collaborate to gain the benefits of scale (JICA 2017b: A-1). Some low-income group users can meet water costs because of tariff reductions, exemptions and cross subsidies (JICA 2017b: I1-2, 19). To cope with aging infrastructure and reduced demand the *Water Supply Act* was modified in 2018. It requires that the national and prefecture governments address known problems directly, encourage cooperation between municipalities and even sell the rights to water supply, if necessary (Global Legal Monitor 2018: 1).

Drought and water scarcity pose critical supply challenges. In 1994 drought spanned most of Japan with millions of people having reduced water supply and agriculture losing an estimated 140 billion yen (MLIT 2008c: 1). During such occurrences, water utilities have customarily reduced water supply for domestic users and industry by lowering water pressure or temporarily halting supply, and, in some cases, industry has been required to meet specified reduced targets for water use (Okada 2016: 72). In recent times, utilities have been aided by substantial upgrading of treatment and water infrastructure, by slight reductions in population and by reduced urban water demand over that experienced in the 1990s (Okada 2016: 73). In cases of severe drought, where reservoirs do not exist, water may be drawn from river flows, provided that sufficient volumes remain for ‘other prioritized users’ (Okada 2016: 77).

Requirements governing sanitation are also complex. In 2016, 99.5% of people in cities of more than 1 million inhabitants had access to domestic sewage treatment (WEPA 2018: 58). Overall, 78% of the entire population was connected to a sewage treatment plant in the same year (OECD 2018). Some municipalities provide financial support to homeowners to install small scale aeration systems producing high quality effluent (WEPA 2018: 58). Municipal sewerage utilities must meet similar requirements to water utilities including planning, design, operational and other licensing requirements as well as financial and performance criteria. Discharges are inspected and monitored against water quality standards and quantity targets, as reviewed in Section 9. Tariffs can only be raised with municipal approval (Ueda and Benouahi 2009: 140). MLIT enforcement orders require plants to be robust enough to remain minimally damaged by earthquakes (World Bank 2018: 10). All sewage is treated to at least secondary level, with discharges from plants into particular lakes and bays being treated to tertiary level (Ueda and Benouahi 2009: 137). BOD levels for these particular receiving waters have been shown to fall well within national standards – as opposed to the problems identified in many other lakes and reservoirs (Ueda and Benouahi 2009: 137).

There are several non-governmental bodies, established with government support, which provide guidance to utilities in meeting these many requirements (World Bank 2018: 9). The Japan Water Research Center (JWRC) has developed performance indicators for all major water utilities spanning bulk water supply, water infrastructure stability, equipment ageing and other compliance and operational matters (JWRC 2014: 6-99). The Japan Water Works Association (JWWA) carries out assessments to ensure that national standards are being met in water supply systems, provides training programs and produces guidelines and manuals for supply authorities (JWWA2017: 7-15). Its design guidelines for water supply systems have been adopted essentially universally in Japan (World Bank 2018: 9). Both these associations have responded to the requirements of the 1961 *Disaster Countermeasures Basic Law* by helping to create mutual support networks for utilities when disaster strikes (World Bank 2018: vi).

The Japanese authorities seek high levels of utility compliance. The Ministry of Internal Affairs and Communications has led a benchmarking exercise which reveals publicly the comparative performance of the myriad water and sewage utilities. This has extended and complemented the indicators of JWRC described above (Ueda and Benouahi 2009: 147). There are more than 100 items straddling service quality, financial and operational performance, depreciation, water and energy use and losses, emergency repairs and customer service which are used to assess the accountability and efficiency of Japanese approaches to water and sanitation services, at the national, prefectural and city level (Ueda and Benouahi 2009: 141-147).

The nation faces the continuing risks posed by natural disasters including earthquakes. The 1997 revision of *Disaster Countermeasures Basic Law* mandates the development of disaster management plans at national, public corporation, prefecture and municipal levels, creates overseeing structures, and requires actions under all subordinate plans to be in concert with the national plan (Japanese Government 1997). The Act also calls for the identification of risks, measures to reduce those risks and the development of recovery processes (World Bank 2018: 5). Japan now has a comprehensive program focused on reform, renewal and resilience. Key elements include progressive reconstruction of ageing facilities, design and use of quake-resistant pipelines and water infrastructure, and building redundancy into water distribution systems (JWWA 2016: 6). The whole approach is inherently iterative and adaptive.

With the rise of industry and urban populations post-war the demand for water in the cities led to increased dependence on groundwater as a quality source. That created major problems, as for example in the case of Tokyo, where alluvial land subsided by more than 3 metres in the latter half of last century (JCOLD 2009: 73). Even today the management of groundwater presents special challenges in Japan. The national government can establish policies which govern the protection of groundwater resources and its water quality and has introduced legislation that requires local government to act to protect and preserve the groundwater environment against adverse social and climatic change (Hori 2016: Section 12). However, the national government has not been able to fashion legislation governing groundwater source use, replenishment, conservation and protection at specific sites. The prime reason lies in the fact that the Civil Law of Japan states that groundwater is a private property, determined by the ownership of the overlying land (Hori 2016: Section 11).

To overcome this problem, prefectures and municipalities have applied common law or more recently introduce local groundwater ordinances designed to deal with groundwater conservation, planning and use (Hori 2016: Section 1). In doing so, they are deriving their authority from the Constitution which empowers them to manage their affairs and to provide local ‘institutional security’ (Hori 2016: Sections 5-8). Prefectural governors also have the authority to regulate new wells in urban areas, restrict groundwater use in emergencies and have inspections carried out (JICA 2017b: C3-7). Even so, the issue is not straightforward. In the case of the town of Niseko, an ordinance to protect the town’s groundwater source of drinking water and its efficient and equitable use could not legally prevent the adverse effects of development of the land overlying this source. To overcome the problem a new ordinance had to be prepared for the whole Hokkaido region to protect and conserve this source (Hori 2016: Section 10). This cumbersome system seems ill-equipped to deal with many contemporary challenges.

11.2 Water Security Consequences

There are extensive health, environmental, technical and operational standards prescribed under laws, plans and ordinances that govern water supply, treatment and distribution as well as sanitation. These measures collectively contribute significantly to state water security. Investment in the physical security of water supply and sanitation services in order to cope better with natural disasters makes a further modest contribution because of efforts to build in system resiliency and system redundancy.

The laws, plans and attendant requirements for departments, utilities and private providers to meet high standards of treatment and operations in water supply, water distribution and sewerage systems are making a positive contribution to human water security. Throughout the nation tap water is reticulated at consistently high standards and domestic sewage treatment is at a high standard in most cities.

Efforts to control leakages from major water supply and distribution systems, coupled with efforts by utilities and industry to conserve, recover and recycle water have made a positive contribution to environmental water security. This is offset by the failure of agricultural water users to make a serious contribution to water and environmental conservation and by groundwater users who have placed many systems at environmental risk through overuse.

Intensive regulation, rooted in standards, measures of performance and management, backed by inspection, helps maintain confidence in water security for industrial and utility users. Agricultural users face commercial insecurity as a result of market pressures and their failure to take account of the actual cost of water as a business factor. With that caveat, cooperative management arrangements, supported by the state and LIDs, do help create a common understanding of some of the challenges in water sharing and management.

12.0 CURRENT WATER SECURITY

This critique of current water security in Japan draws on the analysis and research in the preceding sections. These conclusions are presented within the assessment framework developed in Chapter 1, under the eight identified items. Sub-sections 12.1 to 12.4 focus respectively on the impact and influence of politics, governance, management and climate change on national water security. In addition, the material examined and presented in the introductory sections to this chapter has been drawn on in arriving at the conclusions dealing with politics and governance. Sub-sections 12.5 to 12.8 also build on the analyses in this chapter but focus on the current situation in the four specified water security domains, namely the state, human welfare, the environment and consumptive users. Where the conclusions could be positioned under more than one item, they have been presented in more detail in one primary location.

Shortcomings and deficiencies identified in the analysis of policies and programs have been considered as they impact on water security. The likely contribution of current national reforms and initiatives to near term water security is also explored. In that regard, it is too soon to assess whether recent government attention to respecting and restoring water cycles and building a sustainable society will make significant contributions to future national water security. All the conclusions in this section have been considered in the final chapter in the course of making the country comparisons of national water security, in examining future prospects and in assessing the wider contribution of water security to each nation.

12.1 Impacts of Politics

Japan has in place a wide-ranging network of laws, ordinances and plans, supported by detailed and prescribed administrative procedures and standards for water quality, water conservation, water supply and sanitation. That shows political determination to achieve many water-oriented goals, which contribute to national water security. The long-term position of successive Japanese governments has led to a legal framework within which local government and communities can play key roles. This has been important in improving water management, sharing and planning and in securing national targets and objectives.

On the other side of the ledger, there are several aspects of politics in Japan that constrain the extent to which water management is effective and national water security is advanced. The political dominance of economic growth as a national goal has had a significant effect on the orientation of water management in Japan and on national water security. That has led to concepts such as integrated water resources management (IWRM) and sustainable development being molded to that goal, rather than being focused on the health and resilience of the nation's heavily modified river systems. The strength of the established political parties, especially the LDP, may have limited the influence of those with a political commitment to stronger environmental and water reforms. Similarly, environmental, water and resource policies and priorities have been shaped by the continuing political influence of networks of senior ministers, officials and industry representatives to better reflect their economic and sectoral interests.

12.2 Impacts of Governance

Precision in national water governance is achieved through the interaction of legislative, regulatory, planning and administrative systems. Specific legislation has been introduced to deal with some significant, emerging problems. The administrative and planning frameworks are able to address changing climate, regional, population and land use patterns, often leading to changed objectives in statutory plans. On the other hand, good governance is impeded by the influence of networks known as Iron Triangles and the slow and incremental advance of policy change.

There are many ministries, agencies, prefectural and municipal bodies with some responsibility for water resource management outcomes. There is little apparent appetite for major institutional reforms that would see roles modified and the entities focusing collectively on efforts to improve issues such as river basin management, river system resilience and water security. The national dominance of economic development over objectives that would further water security is reflected both in the national approach to statutory planning and the powerful role of the Ministry of Land, Infrastructure and Transport (MLIT). The way MLIT powers have been exercised and past weakness in the application of Environmental Impact Assessment processes have had a considerable influence on the current state of the nation's rivers.

12.3 Impacts of Management

Japan possesses highly developed technical and engineering skills in government and industry which are engaged in dam and water infrastructure planning, construction and operation, in water and sewage services and in significant water conservation and recycling programs and projects. There are in place many health, environmental, service and operational standards that are widely implemented and respected, as well as scheduled testing, reporting and benchmarking. Water rights and permits are granted through established mechanisms, though there continue to be challenges in managing customary rights and groundwater use. Water pricing is theoretically guided by the principle of cost recovery in the interests of water use and service efficiency. However, that is far from the case in water supply and sanitation, in agriculture and in the building, maintenance and restoration of major water infrastructure.

River management is focused on meeting domestic, agricultural and industrial supply demands and needs; overseeing water usage; moderating the impact of floods, storm surges, droughts and earthquakes; and, maintaining and restoring some elements of the natural environment. The main agencies harness technology in meeting supply targets, forecasting demands and assessing the projected impacts of climate variability and climate change on system security and operations. The government of Japan has asserted that the integration of current approaches is important in building a sustainable society and sustainable systems. However, IWRM is not currently used in Japan to manage current and projected development in river systems in ways that limit impacts on hydrological cycles, biodiversity and system resilience. Rather, the prime Japanese agency responsible for water management and development decisions, namely MLIT, is more focused on legal, financial, construction and operational matters related to efficient water and energy use and overcoming disaster risk.

12.4 Impacts of Climate Change

The impacts of climate change on water, human and infrastructure security have received considerable Japanese governmental policy and legislative attention in recent years. That responds to the existing risks of major natural disasters as well as projected increased risks associated with climate change in some regions. There is extensive meteorological and climatic modelling designed to keep agencies and managers of river systems and reservoirs well-informed, as well as managers of water-based agricultural, industrial and urban facilities and emergency services. The whole approach is able, through advanced technology and telemetry, to provide real time monitoring, warnings and event charting as well as detailed risk-oriented projections of major climatic events. Warning systems and disaster stations, drought and flood risk maps and local plans and strategies also exist to assist in coping with floods and droughts. All these actions benefit national water resources management and many contribute to improving water security.

On the other hand, extremes of climate change may expose some 50 million people, living and working on the alluvial plains of the major rivers of Japan, to the risk of greatly increased climate-induced flooding and seawater intrusion. Such climate change events would have serious implications for major river basins and their environs and for loss of life, business and property. Yet, to date, the Japanese authorities have not set greenhouse reduction standards to meet or exceed IPCC targets.

12.5 Water Security for the State

Japan has recognised the importance of strengthening national management of water resources, adopting more sustainable patterns of river basin development and restoring some river flows and aquatic environs. All of this is making a contribution to improved water security. The state values the concepts of sustainable development and IWRM, leading to their adoption in public and planning documents. However, each of these concepts has been reshaped in ways that have diminished their effectiveness in securing water management and water security goals for the state. The way forward in building a ‘sustainable society’ in Japan is not clear at this time.

Urban water supply security, reliable hydroelectric power generation and mitigation of the major impacts of flood and drought have all contributed to state water security. Heavy investment in the physical security of water and sewage infrastructure and treatment facilities to cope with climate change and future disasters has improved that situation. On the other hand, this same process has led to extensive modification of the nation’s rivers, significant changes in water and land use and greatly increased development. In many river basins, state water security has been compromised as a result of the attendant serious and adverse impacts on river environments and citizen amenity.

A sound base on which to build state water security has been created through ownership of surface waters, the network of legal and administrative instruments, state controls on water rights and permits and robust national standards. Continuing gains in water and wastewater treatment, surface water quality and water conservation and recycling water are making further tangible contributions. On the other hand, industry in Japan has a pervasive influence on some national policies and laws as well as the extent and scale of water infrastructure and economic development in river basins. This has slowed institutional change and public policy reform and reduced national water security for the state.

12.6 Water Security for Human Welfare

Reliable, potable water supply, advanced water and sewage treatment and excellent river water quality have resulted in high levels of human water security for the vast majority of Japanese citizens. This is largely the result of urban water supply, treatment and distribution and sanitation services being subject to many legal, operational and health standards and requirements. Both human water security and physical security of infrastructure have been prime national motivators for the construction and upgrading of extensive dams and reservoirs. While those works have often ameliorated droughts and floods for many citizens, there are significant numbers of other people who have suffered financial, social, and environmental losses as well as diminished water security. Efforts by the state to respond to actual and projected climate change and other possible accidents and adverse natural events such as earthquakes have led to improvements in human and infrastructure readiness, representing positive contributions to human water security. Stable prices for water in many urban and industrial situations have increased human comfort and sense of security in a variety of situations - but that is at risk, as municipal and state authorities seek to address current financial pressures.

12.7 Water Security for the Environment

Water security for the environment has benefited from the extensive national laws, plans, controls and standards and their widespread application in protecting rivers particularly from domestic, utility and industrial pollution. Urban and industrial water conservation, industrial water recycling, water recovery and reductions in leakage from supply and distribution systems are making tangible contributions to reducing pressures on vulnerable environmental water systems. Pollutant and sediment contamination of significant lakes, marshes, reservoirs and groundwater continue, however, continue to create some challenges.

There are a number of factors that contribute to much weaker performance by agriculture in advancing water security for the environment. Those include: the deteriorating quality of irrigation infrastructure; relatively poor performance in water conservation and wastewater treatment; weakened municipal support in the face of significant debt; the failure to price water according to volumes used; and, unremitting global pressures on an aging industry and workforce.

In the majority of cases to date, assessment of patterns of development and introduced water infrastructure has been limited to physical measures designed to moderate some adverse effects on the environment and community amenity. Yet, the national law and plans require agencies to restore water cycles, provide sufficient quality water for the needs of aquatic species and ecosystems and avoid meeting contemporary demands at the cost of river health and biodiversity. This entails far more than creating minimal flows, reducing operational noise and widening channels. While recent legal and administrative requirements call for a significant change in approach that seems unlikely to eventuate in the near future. On the other hand, the impacts of dams on the natural characteristics of rivers and associated water cycles are less in Japan than observed in key situations in Australia and China.

12.8 Water Security for Consumptive Users

The state has accorded a continuing high priority to the water security of consumers of products and services delivered by industry, electricity, urban utilities and agriculture. That has informed regulation, planning and policy development as well as the assignment of water rights and permits. The national approach to setting service and management standards, benchmarking performance and carrying out inspections has enhanced the security of many users. Cost recovery has been accepted by authorities as appropriate in the delivery of most water-related services, development and operations of much water and irrigation infrastructure, as well as in pricing urban and irrigation water. However, many services and operations and much infrastructure have been subsidised, which has resulted in short-term gains for some domestic, industrial and agricultural consumers. Mounting national and municipal debt is rendering reductions in subsidies and increases in prices increasingly likely. The consequences would most acutely be felt by those agricultural producers which are not sufficiently profitable to withstand prices being set on the basis of the actual costs of water and services supplied.

CHAPTER 5
WATER SECURITY IMPERATIVES

1.0 INTRODUCTION

Despite the vast differences in the political systems and states of development of China, Japan and Australia, they must address a number of common problems if national water security is to improve. For example, all three accord a high national priority to harnessing the resources of their major river systems to satisfy the demands of industry and to meet various human needs. Yet, in the process they have often put present and future national water security at risk. The management regimes in the major river systems have not been sufficiently integrative and adaptive to ensure that development is sustainable and that the aqueous systems remain resilient. Each nation has identified many situations where groundwater sources have been dramatically overused, especially at times of water scarcity and prolonged drought. While system stress, water contamination and major land subsidence have often resulted, the analysis in this thesis has revealed comparatively little study of the individual traits and needs of each critical system. In the absence of such study, recharge rates have become inadequate, system resilience compromised and future usage prejudiced.

The research has also identified many problems specific to each country which are currently affecting national water security adversely. China faces deeply entrenched problems in overcoming water scarcity, water pollution and increased water demand with serious implications for citizen welfare, future food production and the stressed national environment. Its extensive legislation, planning and programs are currently not being implemented in ways that are overcoming systemic blockages or delivering the desired outcomes. These critical shortcomings are not only diminishing national water security but could undermine future prosperity and stability.

For Japan, the continued dominance of the LDP means that government is able to draw on long-standing alliances and centres of national influence in shaping water policy. Where ministers, senior officials and industrial managers have worked towards common ends, the scope and effectiveness of water reform have been limited. Major water infrastructure has often become the preferred – or unquestioned - way of meeting water challenges and demands, leading to water security for the environment being compromised. In Australia, significant changes in political outlook since 2013 have interrupted the course of national water reform. The nexus between Australian Government agencies linking national water, energy and climate change policy has been ruptured. Oversight and regulation have been weakened as the government has encouraged increased water exploitation and sought to fast track the building of substantial dams. These changes have diminished the prospects of improving the health of major Australian river systems and rendered more uncertain the water security of many users and the environment.

This chapter compares and contrasts the approaches to national water security in China, Japan and Australia.[13] The following text examines the national water security position in these countries and evaluates how they are placed to meet future demands and challenges, if broad ranging water security is to be achieved. Section 2 considers the many factors that constrain the advance of water security. It underlines just how important issues such as the political, legal and administrative regimes and patterns of development are in shaping water security for better or worse. The critical role of government in overcoming institutional blockages to improved water security is also examined. Section 3 deals with the way politics, governance, management and climate change impact on national water security. These four impacts are experienced by all three countries, but to varying extents, as each strives to meet contemporary demands for water and for water-based development. The variations in national responses have contributed to differing outcomes for the sustainability of major aqueous systems and national water security.

Section 4 compares national water security in each country, based on the analyses of programs, measures and approaches in each country chapter. Here national water security has been examined as an integrated broadly-based concept along the lines identified in Chapter 1. The separation of water security into four primary domains in country analyses has assisted in exploring fundamental relationships between national water security and the state as well as human, environmental and water consumer welfare. Where important contributions to

[13] The conclusions and comparisons made in this chapter draw directly on the research undertaken and the references cited in earlier chapters. Some commentary in this text is also influenced by the author's earlier career in leading water and environmental departments and commissions as well as involvement in political, environmental and water-oriented forums nationally and at the OECD.

national water security by various levels of government, non-state actors or international projects have been identified, they have been taken into account in this section.

Section 5 proposes strategies that each state could adopt to overcome major obstacles to achieving wide-ranging national water security. If the challenges identified in this section were met each country could benefit through improvements to human welfare, national security and the environment. The section highlights the importance of the state role in ensuring that national water security is fully assessed, so that measures can be adopted that contribute to advancing national water security. It argues that the way the nation's peoples value water and equity in its national distribution should be accorded priority in any national review process. Section 6 provides an opportunity to examine what has been achieved in the research carried out under this thesis, set against the goals identified in Chapter 1. It stresses the importance of studying the political and administrative systems as well as key policies and programs in any country if present national water security and future preparedness are to be established. It points to the distinct, and at times unique, contributions made in this thesis and the consequences of failure to accord water security a high national priority.

2.0 NATIONAL CONSTRAINTS AND LIMITS

There are dramatic differences in the geomorphology, laws, plans, administrative arrangements and institutions in each of the three countries. The introductory sections of each case study chapter span natural features as well as political and institutional factors which together create the national context within which water security takes place. This section explores key national characteristics and factors which either advance or constrain water policy development and national water security. It reviews significant influences on national water policy, water reform, water resources management and water security.

2.1 The Water Legacy

How do geomorphology, topography, demography, and climate affect national approaches to water resources management and water security? What are the implications for each country in decisions for water management, water sharing and national water security?

The magnitude of Chinese water-related problems, often described as a national water crisis, is far greater than the challenges facing Japan and Australia. Water scarcity in China has left the state exposed to risks to human health and welfare, food production and the environment. The problem is accentuated by increasing annual demands for water driven by city growth, agriculture, industry, power generators and the expanding middle-class. The lack of water of adequate quality and quantity is now impacting adversely on urbanisation, modernisation, and economic growth, as well as the health, amenity and stability of communities. In the north these trends have been accentuated by climate change.

Abundant seasonal rain and snow fall in Japan have led to frequent flooding with serious impacts on communities, especially on densely populated alluvial plains. Flooding has contributed to landslides, sediment and refuse movements on rivers and damage to water infrastructure, housing and industries. Not all flows are usually intercepted during flooding because of the short rivers which flow rapidly across steep gradients to the sea. Climate change has increased the severity of flooding and its impacts, while, at other times and in other locations, the incidence and duration of droughts have also increased. Even so, Japan's topography, seasonal rainfall and river profiles offer some natural advantages in managing national water resources and associated water security over the situation in China and Australia.

In populated and productive regions of Australia, rainfall patterns vary with season, climate change and global weather cycles, leading to variable flows and frequently to low volumes of water in most of the nation's rivers. Water resources in catchments surrounding the main cities are allocated to domestic and industrial use, while in the nation's major Murray-Darling Basin water has been extensively overallocated and over-used by agricultural, horticultural and irrigation interests. These problems are exacerbated by the rate of evapotranspiration, loss of retained moisture in soils and the continuing drying influences of climate change in much of the basin. Though regions of Australia experience sporadic severe flooding, in recent years many populated and agriculturally productive areas have encountered unprecedented levels of water scarcity during widespread and prolonged drought.

2.2 Sources of Political Power

The exercise of political power and its distribution differ widely between the three jurisdictions. What are the implications of these political factors for water policy, water administration and planning as well as national water security?

Despite these differences, economic growth and water-based development remain high priority political goals in all three countries. In each case that has influenced national water resources management and planning, including the high priority accorded to consumptive users in public water policy, programs and funding. Proportionately far less attention has been paid to achieving sustainable resources management and maintaining the health of major water sources. In none of the countries is there present evidence that heightened public concern about environmental and water security has gained sufficient traction for the prevailing priorities to be challenged and significantly changed.

In China, President Xi Jinping seeks a powerful resurgent state with the ‘socialist market system’ as the prime vehicle for delivering productivity, efficiency, innovation and prosperity. Under Xi, land and water resource as well as environmental policy oversight and program implementation have been recentralised. The benefits of centrally controlled local trials for new approaches to water trading have been recognised. However, if such control presages less support for bottom-up, water-oriented change, the benefits gained by spreading local innovations and experimentation in water governance and management may be lost. Many legal and administrative measures have been introduced nationally with strong political support and associated heavy program expenditure. Yet, the scale of effort has not been rewarded by significant improvements in water quality and reductions in water pollution. Institutional obstacles as well as CCP central controls continue to undermine prospects for further water reform and advances in national water security.

The Japanese Prime Minister Shinzō Abe[14] has focused national attention on economic modernisation, national security and national stability. Under his leadership, the LDP as the dominant political force over several generations has been able to harness established centres of national power to work on its agenda. The so-called ‘iron triangles’ of ministers, senior industry managers and officials have often shaped policies and programs and narrowed reforms. This approach seems likely to continue to slow the development of new programs aimed at improving water resources management, water source health and national water security (see sub-section 3.1.1). In Japan, the authorities frequently rely on local government to deliver results under national environmental and water-oriented legislation.

Modern Australian Governments have sought to maintain a stable, prosperous society. Within the nation, management of water resources is a contested space. Leading politicians and ministers responsible for water resources in the Australian Government aspire to set national directions and focus public funding on political, short-term national economic priorities. That has led them, notably since 2013, to calls for greater exploitation of the nation’s water

[14] The future direction is somewhat less clear given Abe’s resignation on 28 August 2020

resources and investment in supply-oriented water-based development. There are times when national and state jurisdictions are politically aligned in their objectives, particularly when the objectives coincide with those of water users in primary industries. At other times, the states exercise their constitutional powers in Australia over water governance, management, planning and sharing by pursuing their own political, social, economic and environmental goals and priorities. One consequence is that quite variable water resources management and water security outcomes seem likely to continue for the foreseeable future.

2.3 The Legislative Framework

While each country has a legislative framework heavily focused on overcoming water scarcity for its population and protecting human health, none has legislation explicitly designed to advance water security as a wide-ranging national goal. What attributes of t the national legislative frameworks are capable of enhancing water security or impeding its advance?

In China there are a large number of interconnected water-related laws, regulations, programs and guidelines. As the scale of problems associated with water pollution, water scarcity and climate change has become clearer, these instruments have been modified and added to on an almost continuous basis. In part, because these changes have not accomplished the desired results, the state has increasingly resorted to more judicial, inspectorial and punitive approaches. Centrally promulgated laws and other instruments are pre-eminent, but water-oriented provincial, ministry-based, river basin and local level regulations, plans, rules and guidelines also exist. Overall, programs and projects implemented under the legal and institutionalised administrative systems of China have failed to achieve reform targets and to improve national water security (see also sub-section 2.5).

In the latter half of the twentieth century, Japan introduced several major laws to promote cohesive development of land and water resources and to provide funding for drought and flood mitigation. Water resources policies, management, planning and supply have largely been shaped by this suite of laws, which have been subject to occasional updating. There are many ministries, agencies, departments and bureaus as well as prefectural and municipal instrumentalities with defined responsibilities under this national network of laws. Nonetheless, in contrast to China, they have usually combined in ways that have met national standards and targets and thereby contributed to future national water security - though that is not always the case. For example, subsequent sections identify weaknesses in the way legislative and planning frameworks govern the management of the nation's major river basins and the capacity of vested interests to influence water policy and legislation.

In Australia, it is the states and territories that have the statutes under which water management, water planning and the assignment of water entitlements and allocations takes place. Each jurisdiction has its own legal framework which is variously focused on natural resources, catchments, water sources and irrigation. Other legislation deals with the wild rivers of northern Queensland, groundwater and water use for extractive industry, stock and domestic purposes. While convergent goals and approaches were advanced nationally between 2004 and 2013, the impetus for reform under the national suite of legislation has been severely interrupted as a result of political, administrative and institutional changes since that period. This has weakened regulation and changed the national focus to water exploitation and development (see sub-section 3.1) These changes seem likely to endure under the present government and have continuing negative implications for sustainable water use, effective water management and the water security of many users and the environment.

2.4 National Planning Networks

Are the differing planning frameworks facilitating integrative approaches to the management of critical national water resources as well as future national water security?

Each nation has extensive networks of water plans, particularly for major river sources. The way water planning is framed and implemented has important ramifications for national water security. In both Japan and China there is heavy emphasis on central plans that guide national development in ways that are firmly linked to major legislation. These plans then create the context within which subordinate and sectoral water plans are shaped. Australia does not engage in centralised national planning to guide or control future spatial, social or economic development - though the Australian Government does issue sectoral planning documents and white papers, from time to time. Given the powers and responsibilities of the states and to a lesser extent the territories, these Australian Government documents have varying impacts on the way those jurisdictions respond, including in the shaping of major state plans.

The 13th Chinese five-year plan to the year 2020 charts the direction for national economic and social development and modernisation, while alluding to new priorities for a greener economy and greener society. Overarching national plans and guidelines dealing with water pollution, water quality and conservation, as well as enhanced water use efficiency in industry and agriculture are regularly updated. Some plans also call for more integrated management of the nation’s water resources. The centrally formulated and directed targets under major plans and laws are very often either not being achieved or have been set too low. The research in this thesis suggests that significant improvements in water quality and quantity will be difficult to achieve under current settings. The national plans have identified ambitious goals for sustainable development, restoring water ecosystems and comprehensive river basin management. While these are all central to achieving national water security, they have not been supported by well-designed and carefully focused implementation strategies. As a result, such goals seem unrealisable within the existing framework.

In Japan today, high level statutory planning is clearly oriented towards continuing economic growth and waterways development but at the same time does emphasise the importance of efficient and sustainable use of natural resources. The central government determines the need for significant underpinning plans for the environment and water resources management, while local government and stakeholders develop more specific, localised water-oriented plans. This research reveals the basic incompatibility of setting over-riding major developmental goals, leading to significant modification of major surface water systems, while also seeking to achieve sustainable development, integrated water resources management and water cycle restoration.

In Australia, water planning has been used nation-wide to establish water rights, allocate water and facilitate water trading. Water planning is one of those areas where all national jurisdictions came together with the explicit aim of harmonising approaches, a process which strengthened the water security position of the state considerably. However, the overall picture is more complex. Water plans have generally taken account of human needs and welfare in urban surrounds but have been less effective in dealing with rural situations. Positive contributions of water planning to water security and integrative management have been eroded where the impacts of farm dams, overland flows and climate change have not been considered in plan formulation. Since 2013, water security has also been reduced by actions of the Australian Government, which has accorded a high priority to the exploitation of national water resources. Opportunities to advance water security for the environment have often been lost, in situations where water use efficiency goals have not been met and where water quarantined for the environment has been illicitly used or reallocated to consumers.

2.5 Impediments to Reform

While each nation has its own political system, are the similarities and differences in administrative and institutional barriers to reform replicated in national water security outcomes?

At the national level there is one ministry or department in each country with primary responsibility for water resources policy and planning. However, there are many other ministries, departments, agencies and bureaus at more than one level of government with water-oriented responsibilities that interface, intersect or overlap with one another. The actions of these entities are dictated by their mandates and prescribed legal and administrative arrangements as well as the strength of the linkages they have built. All these institutional arrangements have a bearing on water resource management and water security outcomes. Weak water reform and poor management outcomes occur when political interventions, administrative, legal and planning systems fail to act in mutually supportive ways.

The full implications of conflicted and overlapping roles, at various levels, are most evident in China where there are many state actors with some water responsibilities. The central ministries exercise powers and responsibilities at several levels in parallel with those discharged by provincial, prefectural, county and city civil servants. As well, there are considerable differences between localities in their capacity to implement national water resources programs effectively. The interplay of these many government agents with the prevailing institutional arrangements has often limited or stifled those water reforms needed to achieve the desired outcomes or improved water security. Reform has not been noticeably accelerated as a response to public discontent over the adverse effects of existing water infrastructure or proposals to build major new facilities.

There are several reasons why targets and outcomes are more consistently achieved in Japan than in China and, in some situations, in Australia. One ministry in Japan is the dominant actor in many situations involving water resources management, planning, allocation, development and conservation. It is arguably also more straightforward to achieve greater clarity in role definition with only two levels of government. In that regard, local government frequently plays the pivotal role in achieving national water resource management and related goals under central legislation.

As described above, under the Australian Constitution water ownership lies in the hands of the Australian states, which have the primary responsibility for water resources management, planning and sharing. Their legal and administrative arrangements vary from one jurisdiction to another. On the other hand, the Australian Government often uses its national position and control over considerable public funds in efforts to direct water policy and the orientation of reforms. One consequence is that the interactions of many governmental actors, at times from all three levels of government, have led to seriously distorted water management and water security outcomes.

3.0 COUNTERING ADVERSE IMPACTS ON NATIONAL WATER SECURITY

The previous section dealt with those idiosyncratic features of each country which are sufficiently entrenched to constrain efforts to improve national water security. This section focuses instead on four factors that often have an adverse influence on water security outcomes. However, well-designed and targeted responses can counter these adverse effects and improve national water security, as well as future prospects.

3.1 Dealing with Political Interventions

Have political decisions and interventions in each country had obvious negative implications for effective resources management and national water security?

In China, the political focus on maintaining CCP legitimacy and social order is always evident. Political interventions have often contributed to failures to improve efficiency in water use in industry and agriculture and led to inconsistencies in water sharing, trading, pricing and costing. The continuing commitment to supply-side dam building has left basin managers with the unenviable task of trying to manage heavily modified basin systems without the power to assess and address whole system health and needs. Enlighted political leadership is needed if many of the systemic limitations in China are to be removed in ways that foster sustainable management of water resources and improved water security.

There are aspects of political decision making that have shaped water management and water security outcomes in contemporary Japan, including the political commitment to economic growth and modernisation. Networks of senior ministers, officials and industry in various configurations have considerable influence over water and resource policies, programs and projects (see below). While water policy and legislation could be developed in a more open way to take account of a variety of interests, there are no signs of changes in the current approach which would be advantageous to national water security. Political leadership is important if volume-based charging is to become commonplace in agriculture. Though this represents an important way of conserving water, the political and social cost has been judged too high to date.

Recent political decisions by the Australian Government have led to the roles of agencies, statutory commissions and programs involved in managing complex aquatic and environmental systems and climate change being terminated, merged or budgets cut. Key legislation has been weakened and professional skills and capabilities in water and related fields diminished in several jurisdictions. Australian Government politicians have overseen increased water resource exploitation, renewed emphasis on construction and public funding of water infrastructure, reduced water and environmental reform, and diminished regulation of consumptive users. Virtually all of these politically-motivated changes are capable of being reversed. That is necessary if sustainable development and improved national water security are to eventuate.

3.1.1 State and Regulatory Capture

In China, Japan and Australia, there is clear evidence of state and regulatory capture which is distorting priorities, policies and legal requirements. What are the implications of state capture for water resources management and national water security?

State capture has considerable consequences in each nation for the way major water sources are managed, shared and used. While in each jurisdiction human welfare as a key priority remains unchallenged, the water security of selected consumers has been enhanced through these processes leaving others consumers less secure. In general, state capture has eroded the position of the state with respect to water security and impacted negatively on the environment. These patterns are entrenched in each country with little indication of their being reviewed or challenged in the near future.

The construction of the vast network of mega-dams and canals, reservoirs, weirs and hydropower projects has made a considerable contribution to the economic and industrial development of China. This whole process has been heavily influenced by the common interests of politicians, senior industrial personnel and officials who accord high priorities to technological feasibility as well as political and economic advantage. These groups continue to oversee the introduction of major infrastructure into the nation’s waterways without critical community or environmental appraisal prior to construction. In Japan, a similar economic development-dam building nexus exists which is sufficiently powerful to set the direction of water-oriented policy, management processes and priorities for water infrastructure. These coalitions of interest are positioned to override and reshape environmental and resource management policies and reform proposals. It is too soon to gauge whether more advanced environmental impact assessment will help overcome these influences by moderating the negative impacts of major water infrastructure on river systems and national water security.

In Australia, the alignment of some political, civil service, irrigation and economic development interests has influenced the orientation of current plans, funding and associated programs in the major river systems of the nation. At the national level, this has led to increased public investment in, and subsidies for, irrigation infrastructure and farm dams as well as promised financial support for planned substantial river dams. Major irrigators have benefited from their capacity to access water markets, leading in some cases to market dominance. Short-term political and commercial interests have been advanced as the policy and reform focus has diminished on water resource management and regulation, environmental management and climate change. In the state of NSW, state capture has involved a coalition of political, economic and industry interests, particularly those of upstream irrigators such as cotton growers.

3.2 Achieving Good Water Governance

Good water governance is best advanced when there is accountable executive government, a professional civil service, a strong civil society, independent expert advice and open, fair public processes. Have examples emerged in the research where good water governance is making a tangible contribution to effective water management and future water security?

The role of citizens in water-oriented decisions and the strength of civil society vary considerably between countries and even within the same country. In China there are well understood, *albeit* cumbersome, systems and procedures which allow some public involvement in water-oriented issues. In the past, some local communities have been able to bypass state strictures in finding ways of resolving problems relating to water management and sharing. However, the institutional impediments to water reform, described in sub-section 2.5, corrupt actions and processes and the failure to submit major water infrastructure proposals to public review and commentary have often compromised both good governance and water security.

In Japan, it was only in 2012 that assessment of the environmental impact of major water projects was strengthened, including in transparency of processes and public involvement. While water programs and plans frequently deliver the desired outcomes, the absence of open processes continue to contribute to capture by vested interests. On the other hand, good water governance is evident in dealing with localised flooding, where there is common custodianship of shared water resources and shared decision making.

Environmental and water management legislation and associated processes in Australia provide an opportunity for public involvement in many aspects of decision-making, planning and project management. During the recent drought, there was heightened public contestation over the basis on which decisions had been taken which had significant inequitable impacts on water sharing and allocations in fragile river basins systems. As in Japan, safe and reliable, high quality water supplies to cities have largely been achieved, with administrative oversight of water pricing and financing in most major Australian cities. Good governance and water security have been placed at risk where recent political decisions about water infrastructure and management have by-passed or modified key established processes. That has led to some commercial interests receiving favoured treatment, with adverse consequences for many other consumers, communities and the environment.

3.3 Integrative Water Management

Is the health and resilience of major water sources a critical factor in the management of most water resources in each country? Are integrative approaches to management with the potential to advance national water security in widespread use?

The major river systems examined in this thesis have been modified significantly by human activity. States have tried through management and oversight to provide water for their citizens, businesses and industries, recreation and amenity. They have striven to improve the physical security of water infrastructure against natural disasters and climate change. Because the systems are complex, this research has found that states and managers have frequently tried to reduce system complexity by making simplifying assumptions in the management process. As a consequence, there is no certainty that development and use are sustainable and that the ongoing health of systems as well as the water security of many actors and the environment are assured. There are a variety of integrative approaches to management, some of which have been explored in Chapter 1. The analysis in this thesis has found relatively few situations where management has been sufficiently broad and integrative in scope to make a significant contribution to national water security.

Even though future national prosperity and water security in China depend on much greater respect for the health of major surface and groundwater systems, there is little attention evident in official documents to the stresses these systems are currently experiencing. This grave situation continues to be aggravated by the number of state actors, institutional, legal and administrative complexities and by differing local agendas. In the case of major river basins, the adverse consequences of many poorly coordinated political and official decisions could be reduced if river basin commissions were given more legal and administrative power to influence changes in patterns of land, water and urban development and water use. In China, when official documents refer to ‘integrated’ resources management that usually relates to improving water quality or quantity not to whole systems management.

By contrast, there are frequent references in Japan to the importance of integrated water resources management (IWRM) and restoring hydrological cycles in river basins in official state, ministerial and agency policy papers. However, there remains a heavy focus in Japan in river basins on meeting water demands, fostering new water-based development and applying engineering based ‘solutions’ to water management problems. That has narrowed the concept of IWRM and usually limited its application to management focused on delivering efficiency in water supply and use and assuring infrastructure security. Yet, a more integrative approach to management of complex systems is needed if the state is to achieve its stated goals for sustainable resource development, restoration of hydrological cycles and improved national water security.

In Australia, past water planning encouraged conjunctive management of surface and groundwater systems, leading to modest gains for water security. This has not led to wider implementation of approaches designed to manage river basins as whole systems. In the major national basin of the Murray-Darling Basin, critical to national economic and food security as well as water security, the present basin authority faces significant barriers to effective systemic management. It lacks the power to constrain the decisions and actions of Australian states, is not able to deal effectively with conflicts and inequities in water sharing and cannot act to assure the well-being of key sub-basins and their environments. The country lacks any obvious process that would lead to a re-evaluation of priorities, entitlements, extraction limits and patterns of resource development and irrigation across the basin. One approach could involve the Australian Government in developing, leading and funding a structural adjustment process where the primary focus would lie on achieving continued system-wide sustainability. That could involve changes in funding, patterns of development and use, some strategic industry restructuring and support for communities impacted by change.

3.4 Groundwater Management

Groundwater access and use is vital to the industries and urban settlements of each nation, for national economic growth, but current processes have frequently left groundwater systems seriously compromised. Have management regimes changed in each country in ways that are restoring systems or establishing sustainable patterns of extraction and which are likely to improve national water security?

In China there has been significant over-exploitation of groundwater resources, particularly in the four major river basins of the north. The consequences include aquifer depletion, deep drilling to find accessible water, significant ground subsidence in 50 cities and seawater intrusion in coastal locations. The authorities have urged cities to find alternative sources, have limited some access and proposed step-wise reductions in access to other groundwater sources. Even so, there is little prospect that critical groundwater systems could recuperate in coming years. State economic and water welfare are both under serious threat because of continuing overuse, loss of system sustainability and frequent pollution.

Groundwater continues to be at risk in Japan because of overuse and the need to overcome some sources of earlier contamination. In the past, patterns of use often led to significant land subsidence particularly in urban surrounds. In recent years, groundwater continues to meet about 19% of national industrial, agricultural and domestic requirements and is accessed more heavily when other sources have been damaged by earthquakes (JWWA 2016: 5). Groundwater security in Japan is far more uncertain than is the case for surface waters, because it is managed on a case by case basis and is not a public resource under national law. Though the Japanese government now tests water quality in many groundwater wells, the sustainability of these sources is even more dependent on water recharge exceeding usage. Because system sustainability is not assured, both future supply security for users and contributions to national water security are not assured.

There are many parts of Australia where groundwater is the only source of available water for towns, farms, mines and power generation. The patterns of use vary with season and location. Groundwater provides up to one third of water used in Australia of which agriculture is the most significant user. The aquifers of Australia vary enormously in physical characteristics and recharge patterns and respond differently to climate change and the extent of water demand. Most groundwater systems that are in active use have not been well researched physically and biologically. That has left the supply security of many users dependent on the current patterns of water use remaining sustainable.

Each of the three nations depends on groundwater sources. In meeting demands in dry regions and at times of drought, volumes extracted often far exceed water recharge volumes. Contamination frequently occurs and the resilience of such systems is at risk. Many groundwater sources have not been closely regulated, managed and monitored in ways that recognise their particular characteristics and that overcome known deterioration in their condition. One challenge lies in the fact that each system differs in depth, geology, connections to surface waters and recharge rates. Much more extensive research is needed to improve the management and regulation of these groundwater systems, particularly those under severe stress from overuse. These shortcomings have collectively had adverse effects on national water security in each of the countries studied.

3.5 Addressing Climate Change

Water security and national security are both challenged by climate change. All three countries face serious consequences as climate change progresses. Have they made adequate provisions and developed effective responses to climate change to deal with its present and projected future impacts?

While China has introduced programs and policies focused on climate change and is a leader in adoption of renewable energy, the scale of present and future national challenges exceeds those faced by Japan and Australia. The Chinese authorities have modified major existing infrastructure and secured new and recently constructed infrastructure to cope with near-term flooding induced by climate change. In the south, these initiatives are focused on the impacts of heavy rainfall, high tides and seawater intrusion into rivers, all of which have serious consequences for the scale, area, duration and severity of flooding. Massive economic losses have already occurred in recent decades and the lives of many millions of people in low lying areas, as well as urban populations, assets and infrastructure have often been placed at serious risk. Floods of even greater magnitude are anticipated as climate change progresses. On the other hand, the major river systems of the agricultural north are also experiencing climate-induced change, but in this instance the change is leading to serious water scarcity and drought. Since the latter part of last century thousands of smaller rivers and lakes have disappeared and major river reaches have dried up. As climate induced temperatures continue to rise there are increased risks of prolonged drought, widespread water scarcity and further river reaches and reservoirs drying out.

Climate change projections suggest that more than half the population of Japan living on alluvial plains in the coastal strip could be at severe risk from increased climate-induced flooding and seawater intrusion into freshwater sources. In other locations, where climate change is responsible for reduced rainfall and snowfall, it is already contributing to regional droughts of increased frequency, intensity and duration. At a technical level, water and river managers use advanced technology, climate change modelling and monitoring as well as flood and drought planning and profiling. The focus of these efforts is on public safety, infrastructure security and amelioration of floods and droughts with positive consequences for the water security of some citizens and consumers.

All Australian jurisdictions have advanced tools and modelling on which they can draw in assessing climate change risks. Yet, the ravages of recent climate change induced fire and drought, followed by extensive flooding, suggest that these jurisdictions are only partially prepared to deal with the risks posed by climate change. In particular, the drying influence of climate change over much of the Murray-Darling Basin adds to the management challenges in a system where water resources are already over-allocated and overused and where the health of key sub-basins is already at risk. This has serious implications for national economic and water security. On the positive side, the drying climate over much of the continent has led urban utilities to focus on containing water demand, maintaining reliability of supply and carrying out structural and operational modifications to the nation's major urban dams.

Many of these administrative and technical responses are focused on managing the short-term impacts of climate change. While Australia and Japan are better positioned than China to cope with future significant climate induced threats to national water security, none is currently on track to implement strategies to secure the IPCC target of no greenhouse emissions by 2050. As the major greenhouse emitter in the world, China has little choice but to curb emissions further, in an effort to contain ambient temperature rises. That would involve a massive campaign to drive renewable energy uptake further while replacing more greenhouse gas emitting energy sources and industry. The benefits would lie in better shielding national water security, the major river systems, food production and the economy.

4.0 ADVANCING NATIONAL WATER SECURITY

The focus in this section is on the broadly framed concept of national water security developed in Chapter 1. It builds on the critiques of each nation's water security as presented in the final sections of each country based chapter. The assessment of water security by domain in those chapters has helped in understanding the relationships between national water security and human and environmental welfare as well as consumer needs. As the central actor in determining national water security, the role of the state is explored further in this and subsequent sections.

4.1 The Role of the State

How is the state positioned to advance water security given the constraints described above and as revealed in the detailed analyses in each chapter? Is the state meeting its obligations to the nation as the custodian of national water security?

The state has the ultimate responsibility for ensuring that the exploitation and development of national water and land resources is managed sustainably. It is the state, in various guises, that has approved the major developments, which have been found in this research and elsewhere to lead to extensive and frequently irreversible modifications to major river, lake and groundwater systems. For example, in China, myriad pipelines, storages and water transfer schemes have improved urban water security but have had long-term negative impacts on the health of key water sources and national water security. Japan has also built very extensive water infrastructure, but the negative consequences are less because of the topography, river characteristics and the smaller scale of most reservoirs. In the massive, Murray-Darling Basin of Australia, overallocation and overuse as well as failure to give highest priority to river health are contributing significantly to deterioration in national water security.

In all three countries public bodies have provided extensive public funding for water infrastructure, domestic water and wastewater treatment and distribution systems. The benefits for the state in introducing pricing policies that favour cost recovery for the supply and distribution of water have been recognised by each. Yet, in China national political priorities have often undermined efforts to recover costs through pricing, even though guidelines have been issued governing the setting of water tariffs and prices. Public commitments in Japan to cost recovery have often not been achieved because government entities are centrally involved in price setting. For example, cost pressures on supplying water to some cities and irrigators have not led, in most situations, to more market related water pricing.

Water markets can help in conserving water by creating a market-value for water used. In each country companies are not precluded from entering into contracts to supply and treat water. However, in China, higher value-added usage has been impeded because water trading has occurred almost exclusively between state entities. In Japan water permits cannot be sold in a water market. Consequently, these market-oriented measures have not made a significant contribution to advancing national water security in either country. Japan has derived benefits from other measures such as drives to improve water use efficiency and conserve water as well as water accounting associated with the granting of permits.

Australia has been more ready to pursue the perceived advantages of water markets, water trading and market-based pricing than China and Japan. In Australia, the state-initiated introduction of water markets and water trading has led to some modest reductions in water use in river basins, with consequential improvements in national water security. These gains have been eroded by the adverse impacts on water security of variable trading rules and boundaries, politically motivated interventions in markets and by situations where water trading has advantaged some well capitalised, heavy-water using industries over other users. At the urban level, there has been a positive contribution where water costs and pricing have been independently assessed and regulated to contain utility costs, encourage cost recovery and improve consumer equity.

4.2 Contributing to Human Welfare

What are the consequences for national water security of the priority accorded to human welfare in water management programs and projects? How are the rights and interests of citizens in each country respected and taken into account?

Water projects have received a high national priority and massive funding in China in the effort to secure human welfare and human water security. Storages and pipelines have contributed to the water supply quality, quantity and accessibility for many urban populations, though those benefits have been reduced by breakdowns, source contamination and the effects of drought. In the process of building water infrastructure for urban citizens, the rights, interests and life choices of tens of millions of others in rural riverine locations have been compromised. Urban sanitation continues to improve annually though there remains a very considerable backlog for wastewater services and treatment. Rural water supply and sanitation still present massive challenges in relation to human health and provision of basic services. China's domestic politics and policies regarding the use and development of water resources in some, but not all, transnational water basins have contributed to the diminished water security and welfare of tens of millions of people in neighbouring countries.

In the major cities, Australia and Japan have reliable water supplies, that meet international water quality, health, operational and environmental standards, as well as providing advanced sanitation and wastewater treatment. Both countries have engaged in intensive planning and management to assure security of supply, with results varying somewhat from city to city, depending on their abilities to cope with natural disasters and climate change. Japan has also been obliged to provide very high levels of physical security and sophisticated technology to protect city water infrastructure against major floods, landslides and earthquakes.

Water quality for rural dwellers in Japan, who depend on enclosed water bodies such as lakes and groundwater systems, is less secure than elsewhere in the country. In Australia, secure and safe water supply has often not been achieved for remote populations in villages and some Aboriginal peoples and primary producers. During the recent drought lasting 3 to 5 years according to the region, the supply security of many rural towns and communities was markedly and, in some cases, catastrophically eroded leading to water having to be transported to those sites.

In each country, policies governing water rights, allocation and sharing are partially guided by considerations of human welfare. In China there are several hierarchical and parallel arrangements for issuing water use permits, which achieve varying results for equity, efficiency and human welfare. Market-oriented strategies have not been discernible contributors to improved human welfare. Japan has an orderly process under which government, prefectures and municipalities can issue permits for water use lasting 10 years, or in the case of hydropower 30 years. Citizen rights and interests only appear to be a major consideration in the issuing of new permits, when the rights of existing users could be prejudiced. Australia also has a well understood and orderly process for allocation of water rights rooted in statutory water planning and the separation of land and water rights, accompanied by seasonal adjustments in allocations to deal with water availability. On the downside, little account has been taken of the extent to which some users and communities have suffered or could suffer disadvantage as a result of the operations of water programs and water trading.

4.3 Variable Results for Aquatic Systems

How are current national priorities, policies and programs affecting the health of major water sources and aquatic systems? Is deterioration of these systems having a significant impact on national water security?

In China there is a comprehensive network of laws, plans and regulations largely focused on controlling pollution and pollutants, wastewater treatment and improving water quality. This has led to many programs, massive expenditure and strong legal and administrative direction from the centre. However, these programs and measures have not been implemented in ways that have overcome widespread pollution, water scarcity and overuse. Many river reaches, wetlands, groundwater systems and lakes continue to dry up. The extensive water infrastructure in the major rivers has contributed to changes in water levels, temperatures, water flows and sediment movements, erosion of river banks and depletion of stocks of native species. Like Australia and Japan, China has undertaken extensive programs aimed at partial restoration of some aspect of rivers, river flows, ecosystems and land and aquatic environs. Overall, despite the level of commitment and expenditure, the poor state of the environment in major water systems in China is affecting national water security adversely.

Japan has been better placed than China to deal with the relationship between water security and the environment through application of its extensive national laws, plans and controls. These very largely successful measures are designed to protect water sources from pollution and to promote water conservation, industrial water recycling and water recovery, though contamination of some rural, enclosed water bodies and reservoirs remains a problem. Japan does face several other major challenges. Agriculture is having a deleterious impact on aquatic systems as a result of the way water is used and priced, outmoded infrastructure and the practices pursued by an aging workforce. Additionally, the introduction and operation of the very extensive water infrastructure in Japanese rivers is directed at securing urban and economic goals, but has had many adverse impacts on river systems, and in so doing is eroding national water security.

In Australia, legally enforced measures have effectively controlled most water-based pollution, and in some instances responded to changes in the national climate and encouraged recycling, reuse and water conservation. Urban supply security, including at times of drought, has been framed around human security with some benefits for water source environments. While, steps have been taken to secure water for the environment through statutory planning, aqueous river health and environmental security have been undermined by inadequate assessment of water plan outcomes, illicit extractions and decisions to reallocate environmental water. The environment of many river reaches as well as interconnected wetlands, lakes and forests continue to suffer from extensive anthropogenic changes in ways that are undermining national water security.

4.4 Gains and Losses of Commercial Users

What are the consequences for national water sources and aquatic systems when commercial use and development of water resources are accorded a very high priority by the state? What are the positive and negative implications for future national water security?

In China, the economic and supply security of commercial users have improved where water-based development has been the dominant economic goal in both domestic and transnational rivers. Hydropower capacity, shipping movement and trade have often been beneficiaries. The physical security of commercial users has also been enhanced where government action has reduced the incidence of flooding. However, when the pattern of development and water extraction has been shown in this thesis and elsewhere to be unsustainable, the impact on supply for commercial consumers and national water security are both significantly negative. Political, institutional and cost factors have often limited the opportunities of market-based instruments to contribute to commercial water security. Major actors in both primary and secondary industry have often diminished their own water security by failing to comply with state water efficiency, water saving and wastewater treatment requirements - thereby further eroding national water security.

Japan continues to give a high priority to the supply security of those producing goods and services, hydropower generators, urban utilities and agriculture. That priority is also reflected in the patterns of regulation and planning, in policy documentation and the assignment of water permits. The consumers can also draw confidence from the consistent application of national administrative and operational standards. While domestic, utility, industrial and agricultural consumers have benefited from public funding, subsidies and price restraint, the long-term consequences for national water security are questionable, especially as state and municipal authorities are struggling with mounting public debt. Many small agricultural producers are poorly positioned if the state were to decide to recoup more of the actual costs of water supply and services.

The majority of commercial water users in Australia have benefitted from statutory, nation-wide water planning, while some have also been advantaged through access to markets allowing trading in both water entitlements and seasonal allocations. In the major river basins public funding of irrigation infrastructure upgrades, farm dams and other programs has advanced the water and business security of many consumptive users. Water supply for urban industrial consumers is generally reliable and cost conscious, because major urban water utilities have focused heavily on cost effectiveness, demand management, climate and disaster preparedness and because prices have been regulated. These represent considerable net gains for national water security. On the negative side, the security benefits of commercial users and for national water security have both been seriously eroded where surface and groundwater systems have been modified and overused, leading to unsustainable development. The situation of some commercial users has deteriorated, where water trading has impacted negatively on small and downstream users, water has been overused, overallocated or illicitly extracted, and where market operations have allowed market domination by heavy water users.

5.0 WATER SECURITY CHALLENGES

The analysis in this chapter provides a comparison of the strengths and weaknesses of current approaches to water security in each country as well as their state of preparedness for the near-term future. If water security is to improve, and in some cases not to continue to deteriorate, there are major obstacles to be overcome, some of which are country specific, deriving from political ideology, outmoded governance procedures and institutional impediments to reform. There are other issues which the states face in common, that need more explicit recognition and state leadership if national water security is to be advanced and gains maintained.

5.1 Country Specific Challenges

As a vast heavily populated, relatively poor country still undergoing economic development, water security has proven difficult to achieve in China. The continuous stream of legislative and administrative water reforms, massive funding, introduction of water infrastructure and major restoration projects have not together contained many serious water-oriented problems. The analysis in this thesis demonstrates that future national water security is unlikely to improve as a result of more intensive efforts built on present strategies and programs. The research reveals the need for more integrated and cohesive approaches to the management of national water resources and waterways, if national water security is to be advanced. Empowering river basin commissions could represent such a reform strategy, as recommended in sub-section 3.3 above. While it is doubtful whether the Chinese one party state would sanction the establishment of a high level, preferably independent, national water commission, such an institution would help authorities gain far better oversight of the effectiveness of water resources management across China. Such a commission could also audit the contribution of all current programs to national targets for advancing water security, including by seeking feed-back from local authorities and affected communities, and could then advise the authorities on desirable and necessary changes.

In Japan, there is no sign that the close alignment between party political and industry interests will diminish in the near future. Yet, it is shown in this thesis and elsewhere to be at odds with the government's national planning documents calling for sustainable management of natural resources, integrated watershed management, the restoration of hydrological cycles and the claimed formation of a 'sustainable society'. These goals require a significant shift in the balance of management of major Japanese river systems away from maximising consumption of water resources to securing and maintaining river system health. That would entail assessments of the present health of extensively modified rivers as well as their capacities to meet future human demands (see also sub-section 3.3). The present, near-term and future impacts of climate change on water security would represent further key elements in such a review (see also sub-section 3.5). The newly formed Water Security Council could take the lead in conducting such a review, consulting widely and recommending reforms to government for consideration and implementation.

The research in this thesis has revealed an increasing emphasis by the Australian Government and Australian state jurisdictions on water exploitation, economic development and dam building, accompanied by the emasculation of governmental water, environmental and climate change roles. These changes represent a return to outmoded attitudes, with serious implications for water management and planning as well as national water security. Analysis of problems confronting the Murray-Darling Basin reveals a continuing pattern of political ideology overriding environmental, social and scientific advice and facts as well as critical climate change trends (see also sub-section 3.3). More generally, expert forecasts and signals of widespread drying of the land and water scarcity have been set aside in favour of ideological positions built around climate change denial and the promotion of agricultural, mineral and industrial development. This thesis shows that extensive and difficult reforms are needed in order to restore the policy and expenditure balance. Then, prospects for major water system health, sustainability and resilience as well as national water security could all improve.

5.2 Generic Challenges for the State

Water security is important culturally and spiritually for the peoples of these three countries. For Chinese people there are strong traditional and spiritual links with water and rivers, which as well as ethnic, economic and lifestyle rights and interests have often been compromised in major water-based development. Water is of considerable importance to Japanese people in terms of identity, lifestyle, arts and religion, but that has had little bearing on the way rivers have been modified. The lifestyles of riverine communities have traditionally been shaped by the major river systems of Australia, though that has not received serious consideration in major decisions affecting these systems. Only some Aboriginal peoples have benefited where recent decisions have recognised the role of water in sustaining their cultural and spiritual needs.

The analysis in this thesis shows that while each of the governments acknowledges the cultural, spiritual and lifestyle needs of its peoples, such considerations have generally been accorded a low priority in shaping policy, programs and projects. No signs have been found that any of the states is considering the review of current measures such as water rights, permits or the outcomes of water trading. Yet, the present inequities resulting from their impacts on the water security of users, communities, the environment and the needs of future generations call for urgent attention.

Politics plays a key role in determining national priorities for water management and whether national water security is advanced or retarded. For instance, in China, both centralised CCP controls and political alliances have favoured heavy engineering-based approaches to providing water supply, in order to meet urban and industry demands. The powerful bonds between political, bureaucratic and industrial interests in Japan have often shaped legislated measures and major projects in ways that have actively supported commercial development at the expense of other stakeholders. In Australia, the influence of key politicians in the National Party, ostensibly representing rural and primary industry interests in the present Coalition Government, has been directed at freeing users from regulatory and administrative constraints and promoting increased sources of water supply.

Though the political ideologies and alignments are very different in these countries, the research in this thesis has shown that the exercise of political power, as instanced in these examples, has often had adverse consequences. Those engaged in in primary and secondary production have often been advantaged in the short-term. However, because the decisions have not taken account of the impacts on the health of the major water systems, there have been long-term adverse implications for both economic and water security. Given the dependence of all consumers on the sustainability of the rivers and their ecosystems, the water security of all actors, including those favoured consumers, has been placed at serious risk.

Water ownership is almost exclusively vested in the state in each of the three countries. They all have legal, planning and administrative arrangements in place aimed at maintaining or improving water quality, overcoming water scarcity, assuring security of urban supply and, in principle, fostering the sustainable use of water resources. While effective management of all those factors is important, that is not sufficient to assure national water security. In the analysis carried out for this thesis no official documentation has been identified in any of the countries which defines water security in the broad, integrative way established in Chapter 1. Nor have the critical links between water security and the building of national security and prosperity been publicly explored. When the term water security has been used, it has often been narrowly framed around efforts to overcome localised water scarcity.

An early step in advancing water security could involve assessing the nation's current water security position, followed by decisions about further actions to secure the future. The state has the pivotal role to play in changing priorities, adjusting laws and removing institutional and administrative impediments if management of the nation’s water resources is to contribute to national water security. In particular, strong state support, guidance or oversight are needed if integrative and adaptive management approaches to water management are to be applied in complex water-based/socio-economic systems. Because of the national importance of these systems, the state is responsible for ensuring that the skills and knowledge of concerned actors, stakeholders, communities and independent experts are taken into account in transparent ways in efforts to set water security goals for these complex systems.

Though the states have complex arrangements which ostensibly protect water and govern its management, distribution, sharing and use, these arrangements have not assured the long-term health and sustainability of major natural water systems. It would assist materially if one independent entity was designated and accorded the power to act as the custodian of these systems and could stand-up for their needs and interests in national forums. The commissions studied in this thesis, which have been identified by governments as water basin managers, are not so empowered. That weakness is very evident in the failure to safeguard the complex, highly developed river systems of each nation, where expedient decisions have regularly been made to narrow and simplify the management task. Undesired and flawed outcomes have resulted, leading in some cases to key system elements being degraded and to the inability to deliver past, customary services.

6.0 FUTURE WATER SECURITY

This thesis reviews and critiques how Australia, China and Japan are dealing with water security through their policies, programs and legal and administrative arrangements. The literature based-analysis has drawn on very diverse sources of data and information spanning government entities, national and international researchers, international organisations, national public interest and scientific bodies, professional associations, business collectives and individual corporations. The thesis has built a comprehensive picture of how the three countries have dealt with water security to the end of 2019, added the impacts of notable events in 2020, and indicated how each is positioned to face the future. The link has been made between how the states perceive the seriousness of water-oriented problems, the responses and the outcomes. The relative success of these endeavours has had a considerable bearing on present and future national water security.

Chapter 1 explores the concept of water security and its contested nature in some detail. Experts, international organisations and a few countries explicitly recognise the concept of water security and its pivotal position not only in the web of life but also in reinforcing national security, stability and economic prosperity. The analysis in this thesis provides further evidence in strong support for that position. National water security is also widely recognised as critical for human and environmental health, food, industrial and energy production. The research reveals instances where deterioration in national water security threatens not only present and future human and environmental welfare but risks undermining national prosperity and stability.

All the chapters focus on the consequences of political decision-making and influence, frequently motivated by support for partisan and other vested interests. Section 5 speaks to just how often this situation has been identified in each country. The analysis highlights some of the adverse consequences, in those critical situations where political decisions have run counter to evidence-based, independent expert advice on the health of national water resources. This aspect of research has played an important part in the assessment and comparisons of national water security as distinct from many published sources. The country case studies and the comparisons made in this chapter provide some further important lessons. Each makes its own unique contribution to the study of water security in the three countries, with their vastly different physical constraints, needs and political systems. While it could be argued that each of the three states has some form of implicit water security strategy, this thesis has shown that implementation of the various assorted national measures have actually created some positive but many negative effects on national water security.

One of the reasons for selecting and studying water security in China, Japan and Australia lay in the opportunity to examine the impact on water security of these contrasting political and administrative systems and traditions. As demonstrated above, that has proved to be a significant element in this research. As well, the examination of water security in each country has shown the value and the importance of examining the influence of individual policies, programs and projects on national water security outcomes and future preparedness. China is a world power with a one party, centrally controlled socialist system; Japan is a constitutional monarchy and powerful capitalist democracy; while Australia is a middle power and liberal democratic federation, with all of the complexities associated with the sharing of power and responsibility. Yet, notwithstanding these differences, to date each state has failed to accord water security its rightful priority as a key determinant of future social and economic development. Similarly, none of these countries has developed policies which accord clear political and administrative recognition to the long-term impacts of climate change on both future water and economic security.

This research points to the value of extending the approach developed in this thesis to the study of water security in other states. Advances in national water security are hard won, yet are critical in securing long-term national security, including economic security. The analysis has shown that a considered national water security strategy needs to draw widely on national expertise, and requires committed political and state leadership in its formulation and implementation. Leadership is particularly important to ensure that crucial reforms are carried through, institutional blockages overcome, the efforts of governmental bodies are directed at achieving common goals, and that major aquatic systems are managed in integrative ways. This research has demonstrated that water security is not achieved through a series of legal, administrative and planning measures that are disconnected from such a national water security strategy. The assessment framework developed in this thesis, and the study of political interventions, national policies, plans and projects (as developed in the country chapters) can be employed to reveal in which areas specific states exhibit strengths and weaknesses. Such analyses would be valuable in identifying optimal approaches to national water security in individual states, in reinforcing the vital importance of this subject in multilateral forums and in strengthening international efforts to benchmark state performance.

REFERENCES

Abbasi Haq Nawaz, Lu Xiwu, Xu Feng and Xie Jing 2016, 'Wastewater Treatment Strategies in China: An Overview', *Science Letters*, 4(1), 15-25

ABC News 2019, 'Adani gets final environmental approval for Carmichael mine', 14 June, https://www.abc.net.au/news/2019-06-13/adani-carmichael-coal-mine-approved-water-management-galilee/11203208, accessed 07 July 2019

Academy of Technological Sciences and Engineering (ATSE) 2012, *Sustainable Water Management: Securing Australia's future green economy*, Australian Research Council, Canberra

ACT Government (ACT) 2014, 'ACT Water Strategy 2014-44', *Environment and Planning*, http://www.environment.act.gov.au/_data/assets/pdf_file/0019/621424/ACT-Water-Strategy-ACCESS.pdf , accessed 13 March 2017

Adachi Yukio, Hosono Sukehiro and Iio Jun (eds.) 2015, *Policy Analysis in Japan*, Pluto Press, Bristol

Adeel Zafar 2017, 'Water security: A new hope', *Japan Today*, 18 April, https://japantoday.com/category/features/opinions/Water-security-A-new-hope, accessed 22 September 2019

Adeyemo Emmanuel A 2003, 'Effective Water Governance through the Paradigm of IWRM', *29th WEDC International Conference*, 169, https://wedc-knowledge/boro.ac.uk/resources/conference/29/Adeyemo.pdf , accessed 30 December 2017

Agilient 2020, 'Safeguarding Australia's Critical Infrastructure from Cyber-Attack, https://www.agilient.com.au/2020/05/29/safeguarding-australias-critical-infrastructure-from-cyber-attack/, accessed 08 June 2020

Agriculture Victoria 2017, 'Water supply options for rural lifestyle properties', Updated 8 May, http://agriculture.vic.gov.au/agriculture/farm-management/soil-and-water/water/farm-water-solutions/what-are-my-options/water-supply-options-for-rural-lifestyle-properties , accessed 26 April 2018

Aither 2017, *Water Markets in New South Wales, Final Report*, March, *Aither*, http://www.aither.com.au/wp-content/uploads/2017/03/water-markets-in-nsw-aither-report-for-dpi-water.pdf , accessed 29 July 2017

Akimov Alexandr and Simshauser Paul 2018, 'Performance Measurement in Australian Water Utilities: Current state and future directions', *Griffith University Business School*, https://www120.secure.griffith.edu.au/research/file/c0ccfa23-065c-4ca2-8e6a-53d55f4f3af1/1/2018-02-performance-measurement-in-australian-water-utilities.pdf, accessed 11 October 2019

Albert Eleanor and Xu Beina 2016, 'China's Environmental Crisis', *Council on Foreign Relations*, January 18, http://www.cpr.org/china/chinas-environmental-crisis/p12608 , accessed 05 October 2016

Alexander Harriet 2020, 'NRC concerns as state water sharing plans bypass scrutiny' *Sydney Morning Herald*, 10 March

Alston Margaret and Mason Robyn 2008, 'Who Turns the Tap Off? Introducing social flow to the Australian water debate', *Rural Society*, Vol 18(2), 131-139

Andrew Neil 2015, 'The heart of the nation's water', *ATSE Focus*, April, 11-12

Apte Simon and Batley Graeme 2011, 'Water Quality', in Ian Prosser (ed.), *Science and Solutions for Australia: Water*, CSIRO Publishing, Collingwood, 61-74

Ansar Atif, Flyvberg Bent, Budzier Alexander and Lunn Daniel 2014, 'Should we build more large dams? The actual costs of hydropower megaproject development', *Energy Policy*, 69, 43-56

Aregay Fanus A, Liuyang Yao and Zhao Minjuan 2016, 'Spatial Preference Heterogeneity for Integrated River Basin Management: The Case of the Shiyang River Basin, China', *Sustainability*, 8(10), 970; doi: 10.3390/su8100970

Argent Robert M, *Australia State of the Environment Report 2016*, Key findings: Inland water, https://soe.environment.gov.au/theme/inland-water/key-findings?year=96 , accessed 06 March 2018

Arie Hiroyuki 2017, ‘Japan’s approach to tackling cybersecurity challenges’, *Japan Industry News*, January 17, https://www.japanindustrynews.com/2017/01/japans-approach-tackling-cybersecurity-challenges/, accessed 08 June 2020

Asayama Yumiko 2016, ‘Policies, Measures and Collaboration for Integrated Implementation of SDG 6.5, 11.3 and 11.5; Toward Sustainable IWRM and Water-Resilient City; Case Study: City of Nagoya, Japan’, Regional Seminar 29 November, https://www.unescap.org/sites/default/files/Session%205_Yumiko%20A._JWF.pdf, accessed 23 September 2019

ASEM Water Resources Research and Development Center 2018, ‘Chiangjiang Water Resources Commission (CWRC), *China CP*, http://www.asemwater.org/Partnerships/Partners/2011-05-19/178.html , accessed 01 June 2018

Ashton Dale 2018, ‘Cotton farms in the Murray-Darling Basin’, http://www.agriculture.gov.au/abares/research-topics/surveys/irrigation/cotton , accessed 19 April 2018

Asian Development Bank (ADB) 2010, *Every Drop Counts: Learning from Good Practices in Eight Asian Cities*, ADB, Manila, Philippines

Asian Development Bank (ADB) 2016, *Asian Development Outlook 2016: Strengthening Water Security in Asia and the Pacific*, appendices, ADB Manila, Philippines, https://www.adb.org/sites/default/files/publication/189411/awdo-2016.pdf, accessed 19 February 2019

Asian River Restoration Network (ARRN), ‘Reference Guideline for Restoration by Eco-Compatible Approach in River Basins of Asia, Version 2’, http://www.a-rr.net/publication/reference_guideline/docs/ARRNguideline2brochure.pdf, accessed 12 March 2019

Atsuko Masano 2010, ‘The Immense Cost of Japanese Dams and Dam-Related Landslides and Earthquakes’, *The Asia-Pacific Journal, Japan Focus*, 8 (1 No.2), 4 January, https://apjjf.org/-Masano-Atsuko/3280/article.pdf, accessed 12 November 2019

Australian Academy of Science (AAS) 2019, ‘Investigation of the causes of mass fish kills in the Menindee region in NSW over the summer of 2018-2019’, 18 February , https://www.science.org.au/files/userfiles/support/reports-and-plans/2019/academy-science-report-mass-fish-kills-digital.pdf, accessed 20 February 2019

Australia-New Zealand Counter-Terrorism Committee 2015, 'National guidelines for Protecting Critical Assets from Terrorism', https://www.nationalsecurity.gov.au/Media-and-publications/Publications/Documents/national-guidelines-protection-critical-infrastructure-from-terrorism.pdf, accessed 09 June 2020

Australian and State and Territory Governments (AST) 2017a, 'A module to support water planners and managers consider and incorporate possible impacts from climate change and extreme events on water resources', *Australian Government,* http://www.agriculture.gov.au/SiteCollectionDocuments/water/climate-change.pdf, accessed 26 July 2018

Australian and State and Territory Governments (AST) 2017b, 'National Groundwater Strategic Framework, 2016-2026', *Australian Government*, Canberra, http://www.agriculture.gov.au/SiteCollectionDocuments/water/national-groundwater.pdf, accessed 26 July 2018

Australian and State and Territory Governments (AST) 2017c, 'Engaging Indigenous Peoples in Water Planning and Management (2017)', http://www.agriculture.gov.au/SiteCollectionDocuments/water/indigenous-engagement.pdf, accessed 29 July 2018

Australian Broadcasting Commission (ABC) 2008, 'Water Plant a billion dollar bungle – economists', 18 July, http://www.abc.net.au/2008-07-18/water-plant-a-billion-dollar-bungle-economists/443790 , accessed 10 July 2017

Australian Broadcasting Commission (ABC), Mildura 2011, 'Concerns raised over MDBA decision to increase groundwater limits', 10 November, http://www.abc.net.au/local/stories/2011/10/27/3349417.htm , accessed 19 February 2018

Australian Broadcasting Commission (ABC) 2014, 'National Water Commission releases final report, warns government not to backtrack on water reform', 20 October, http://www.abc.net.au/news/2014-10-20/final-national-water-commission-report-advises-against-changes/5826790 , accessed 10 July 2017

Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) 2016, *Australian Water Markets Report 2014-15, National Overview*, http://www.mdba.gov.au/sites/default/pubs/ABARES-water-market-report-14-15.pdf, accessed 08 August 2017

Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) 2017, *Australian Water Markets Report 2015-16, National Overview*, http://www.agriculture.gov.au/ABARES/research-topics/aust-water-markets-reports/national-overview , accessed 08 August 2017

Australian Bureau of Statistics (ABS) 2015, '4610.0 Water Account, Australia 2014-15, Main Findings', http://www.abs.gov.au/ausstats/abs@nsf/mf/4610.0 , accessed 20 April 2017

Australian Bureau of Statistics (ABS) 2017, '4618.0 Water Use on Australian Farms, 2015-16', http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/4618.0Main%20Features22015-16?opendocument&tabname=Summary&prodno=4618.0&issue=2015-16&num=&view= , accessed 19 April 2018

Australian Government (AG) 2007, *A National Plan for Water Security*, 25January, Australian Government, Canberra

Australian Government (AG) 2010, 'Water for the Future', *Department of Sustainability, Environment, Water, Population and Communities,* http://155.187.2.69/water/publications/action/pubs/water-for-the-future.pdf , accessed 16 March 2017

Australian Government (AG) 2012a, *Water Act 2007, Water Basin Plan 2012*, https://www.legislation.gov.au/Details/F2012L02240/Downloads.pdf , accessed 16 March 2017

Australian Government (AG) 2012b, *National Partnership Agreement on Coal Seam Gas and Large Coal Mining*, Australian Government, Canberra

Australian Government (AG) 2013, *Water Act 2007,* Amended as Act No.13, 2013

Australian Government (AG) 2014a, 'Agricultural Competitiveness Green Paper', 7 April, *Australian Government*, Canberra

Australian Government (AG) 2014b, ‘Water Infrastructure Options Paper’, 29 October, *Australian Government*, Canberra

Australian Government (AG) 2015, ‘Agricultural Competitiveness White Paper’, *Australian Government*, Canberra

Australian Government (AG) 2017a, ‘National Water Market: Water Rights’, http://www.nationalwatermarket.gov.au/about/rights.html , accessed 25 January 2017

Australian Government (AG) 2017b, ‘National Water Market: About the Water Market’, http://www.nationalwatermarket.gov.au/about/index.html , accessed 25 January 2017

Australian Government (AG) 2018, *Security of Critical Infrastructure Act 2018*, https://www.nationalsecurity.gov.au/Media-and-publications/Publications/Documents/national-guidelines-protection-critical-infrastructure-from-terrorism.pdf, accessed 09 June 2020

Australian Government (AG) 2019, ‘Planning for Australia’s Future Population’, *Australian Government*, 20 March, https://www.pmc.gov.au/resource-centre/domestic-policy/planning-australias-future-population, accessed 18 November 2019

Australian National Audit Office (ANAO) 2018, *Design and Governance of the National Water Infrastructure Development Fund*, 28 February, https://www.anao.gov.au/work/performance-audit/design-and-governance-national-water-infrastructure-development-fund#footnote-000 , accessed 26 April 2018

Australian Productivity Commission (APC) 2017, ‘National Water Reform Issues’, Inquiry Report No 87, publicly released 31March 2018, *Australian Government*, Canberra

Australian Productivity Commission (APC) 2018, ‘Murray-Darling Basin Plan: Five Year Assessment, Overview’, 19 December, *Australian Government*, Canberra

Australian Water Association (AWA) 2016, ‘Water Security for all Australians’, *AWA*, http://www.awa.asn.au/documents/Water_Security_for_all_Australians.pdf , accessed 15 January 2017

Australian Water Partnership (AWP) 2019a, ‘Water Tools: A Guide to three national level platforms that support the management of Australia’s scarce water resources’, https://waterpartnership.org.au/wp-content/uploads/2019/08/WaterTools.pdf, accessed 21 October 2019

Australian Water Partnership (AWP) 2019b , ‘Australia-Mekong Facility: Strengthening resilience for the Greater Mekong region’, 28 June, https://waterpartnership.org.au/australia-mekong-water-facility-strengthening-resilience-for-the-greater-mekong-region/, accessed 28 June 2019

AWA/ARUP 2016a, *Australian Water Outlook, AWA,* http://www.awa.asn.au/documents/Australian_Water_Outlook_Report_2016.pdf , accessed 15 June 2017

AWA/ARUP 2016b, *Australian Water Outlook,* State and Territory reports: NSW Industry, *AWA*, http://www.awa.asn.au/documents/Water_Outlook_2016_NSW_Report.pdf , accessed 15 June 2017

Babones Salvatore 2018, ‘China’s Cabinet Shuffle Suggests Xi Will Rule China Through the State, not the Party, https://www.forbes.com/sites/salvatorebabones/2018/03/14/chinas-cabinet-shuffle-suggests-that-xi-will-rule-china-through-the-state-not-the-party/#19b38e9923f2 , accessed 11 May 2018

Baldwin David A 1997, ‘The Concept of Security’, *Review of International Studies, 23, 5-26*

Ball Philip 2017, *The Water Kingdom*, Vintage, New York

Barrett Brendan FD and Therivel Riki 1991, *Environmental Policy and Impact Assessment in Japan*, Routledge, London

Barron OV, Crosbie RS, Charles SP, Dawes WR, Ali R, Evans WR, Cresswell R, Pollock D, Hodgson G, Currie D, Mpelasoka F, Pickett T, Aryal S, Donn M and Wurcker B 2011, ‘Climate change impact on groundwater resources in Australia’, Summary Report, *NWC*, https://www.researchgate.net/profile/Geoff_Hodgson2/publication/265350862_Climate_change_impact_on_groundwater_resources_in_Australia/links/547b8620cf2bd04be33c0e6.pdf , accessed 2 March 2017

Bartel Robyn, Noble Louise and Beck Wendy 2018, ‘Quixotic water policy and the prudence of place-based voices’, in Robyn Bartel, Louise Noble, Jacqueline Williams and Stephen

Harris (eds.), *Water Policy, Imagination and Innovation: Interdisciplinary Approaches*, Routledge, New York, 211-233

Beasley R 2018, 'Submission to the Murray-Darling Royal Commission by Senior Counsel', *Transcript of Proceedings of the Murray-Darling Royal Commission*', 3490-3523, https://mdbrcsa.govcms.gov.au/sites/g/files/net3846/f/30_october_2018_hearing_transcript_final_0.pdf?v=1542094262, accessed 08 January 2018

Bennett Jeff (ed.) 2005, *The Evolution of Markets for Water: Theory and Practice in Australia*, Edward Elgar, Cheltenham, UK

Bennett Michael and Gardener Alex 2014, 'Saving water in a drying climate: lessons from south-west Australia', *The Conversation*, July 1

Bernstein Richard 2017, 'China's Mekong Plans threaten Disaster for Countries Downstream', *Foreign Policy*, Dispatch, 27 September

Besser Linton, Fallon Mary and Carter Lucy 2017a, 'Murray-Darling Basin Plan: Taxpayer-purchased water intended for rivers harvested by irrigators', *ABC News*, 11.07 AM, 24 July, http://www.abc.net.au/2017-07-24/murray-darling-basin-water-pumped-by-irrigators/8732702 , accessed 24 July 2017

Besser Linton, Fallon Mary and Carter Lucy 2017b, 'Murray-Darling Basin Plan: Irrigation lobbyists offered access to confidential government documents', *ABC News*, 24 July, http://www.abc.net.au/2017-07-24/top-water-bureaucrat-offered-confidential-documents-to-lobbyists/8738568 , accessed 24 July 2017

Bhullar Lovleen 2013, 'Urban Water Governance in China: legal and policy framework', in Asanga Gunawansa and Lovleen Bhullar (eds.), *Water Governance: An Evaluation of Alternative Architectures*, Edward Elgar, Cheltenham, UK, 216-241

Bijker Wiebe E 2007, 'Dikes and Dams, Thick with Politics', *Isis*, 98: 109-123

Boren ZD 2017, 'Mapped: Nearly half of China's provinces have failed to clean up their water', 1 June, https://unearthed.greenpeace.org/2017/06/01/china-water-quality-data-shanghai-beijing/ , accessed 21 October 2017

Bourke Tony 2012, ‘Explanatory Statement, Basin Plan 2012’, *Australian Government*, http://www.legislation.gov.au/Details/F2012L02240/Explanatory%20Statement/Text , accessed 16 March 2017

Bosshard Peter 2011, ‘Chinese Government Acknowledges Problems of Three Gorges Dam’, 19 May, https://www.internationalrivers.org/blogs/227/chinese-government-acknowledges-problems-of-three-gorges-dam , accessed 12 January 2018

Boyd Oscar and Baird Cory 2018, ‘As IPCC report warns of growing climate change risks, Japan seeks to adapt’, *The Japan Times*, 29 October

Brackburn-Dwyer Brandon 2016, ‘Japan could hold the key to surviving floods, *Global Citizen*, https://www.globalcitizen.org/en/content/japan-flood-control-superstructure-china-tokyo/ , accessed 14 October 2018

Brasor Philip 2010, ‘Public works project has DPJ in a dam mess’, *The Japan Times*, 11 April, https://www.japantimes.co.jp/news/2010/04/11/national/media-national/public-works-project-has-dpj-in-a-dam-mess/#.W8a5EuRReM8 , accessed 17 October 2018

Brasor Philip and Tsubuku Masako 2015, ‘Water, water everywhere in Japan, but fewer people to pay for it’, *The Japan Times*, 24 October, https://www.japantimes.co.jp/news/2015/10/24/business/water-water-everywhere-japan-less-people-pay/#.XMaSCOR7mM8, accessed 28 February 2019

Brasor Philip and Tsubuku Masako 2019, ‘Examining the high price of Japan’s water systems’, *The Japan Times*, 8 February, https://www.japantimes.co.jp/news/2019/02/08/business/examining-high-price-japans-water-systems/#.XMY4wuR7mM8, accessed 29 April 2019

Bray Joshua 2018, ‘Examining Water Issues in China’, http://sydney.edu.au/environment-institute/blog/examining-water-issues-china/, accessed 15 February 2019

Ortiz Diego Arguedas 2018, ‘The Underground Cathedral Protecting Tokyo from Floods’, 30 November, https://www.bbc.com/future/article/20181129-the-underground-cathedral-protecting-tokyo-from-floods, accessed 10 February 2020

Brown Kerry and Berzina-Ĉerenkova Una Aleksandra 2018, ‘Ideology in the Era of Xi Jinping’, *Journal of Chinese Political Science*, 23(3), 323-339, https://link.springer.com/article/10.1007/s11366-018-9541-z

Brundtland Gro Harlem 1987, *Our Common Future*, World Commission on Environment and Development, Oxford University Press, Oxford

Bryan Brett A, Gao Lei, Ye Yanqiong *et al* 2018, ‘China’s response to a national land-system sustainability emergency’ *Nature*, 559, 193-204

Building Research Institute (Japan) 2011, ‘Building an Ultra Water Saving Society’, https://www.kenken.go.jp/english/contents/topics/japan-journal/pdf/jj2011aug_38-42.pdf, accessed 22 September 2019

Bureau of Meteorology, Australia (BOM) 2015, ‘National Water Account 2015, National Overview’, http://www.bom.gov.au/water/nwm/2015/ , accessed 20 April 2017

Bureau of Meteorology, Australia (BOM) 2019, ‘Water in Australia 2017-18’, http://www.bom.gov.au/water/waterinaustralia/files/Water-in-Australia-2017-18.pdf, accessed 04 July 2020

Bureau of Waterworks, Tokyo Metropolitan Government, 2019, ‘Notification and Charges, List of Charges https://www.waterworks.metro.tokyo.jp/eng/charge/ryokin/charge-list.html, accessed 29 April 2019

Buruma Ian 2011, ‘Japan’s Political Tremors’, *Project Syndicate*, 7 April, 1-3

Butterworth John, Warner Jeroen, Moriarty Patrick, Smits Stef and Batchelor Charles 2010, ‘Finding Practical Approaches to Integrated Water Resources Management’, *Water Alternatives*, Vol 3(1), 68-81

Byron Neil 2015, ‘Climate, energy and water: the potential roles and limitations of markets’ in Jamie Pittock, Karen Hussey and Stephen Dovers (eds.), *Climate, Energy and Water: Managing trade-offs, seizing opportunities*, 218-230, Cambridge University Press, Cambridge

Carmody Emma 2015, ‘Threats to wetlands in the Murray-Darling Basin’, 23 October, *EDO NSW*, http://www.edonsw.org.au/threats_to_wetlands_in_the_murray_darling_basin , accessed 19 February 2018

CDP 2019, 'CDP Japan Water Security Report 2018', https://6fefcbb86e61af1b2fc4-c70d8ead6ced550b4d987d7c03fcdd1d.ssl.cf3.rackcdn.com/cms/reports/documents/000/004/174/original/CDP2018_Water_Japan_Report_EN.pdf?1551347385, Accessed 02 October 2019

Carney Matthew 2018, 'Forget Geopolitics, water scarcity shapes up as the biggest threat to China's rise', *ABC News*, 26 November, https://www.abc.net.au/news/2018-11-23/china-water-crisis-threatens-growth/10434116 , accessed 15 February 2019

Central Committee of the Communist Party of China 2016, 'The 13th Five-Year Plan for Economic and Social Development of the People's Republic of China, 2016-2020', http://en.ndrc.gov.cn/newsrelease/201612/P020161207645765233498.pdf, accessed 26 October 2018

Central Environment Council of Japan 2015, 'Report on Assessment of Impacts of Climate Change in Japan and Future Challenges', 1 March, https://www.env.go.jp/en/focus/docs/files/20150300-100.pdf, accessed 16 October 2019

Changjiang Water Resources Commission (CWRC) 2018, 'Chinese vice premier calls for high-quality growth in Yangtze River Economic Belt development', 28 May, http://www.cjw.gov.cn/English/CWRCNews/32636.html , accessed 01 June 2018

Chen, A 2007, 'The failure of Organizational Control: Changing Party Power in the Chinese Countryside', *Politics and Society,* Vol 35, No 1, 145-79

Chen Xuelian 2017, A U-Turn or Just Pendulum Swing? Tides of Bottom-Up and Top-Down in Contemporary China, *Journal of Chinese Political Science,* 22(4), 651-673

Cheng Hefa and Hu Yuanan 2012, 'Improving China's water resources management for better adaptation to climate change', *Climatic Change,* Vol 112, 253- 282

Cheng Xiaotao, Wan Hongtao, Huang Shifeng, Li Changzhi and Zhang Hongbin 2018, 'Lessons learned from the 2016 Yangtze River flood in Anhui province, China', *International Journal of River Basin Management*', 307- 314, doi:10.180/15715124.2018.1437741

Cheong Danson 2018, 'China's new, more powerful environment ministry will prevent systemic destruction of ecology', *Straits Times,* 17 March, https://www.straitstimes.com/asia/east-asia/npc-2018-chinas-new-more-powerful-environment-ministry-will-prevent-systemic, accessed 15 June 2019

China Council for International Cooperation on Environment and Development (CCICED) 2019, 'Ecological Compensation and Green Development Institutional Reform in the Yangtze River Economic belt (YREB)' Research Report, cciced-sps-2-2-yangtze%20(1).pdf, accessed 21 June 2019

China Daily 2011a, 'China to set up water facilities construction', 10 July, http://www.chinadaily.com.cn/china/2011-07/10/content_12870109.htm , accessed 24 January 2018

China Daily 2011b, 'Party focuses on drought, flood battles', 11 July, http://www.chinadaily.com.cn/china/2011-07/11/content_12872227.htm , accessed 24 January 2018

China Daily 2017, 'South-to-north diversion benefits 50 million Chinese', 14 September, http://www.chinadaily.com.cn/china/2017-09/14/content_32000250.htm , accessed 27 January 2018

China Direct 2011, 'China's Twelfth Five Year Plan (2011-2015)', 11 May, http://typepad.com/china_direct/2011/05/chinas-twelfth-five-year-plan-the-full-english-version.html/ , accessed 13 January 2018

China (Internet) Information Center 1998, 'Promoting the Common Development of All Ethnic Groups', Section IV, Government White Paper, http://www.china.org.cn/e-white/4/4.4.htm , accessed 05 June 2018

China (Internet) Information Center 2002, 'Water Law of the People's Republic of China', promulgated 29 August, http://www.china.org.cn/english/government207454.htm , accessed 09 October 2017

China (Legal) Information Center 2015, 'China's Basic System', 30 May, http://chinadaily.com.cn/m/chinalic/2015-05/30/content_20725720.htm , accessed 19 November 2017

China National Bureau of Statistics (CNBS) 2016, *China Statistical Yearbook 2016*, Sections 8-11 to 8-14, http://www.stats.gov.cn/tjsj/ndsj/2016/indexeh.htm , accessed 1 March 2018

China Water Risk (CWR) 2014a, 'Pollution: Is the Data Real?' *China Water Risk*, 9 July, http://chinawaterrisk.org/notices/resources/analysis-reviews/pollution-is-the-data-real/ , accessed 29 September 2017

China Water Risk (CWR) 2014b, 'Water Permits: How to Get Water in China' *China Water Risk*, 17 November, http://chinawaterrisk.org/resources/analysis-reviews/water-permits-how-to-get-water-in-china/ , accessed 17 October 2017

China Water Risk (CWR) 2014c, 'Water Rights in China' *China Water Risk*, 17 November, http://chinawaterrisk.org/interviews/water-rights-in-china/ , accessed 17 October 2017

China Water Risk (CWR) 2015, 'New Water Ten Plan to Safeguard China's Waters', *China Water Risk*, April, http://chinawaterrisk.org/notices/new-water-ten-plan-to-safeguard-chinas-waters/ accessed 26 September 2017

China Water Risk (CWR) 2016, 'China's 13th Five-Year Plan for Ecological and Environmental Protection (2016-2020)', *China Water Risk*, 5 December, http://chinawaterrisk.org/notices/chinas-13th-five-year-plan-2016-2020/ accessed 23 September 2017

China Water Risk (CWR) 2017, 'Revised Water Pollution Prevention Control Law Approved' *China Water Risk*, 27 June, http://chinawaterrisk.org/revised-water-pollution-orevebtuib-and-control-law-approved/ , accessed 21 October 2017

China Water Risk (CWR) 2018, '2017 State of Ecology and Environment Report Review', 14 June, http://www.chinawaterrisk.org/resources/analysis-reviews/2017-state-of-ecology-environment-report-review/, accessed 23 March 2019

Chinese Daily 2018, 'Five-Year Plan on Lancang-Mekong Co-operation (2018 – 2022), 11 January, http://www.chinadaily.com.cn/a/201801/11/WS5a56cd04a3102e5b17374295.html , accessed 03 May 2018

Christian Science Monitor 2017, 'China spent $100 billion on reforestation. So why does it have green deserts?' https://www.csmonitor.com/World/Asia-Pacific/2017/0628/China-spent-100-billion-on-reforestation.So-why-does-it-have-green-deserts , accessed 26 December 2017

Climate Action Tracker (CAT) 2019, 'China: Country Summary', 2 December, https://climateactiontracker.org/countries/china/, accessed 30 August 2020

Climate Reality 2019, 'How the Climate Crisis Impacts Japan', https://www.climaterealityproject.org/blog/how-climate-crisis-impacts-japan, accessed 08 February 2020

Connell Daniel 2013, 'The role of national governments in river management', *Global Water Forum*, March 13, http://www.globalwaterforum.org/2013/03/13/international-water-politics-the-role-of-national-governments-in-river-management/ , 08 December 2018

Consortium on Non-Traditional Security Studies in Asia 2007, 'Our Consortium, Background', http://www.rsis-ntasia.org/ourConsortium/history.html , accessed 02 November 2016

Consulate-General of the People's Republic of China in Gothenburg (CGG) 2018: 'China's Administrative System', http://www.fmprc.gov.cn/ce/cggb/eng/xnyfgk/t216950.htm , accessed 10 February 2018

Contreras Elsa Galarza and Nelson Jane, 2018, 'Why the answer to water insecurity is working together', World Economic Forum (WEF), https://www.weforum.org/agenda/2018/01/why-the-answer-to-water-insecurity-is-working-together/ , accessed 31 March 2018

Cook Christina and Bakker Karen 2012, 'Water Security: Debating an emerging paradigm', *Global Environmental Change*, 22, 94-102

Council of Australian Governments (COAG) 1994, Council of Australian Governments' Water Reform Framework, Communiqué, Hobart, Tasmania, February

Council of Australian Governments (COAG) 2009, *National Framework for Compliance and Enforcement Systems for Water Resource Management*, Australian Government, Canberra

Counter-Terrorism Committee, Executive Directorate, UN Security Council (CTED) and UN Office of Counter-Terrorism (UNOCT) 2018, 'The protection of critical infrastructure against terrorist attacks: Compendium of good practices', https://www.un.org/sc/ctc/wp-content/uploads/2018/06/Compendium-CIP-final-version-120618_new_fonts_18_june_2018_optimized.pdf, accessed 08

Crase Lin 2010, 'Water - The Role of Markets and Rural-To-Urban Water Trade: Some Observations', https://www.accc.gov.au/system/files/Roles%20of%20water%20markets%20-%20Lin%20Crase%20%28paper%29.pdf , accessed 5 August 2017

Crase Lin 2012, 'Resisting the Murray Darling Plan - in whose interest?' *The Conversation*, https://theconversation.com/resisting-the-murray-darling-basin-plan-in-whose-interest-8771 , accessed 15 March 2017

Crase Lin, Pawsey Nicholas and Cooper Bethany 2015, 'Water Pricing in Australia: Unbundled Politics, Accounting and Water Pricing', in Ariel Dinar, Victor Pochat and José Albiac-Murillo (eds.), *Water Pricing Experiences and Innovations*, Springer, London, 15-40

Crawford Peter J 2002, 'Water Law and Policy: Back to Basics', *Fourth Australian Water Law and Policy Conference*, Sydney

Crawford Peter J 2003, *Captive of the System*, Richmond, Sydney

Crawford Peter J 2008, 'Only a whole-system approach can save our rivers', *ATSE Focus*, 153, 5-7

Crothers Tom 2019, 'Minister should not bow to pressure on Adani', *Sydney Morning Herald*, 09 April

Crow-Miller Britt, Webber Michael and Rogers Sarah 2017, 'The Techno-Politics of Big Infrastructure and the Chinese Water Machine', *Water Alternatives*, 10(2), 233-249

CSIRO 2008, 'Water Availability in the Murray-Darling Basin, Executive Summary', *CSIRO*, https://publications.csiro.au/rpr/download?pid=legacy:530&dsid=DS1 , accessed 15 March 2017

Dale A 2015, 'Time for the green tape debate to mature: jobs and the environment are not implacable foes', *The Conversation*, 25August, http://theconverstioon.com/time-for-the-greeen-tape-debate-to-mature-jobs-and-the-environment-are-not-implacable-foes-46538, accessed 11 November 2015

Davidson Helen 2017, 'Irreversible consequences: Adani coalmine granted unlimited water access for 60 years', *The Guardian*, 05 April, https://theguardian.com/environment/2017/apr/05/irreversible-consequences-adani-coalmine-granted-unlimited-water-access-for-60-years ,accessed 11 September 2017

Davies Anne 2017, '$78m buyback of Darling water was nearly double its valuation', *The Guardian*, 26 October, *https://www.theguardian.com/australia-news/2017/oct/26/78m-spent-on-darling-water-buyback-nearly-double-its-valuation* , accessed 27 April 2018

Davies Anne 2018. 'Murray-Darling inquiry: former water chief moved on over crackdown plan, *The Guardian*, 19 July, https://www.theguardian.com/australia-news/2018/jul/18/murray-darling-inquiry-former-water-chief-moved-on-over-crackdown-plan, accessed 21 July 2018

Davies Paul A and Westgate R Andrew 2018, 'China Faces Serious Water Supply Problems', *Environment, Land and Resources*, June 6, https://www.globalelr.com/2018/06/china-faces-serious-water-supply-problems/ , accessed 20 February 2019

De Loë Rob, Varghese Jeji, Ferreyra Cecilia and Kreutzwiser Reid 2007, *Water Allocation and Water Security in Canada: Initiating a Policy Dialogue for the 21st Century*, University of Guelph, Ontario

Deloitte 2016, 'Environmental Protection Tax Law to take effect in 2018', 29 December, https://www.taxathand.com/article/5843/Environmental-Protection-Tax-Law-to-take-effect-in-2018 , accessed 02 January 2018

Deng Quanlun 2012, 'Floods Test Three Gorges Dam', 15 August, https://www.chinadialogue.net/article/5108-Floods-test-Three-Gorges-Dam , accessed 13 January 2018

Deng Tingting 2017, 'In China the water you drink is as dangerous as the air you breathe', *The Guardian*, 2 June, https://www.theguardian.com/global-development-professionals-network/2017/jun/02/china-water-dangerous-pollution-greenpeace , accessed 24 October 2017

Deng Fuliang, Lin Tao, Zhao Yue and Yuan Ying 2017, 'Zoning and Analysis of Control Units for Water Pollution Control in the Yangtze River Basin, China', Introductory Section, *Sustainability*, 9, 1374; doi:10.3390/su9081374

Department of Agriculture and Water Resources, Australia (DAWR) 2015, 'National Water Quality Management Strategy', http://agricuture.gov.au/water/quality/nwqms , accessed 13 June 2017

Department of Agriculture and Water Resources, Australia (DAWR) 2017, 'National Water Security Plans for Cities and Towns', https://www.agriculture.gov.au/water/urban/completed-programmes/national-water-security-plan, accessed 21 April 2018

Department of Agriculture and Water Resources, Australia (DAWR) 2018a, 'Cotton', http://www.agriculture.gov.au/ag-farm-food/crops/cotton , accessed 19 April 2018

Department of Agriculture and Water Resources, Australia (DAWR) 2018b, 'Rice', http://www.agriculture.gov.au/ag-farm-food/crops/rice , accessed 21 April 2018

Department of the Environment, Australia 2015, *Review of the National Water Planning Principles, Final Report*, May, Australian Government, Canberra

Department of Environment, Land, Water and Planning, Victoria (DELWP) 2016, 'Catchment Management Authorities', http://www.delwp.vic.gov.au/water/governing-water-resources/catchment-management-authorities , accessed 18 April 2017

Department of Industry, NSW (DOI) 2017, 'Water Security for Regions Program', https://www.industry.nsw.gov.au/water/water-utilities/infrastructure-programs/water-security-for-regions, accessed 02 August 2018

Department of Infrastructure, Regional Development and Cities, Australia (DIRDC) 2018a, 'National Water Infrastructure Development Fund', 20 April, https://infrastructure.gov.au/infrastructure/water-infrastructure/nwi-development-fund/ , accessed 25 April 2018

Department of Infrastructure, Regional Development and Cities, Australia (DIRDC) 2018b, 'Water Infrastructure Projects', 20 April, https://infrastructure.gov.au/infrastructure/water-infrastructure/nwi-development-fund/water-infrastructure-projects.aspx , accessed 25 April 2018

Department of Infrastructure, Regional Development and Cities, Australia (DIRDC) 2018c, 'National Water Infrastructure Loan facility', 20 April, https://infrastructure.gov.au/infrastructure/water-infrastructure/nwi-loan-facility/ , accessed 25 April 2018

Department of Natural Resources and Mines, Queensland (DNRM) 2017, 'The Planning Process', *DNRM*, http://www.dnrm.qld.gov.au/water/catchments-planning/planning-process , accessed 24 February 2017

Department of Primary Industries NSW (DPI) 2015, 'Recycled Water Management Systems', http://www.water.nsw.gov.au/__data/assets/pdf_file/0019/560530/RWMS-Guidelines_final.pdf , accessed 14 August 2018

Department of Primary Industries, NSW (DPI) 2016a 'Replacement, merged and new water sharing plans commenced 1 July 2016', *Office of Water*, http://www.water.nsw.gov.au/water-management/water-sharing , accessed 25 February 2017

Department of Primary Industries NSW (DPI) 2016b, 'Delivering Water Resource Plans for NSW: Roadmap 2016-2019', *DPI*, Sydney

Department of Water, Western Australia (DWWA) 2014, 'Water quality protection note 53: Dam construction and operation in rural areas', https://www.water.wa.gov.au/__data/assets/pdf_file/0008/4022/107820.pdf , accessed 07 April 2018

Dickey Lauren 2017, 'China's water footprint: an example for future policymakers', *China Dialogue*, 22 February, https://www.chinadialogue.net/article/show/single/en/9621-China-s-water-footprint-an-example-for-future-policymakers , accessed 29 January 2018

Dickson BJ 2003, 'Threats to Party Supremacy: China's Changing of the Guard', *Journal of Democracy*, Vol 14, No 1, 27-35

Dilley Luke, Shinzato Sae and Ando Mitsuyoshi 2017, 'Revitalising the Rural in Japan: Working through the Power of Place', *Electronic Journal of Contemporary Japanese Studies*, 17(3), 1-19

Dix Monika 2017, 'Water, Tradition and Innovation Flowing through Japan's Cultural Heritage, *Education About Asia*, 22(2), 48-51

Doolan Jane 2016, 'The Australian Water Reform Journey: an overview of three decades of policy, management and institutional transformation', *Australian Water Partnership*, Canberra

Downes Peter W, Gregory Kenneth J and Brookes Andrew 1991, 'How Integrated is River Basin Management', *Environmental Management*, 15(3), 299-309

E2Designlab 2017, 'Sponge Cities – China's Green-Blue Approach to Urban Water Management', 5 May, http://e2designlab.com.au/blog/i_2017-12-05-sponge-cities-chinas-green-blue-approach-to-urban-water-management, accessed 9 February 2018

Eakin Hallie and Luers Amy Lynd 2006, 'Assessing the Vulnerability of Social-Environmental Systems', *Annual Review of Environmental Resources*', 31, 365-394

Earthscan 2000, 'Dams and Development: A New Framework for Decision-Making', *Report of the World Commission on Dams*, Earthscan Publications Ltd, UK

Eldis 2007, 'Cost of pollution in China: economic estimates of physical damage', *World Bank*, http://www.eldis.org/document/A33800 , accessed 22 November 2018

Electric Power Research Institute 2010, 'Sustainable Water Resources Management', Volume 1: Executive Summary, Final Report, http://www.ndwrcdp.org/documents/DEC6SG06/Executive%20Summary.pdf , accessed 27 March 2018

Environmental Assessment Agency (EAA), Netherlands 2018, 'The Geography of Future Water Challenges', *PBL Netherlands*, https://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2018-the-geography-of-future-water-challenges-2920_2.pdf, accessed 21 June 2019

Environmental Defenders Office, Victoria (EDO) 2012, 'Legal Analysis of the Proposed Murray-Darling Basin Plan, *EDO*, https://envirojustice.org.au/downloads/files/law-reform/EDO_legal_analysis_of_draft_MD_Basin_Plan.pdf , accessed 14 March 2017

Environmental Defenders Office, Queensland (EDO) 2017, 'Adani Carmichael project receives water licences-what does this mean?' *EDO News Archive*, 31 March, http://www.edoqld.org.au/news/adani-project-receives-water-licence/ , accessed 14 September 2017

Environmental Law Australia 2017, 'Carmichael Coal Mine Cases in the Land Court and Supreme Court of Qld', http://envlaw.com.au/carmichael-coal-mine-case/ , accessed 14 September 2017

European Union (EU) SME 2013, 'The Water Sector in China', Report, http://www.eusmecentre.org.cn/report/water-sector-china , accessed 05 October 2016

Fan Linlin, Wang Hongrui, Lai Wenli and Wang Cheng 2015, 'Administration of water resources in Beijing: problems and countermeasures', *Water Policy* (Oxford), 17(4), 563-580

Farrelly Paul J, Golley Jane and Jaivin Linda 2019, 'Introduction: Powering Up' in Jane Golley, Linda Jaivin, Paul J Farrelly and Sharon Strange (Eds.), *China Story Yearbook: Power*, ANU Press, Canberra

Food and Agriculture Organization (FAO) 2018, 'FAO in China', http://www.fao.org/china/fao-in-china/china-at-a-glance/en/ , accessed 25 October 2018

Ford Emily 2013, '28,000 rivers wiped off the map of China', *The Times*, March 29, http://theaustralian.com.au/news/world/rivers-wiped-off-the-map-of-china/news-story/60d7b1ebcba2654469434bebebdd6ffa , accessed 13 November 2017

Freebairn John 2005, 'Principles and Issues for Effective Australian Water Markets', in Jeff Bennett (ed.), *The Evolution of Markets for Water: Theory and Practice in Australia*, Edward Elgar, Cheltenham, UK

Funabashi Yoichi 2019, 'Water: China's Achilles Heel', *The Japan Times*, 09 September, https://www.japantimes.co.jp/opinion/2019/09/09/commentary/japan-commentary/water-chinas-achilles-heel/#.XavU0OR7mM8, accessed 15 September 2019

Garrick Dustin and Hall Jim W 2014, 'Water Security and Society: Risks, Metrics and Pathways', *The Annual Review of Environment and Resources*, 39, 611-39

General Office of the State Council of China (GOSC) 2016, 'Opinions of the General Office of the State Council on Promoting the Comprehensive Reform of Agricultural Water Price', 29 January, http://www.gov.cn/zhengce/content/2016-01/29/content_5037340.htm , accessed 10 January 2018

GHD 2014, *Approaches to Achieve Sustainable Use and Management of Groundwater Resources in the Murray-Darling Basin Using Rules and Resource Condition Limits*, GHD, https://www.mdba.gov.au/sites/default/files/pubs/Approaches-to-achieve-sustainable-groundwater-management.PDF, accessed 10 July 2017

Gill Bates 2017, 'China's future under Xi Jinping: challenges ahead', *Political Science*, Routledge, doi.org/10.1080/00323187.2017.1313713

Gleick Peter H 2006, 'Water and terrorism', *Water Policy*, 8, 481-503

Global Development Research Center (GDRC) 2019, 'Local Governments in Japan', http://www.gdrc.org/uem/observatory/logov-japan.html, accessed 09 August 2019

Global Legal Insights 2020, Bribery and Corruption 2020, Japan', https://www.globallegalinsights.com/practice-areas/bribery-and-corruption-laws-and-regulations/japan, accessed 05 February 2020

Global Legal Monitor 2018, 'Japan: Water Supply Act Amended', *US Library of Congress*, 18 December, https://www.loc.gov/law/foreign-news/article/japan-water-supply-act-amended/, accessed 05 August 2019

Global Water Forum (GWF) 2018, 'China's water policy and the sharing of international rivers in Asia', Q & A, 21 March, http://www.globalwaterforum.org/2018/03/21/q-a-chinas-water-policy-and-the-sharing-of-international-rivers-in-asia/ , accessed 03 May 2018

Global Water Partnership (GWP) 2013, The Murray-Darling Basin Commission, Australia, Case #25, https://www.gwp.org/globalassets/global/toolbox/case-studies/australia-and-oceania/australia.-the-murray-darling-basin-commission-25.pdf, accessed 20 June 2018

Global Water Partnership (GWP) 2015, 'China's water resources management challenge: The three red lines', *GWP*, Elanders, Sweden

Goulburn-Broken Catchment Management Authority (GBCMA) 2016, *Annual Report 2015-16*, GCMA, https://www.gbcma.vic.gov.au/downloads/Annual_Report_2015_-_2016/GBCMA_Annual_Report_2015_-_2016.pdf , accessed 30 March 2017

Grafton R Quentin and Peterson Deborah 2007, 'Water Trading and Pricing', in Karen Hussey and Stephen Dovers (eds.), *Managing Water for Australia: The Social and Institutional Challenges*, Ch. 6, 73-84

Grafton R Quentin, Landry Clay, Libecap Gary D, and O'Brien Robert J 2009, 'Water Markets: Australia's Murray-Darling Basin and the US Southwest', https://www.accc.gov.au/system/files/The%20Problem%20of%20WaterAustUS%20-%20Gary%20Libecap%20%28paper%29.pdf , accessed 17 July 2017

Grafton R Quentin, Landry Clay, Libecap Gary D, McGlennon Sam and O'Brien Robert J 2010, 'An Integrated Assessment of Water Markets: Australia, Chile, China, South Africa and the USA', Working Paper 16203, *National Bureau of Economic Research*, Cambridge, MA, http://www.nber.org/papers/w16203 , accessed 1 February 2017

Grafton R Quentin and Williams John 2018, 'Failures to Deliver on the Key Objectives of the *Water Act 2007*', Submission to the Murray-Darling Basin Royal Commission, 19 April, https://www.mdbrc.sa.gov.au/sites/g/files/net3846/f/mdbrc-submission-quentin-grafton-john-williams-act.pdf?v=1525415723, accessed 05 November 2019

Grafton R Quentin and Williams John 2019, 'Rent-seeking behaviour and regulatory capture in the Murray-Darling Basin, Australia', *International Journal of Water Resources Development*, 24 October, doi:1080/07900627.2019.1674132

Grattan Michelle 2019: 'Dams are being built, but they are private: Australia Institute', *The Conservation*, 08 October, https://theconversation.com/dams-are-being-built-but-they-are-private-australia-institute-124807, accessed 17 October 2019

Greenpeace 2018, 'Glacial lake in western China bursts, annual average temperatures in area up 2 to 3°C since 1961', 15 August, http://www.greenpeace.org/eastasia/press/releases/climate-energy/2018/Glacial-lake-in-western-China-bursts-annual-average-temperatures-in-area-up-2-to-3-C-since-1961/ , accessed 28 November 2018

Greig Lorne A, Marmorek David R, Murray Carol and Robinson Donald C 2013, 'Insight into Enabling Adaptive Management', *Ecology and Society*, 18(3), 24

Grey D and Sadoff Claudia W 2007 'Sink or Swim? Water security for growth and development', *Water Policy* (Oxford), 9(6), 545-71

Gu Shuzhong, Jenkins Alan, Gao Shi-Ji *et al* 2017, 'Ensuring water resource security in China; the need for advances in evidence-based policy to support sustainable management', *Environmental Science and Policy*, 75, 65-69

Guo Sujian and Jiang Tianyu 2018, 'China's "New Normal": from Social Control to Social Governance', *Journal of Chinese Political Science*, 22, 327-340

Hafner-Cai Junwei 2014, ‘As China’s cities grow, so must water infrastructure’, *RobecoSAM*, 28 June, http://robecosam.com/en/sustainability-insights/library/foresight/2014/as-chinas-cities-grow-so-must-water-infrastructure.jsp , accessed 12 January 2018

Han Dongmei, Currell Matthew J and Co Guoliang 2016, ‘Deep Challenges for China’s War on Water Pollution’, *Environmental Pollution*, 218, 1222-1233

Hannam Peter 2017, ‘Stop greenies running the show: Joyce unloads on Four Corners water report’, *Sydney Morning Herald*, 27 July

Hannam Peter 2018, ‘Land clearing triples after law changes’, *Sydney Morning Herald*, 07 September

Hannam Peter 2020a, ‘Federal Court challenge to Adani’s plan to pump river water’, *Sydney Morning Herald*, 17 March

Hannam Peter 2020b, ‘NSW Closer to federal Murray-Darling fight’, *Sydney Morning Herald*, 01July

Hardin Garrett 1968, ‘The Tragedy of the Commons’, *Science*, 162 (3859), 1243-1248

Harrington Nikki and Cook Peter 2014, *Groundwater in Australia*, *National Centre for Groundwater Research and Training* (NCGRT), Adelaide

Harris Stephen, Bartel Robyn, Williams Jacqueline and Noble Louise 2018, ‘Introduction: Water Policy and the Anthropocene’, in Robyn Bartel, Louise Noble, Jacqueline Williams and Stephen Harris (eds.), *Water Policy, Imagination and Innovation: Interdisciplinary Approaches*, Routledge, New York, 1-21

Hartsuyker Luke 2017, ‘Groundwater experts gather in Sydney’, *Australian Government Media Release*, 11 July, http://minister.agriculture.gov.au/hartsuyker/Pages/Media-Releases/groundwater-sydney.aspx , accessed 28 August 2017

Hasselman Lyndal and Stoker Gerry 2017, ‘Market-based governance and water management: the limits to economic rationalism in public policy’, *Policy Studies*, 38(5), 502-517

Hayes Louis D 2017, *Introduction to Japanese Politics*, 6th edn, Routledge, New York

Hays Jeffrey 2012, 'Politics in Japan: Bureaucrats, iron triangles, public works and reforms begun in 2009', http://factsanddetails.com/japan/cat22/sub146/item803.html, accessed 23 August 2019

Hays Jeffrey 2013, 'Local Government in Japan; Facts and Details', http://factsanddetails.com/japan/cat22/sub146/item2786.html, accessed 14 September 2019

Hays Jeffrey 2014, 'Water Shortages in China: Facts and Details', http://factsanddetails.com/china/cat10/sub66/item390.html#, accessed 11 November 2017

Herczeg Andrew 2011, 'Groundwater', in Ian Prosser (ed.), *Water: Science and Solutions for Australia*, CSIRO Publishing, Melbourne

Herington Jonathon 2012, 'The Concept of Security' in Michael Selgelid and Christian Enemark (eds.), *Ethical and Security Aspects of Infectious Disease Control: Intradisciplinary Perspectives*, Ashgate, Burlington, USA

Hollingsworth Julia 2016, 'The firms being tipped to tap into China's quest for cleaner water', *South China Morning Post*, 02 August, http://www.scmp.com/business/companies/article/1998224/firms-being-tipped-tap-chinas-quest-cleaner-water , accessed 03 October 2017

Holz Michael 2017, 'China spent $100 billion on reforestation. So why does it have green deserts?', *The Christian Science Monitor*, June 28

Hooper Bruce P 2003, 'Integrated Water Resources Management and River Basin Governance', *Universities Council on Water Resources*, Water Resources Update, 126, 12-20

Hori Sayaka 2016, 'The Structure of Local Groundwater Law for Sustainable Groundwater Policy in Japan', *Laws* (MDPI), 5, 19; doi:10.3390/laws5020019

Horne James 2017, 'A low-water mark for the Murray-Darling Basin: Political commitment to the Basin Plan is long overdue', *Policy Forum*, 15 December, https://www.policyforum.net/low-water-mark-murray-darling-basin/, accessed 06 November 2019

Hosono Sukehiro 2015, 'Beyond a formal approach? Seeking adequate policy analysis in Japan', in Yukio Adachi, Sukihiro Hosono and Jun Iio (eds.) 2015, *Policy Analysis in Japan*, Pluto Press, Bristol, 91-102

Hu Feng 2018, '8 Key Challenges in Rural Water Security', *China Water Risk*, 16 July,

Huang Qidong and Xu Jiajun 2017, 'Scales of Power in Governance in China: Examples from the Yangtze River Basin', *Society and Natural Resources*, 30(4), 421-435

Huitema Dave and Meijerink Sander 2017, 'The politics of river basin organizations: institutional design choices, coalitions and consequences', *Ecology and Society*, 22(2), 42, https://doi.org/10.5751/ES-09409-220242

Hussey Karen, Pittock Jamie and Dovers Stephen 2015, 'Justifying, extending and applying "nexus" thinking in the quest for sustainable development', in Jamie Pittock, Karen Hussey and Stephen Dovers (eds.), *Climate, Energy and Water: Managing trade-offs, seizing opportunities*, 1-5, Cambridge University Press, Cambridge

Infrastructure Australia 2019, *Australian Infrastructure Audit 2019*, https://www.infrastructureaustralia.gov.au/sites/default/files/2019-08/Australian%20Infrastructure%20Audit%202019.pdf, accessed 09 June 2020

Intergovernmental Agreement on a National Water Initiative (IGANWI) 2004, 'Intergovernmental Agreement on a National Water Initiative', http://www.pc.gov.au/inquiries/current/water-reform/national-water-intergovernmental-agreement.pdf , accessed 15 March 2017

Iio Jun 2015a, 'Historical background of policy analysis in Japan' in Yukio Adachi, Sukehiro Hosono and Jun Iio (eds.) 2015, *Policy Analysis in Japan*, Pluto Press, Bristol, 15-26

Iio Jun 2015b, 'Policy analysis and the policy process in Japanese Government' in Yukio Adachi, Sukehiro Hosono and Jun Iio (eds.) 2015, *Policy Analysis in Japan*, Pluto Press, Bristol, 91-102

Iinuma Sayoko 2013a, '4-1 Japan: A Forest Rich Nation Buying Up Global Timber' in 'Nature and Our Future: The Mekong Basin and Japan', *Mekong Watch*, http://www.mekongwatch.org/platform/bp/english.pdf, accessed 22 March 2019

Iinuma Sayoko 2013b, '4-2 Removal of the Arase Dam: Japan's First Attempt to Dismantle a hydroelectric Dam and Restore the Original River Environment' in 'Nature and Our Future: The Mekong Basin and Japan', *Mekong Watch*, http://www.mekongwatch.org/platform/bp/english.pdf, accessed 22 March 2019 iMINCO 2015, '5 Galilee Basin coal mines now approved', http://iminco.net/5-queensland-galilee-basin-coal-mines-now-approved/ accessed 27 April 2019

Infrastructure Australia 2019, 'An Assessment of Australia's Future Infrastructure Needs: The Australian Infrastructure Audit 2019, *Infrastructure Australia*, Canberra

International Centre for Research in Agroforestry (ICRAF) 2017, 'New look at satellite data questions scale of China's afforestation success', 3 May, https://phys.org/news/2017-05-satellite-scale-china-afforestation-success.html , accessed 26 May 2018

Intergovernmental Panel on Climate Change (IPCC) 2014, 'Climate Change 2014: Impacts, Adaptation and Vulnerability', Working Group II Report, Chapter 24, http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap24_FINAL.pdf , accessed 28 November 2018

International Rivers 2009, 'China's Three Gorges Dam: A Model of the Past', https://www.internationalrivers.org/sites/files/attached-files/threegorgesfactsheeet.pdf , accessed 22 January 2018

International Rivers 2014, 'True Cost of Hydropower in China', https://www.internationalrivers.org/resources/true-cost-of-hydropower-in-china-8445 , accessed 24 January 2018

International Rivers 2016, 'China', https://www.internationalrivers.org/programs/china , accessed 12 January 2018

International Water Centre 2020, 'Integrated Water Governance', Griffith University, Queensland, https://watercentre.org/study/information-for/integrated-water-governance/, accessed 05 January 2020

Ito Masafumi 2012, 'Urban River Management in Japan', http://www.a-rr.net/report/docs/9thARRNpresen2.pdf, accessed 21 March 2019

Japan Commission on Large Dams (JCOLD) 2009, *Dams in Japan: Past, Present and Future*, CRC Press, Netherlands

Japan Commission on Large Dams (JCOLD) 2015, 'Dams in Japan Overview 2015', http://jcold.or.jp/cm/wp-content/uploads/2018/03/Dams-in-Japan-overview-2015.pdf , accessed 04 October 2018

Japan for Sustainability (JFS) 2014a, 'Water Infrastructure in Japan: Toward an Age of Maintenance and Demolition', 10 August, https://www.japanfs.org/en/news/archives/news_id035008.html, accessed 14 September 2019

Japan for Sustainability (JFS) 2014b, 'Let's Use Rainwater! Recent Trends in Rainwater Use in Japan', 24 April, https://www.japanfs.org/en/news/archives/news_id035023.html, accessed 19 August 2019

Japan for Sustainability (JFS) 2015, 'Cabinet of Japan Decide to Make Full Use of Rainwater in Newly Constructed Buildings', 25 May, https://www.japanfs.org/en/news/archives/news_id035257.html, accessed 19 August 2019

Japanese Government (JG) 1958, *Sewerage Act*, http://www.japaneselawtranslation.go.jp/law/detail_main?re=01&vm=02&id=2810, accessed 09 October 2018

Japanese Government 1972, *Japan Sewerage Works Agency Act*, 29 May, http://extwprlegs1.fao.org/docs/pdf/jap158028.pdf , accessed 09 October 2018

Japanese Government 1997, *Disaster Countermeasures Basic Act*, June, http://www.adrc.asia/documents/law/DisasterCountermeasuresBasicAct.pdf , accessed 12 October 2018

Japanese Government 2003, 'Overview of the Law for the Promotion of Nature Restoration', https://www.env.go.jp/en/nature/npr/nrp_japan/pdf/50_overview.pdf, accessed 21 April 2019

Japanese Government 2015, 'Cybersecurity Strategy', https://www.nisc.go.jp/eng/pdf/cs-strategy-en.pdf, accessed 08 June 2020

Japanese Government 2017, 'Japan's Voluntary National Review: Report on the Implementation of the Sustainable Development Goals', *SDGs Promotion Headquarters*, https://sustainabledevelopment.un.org/content/documents/16445Japan.pdf, accessed 07 October 2019

Japanese Government 2018a, 'The Basic Environment Plan', April (officially translated October), https://www.env.go.jp/en/policy/plan/5th_basic/plan.pdf, accessed 14 March 2019

Japanese Government 2018b, 'Climate Change Adaptation Act', https://www.env.go.jp/en/earth/cc/adaptation/mat01.pdf, accessed 08 February 2020

Japanese Government 2020 'Abenomics: For future growth, for future generations and for a future Japan', https://www.japan.go.jp/abenomics/business/, accessed 12 January 2020

Japan International Cooperation Agency (JICA) 2017a, 'JICA's Cooperation Strategy for Water Resources Sector - Water Supply, Sanitation and Water Resources Management', https://www.jica.go.jp/activities/issues/water/ku57pq00000w99g4-att/position_paper_e.pdf , accessed 03 October, 2018

Japan International Cooperation Agency (JICA) 2017b, 'Japan's Experiences on Water Supply Development', https://www.jica.go.jp/english/our_work/thematic_issues/water/c8h0vm0000ammj2q-att/activity_01.pdf , accessed 18 October 2018

Japan Sewage Works Association (JSWA) 2014, 'Essence of Japanese Sewerage Law', http://www.jswa.jp/en/jswa-en/pdf/Essence%20of%20Japanese%20Sewerage%20Law.pdf , accessed 08 October 2018

Japan Today 2015, 'Construction of controversial Yamba dam resumes', 23 January, https://japantoday.com/category/national/construction-of-controversial-yamba-dam-resumes, accessed 04 April 2019

Japan Water Agency 2016, 'An Affluent Society Supported by Water: Outline of Japan Water Agency', http://www.narbo.jp/data/03_mi/materials/2016_Out_line_of_Japan_Water_Agency.pdf, accessed 31 October 2019

Japan Water Research Center (JWRC) 2014, 'Analysis of Performance Indicators (PI) for the Management and Assessment of Drinking Water Services in F.Y.2013', http://www.jwrc-net.or.jp/english/data/2013/pi-e13.pdf , 03 October 2018

Japan Water Works Association (JWWA) 2016, 'Water Supply in Japan 2016', http://www.jwwa.or.jp/jigyou/kaigai_file/2016WaterSupplyInJapan.pdf , accessed 09 October 2018

Japan Water Works Association (JWWA) 2017, 'Case Study 1: Collaboration among Water Utilities', http://gwweb.jica.go.jp/km/FSubject0301.nsf/VWPrint/58841DBF2F9A88D94925810C00270B4C/$FILE/18_C1_EN.pdf , accessed 04 October 2018

Jiang Min 2017, *Towards Tradable Water Rights: Water Law and Policy Reform in China*, Global Issues in Water Policy No 18, Springer, New York

Jiang Min, Webber Michael, Barnett Jon, Rogers Sarah, Rutherfurd Ian, Wang Mark and Finlayson Brian 2020, 'Beyond contradiction: The state and the market in contemporary Chinese water governance', *Geoforum*, 108, 246-254

Jiang Yi, Renz Adrian T Calub and Zheng Xiaoting 2019, 'Water Tariff Setting and its Welfare Implications: Evidence from Cities in the People's Republic of China', https://www.adb.org/sites/default/files/publication/502196/ewp-580-water-tariff-setting-peoples-republic-china.pdf , accessed 14 January 2021

Jiang Yong 2015, 'China's water security: Current status, emerging challenges and future prospects', *Environmental Science and Policy*, 54, 106-125

Jovanović Miloš, Sweijs Tim, Chmutina Ksenia, Vietti Francesca, Tibaldeo Roberto, Burbiel Joachim, Bosher Lee and Dainty Andrew 2016, 'Non-traditional Transnational Security Challenges in Serbian, British and Dutch Security Discourses: A Cross Country Comparison', in Anthony Masys (ed.), Exploring the Security Landscape: Non-traditional Challenges, Springer Publishing, New York

Global Water Partnership (GWP) 2013, 'Tsurumi River Basin Water Master Plan, Japan (#302)', https://www.gwp.org/en/learn/KNOWLEDGE_RESOURCES/Case_Studies/Asia/151Japan-Tsurumi-River-Basin-Water-Master-Plan-302/, accessed 12 April 2019

Kagawa-Fox Midori 2010, 'The Ethics of Japan's Global Environmental Policy', PhD Thesis, University of Adelaide, https://digital.library.adelaide.edu.au/dspace/bitstream/2440/77316/8/02whole.pdf, accessed 16 March 2019

Kelly Dave 2017, 'WA supercomputer employed in water response to climate change', *WA Government Media Release*, 16 August, https://www.mediastatements.wa.gov.au/Pages/McGowan/2017/08/WA-supercomputer-employed-in-water-response-to-climate-change.aspx , accessed 31 August 2017

Kiguchi Yuka 2013, ‘The Past, Present and Future of Japan’s River Development’ in ‘Nature and Our Future: The Mekong Basin and Japan, Section 4-3’, *Mekong Watch*, http://www.mekongwatch.org/platform/bp/english.pdf, accessed 22 March 2019

Kitamura Tadashi 2012, ‘Water Environment Management in Japan’, http://www.env.go.jp/en/focus/docs/files/20120801-50.pdf, accessed 22 March 2019

Klinken Andreas and Renn Ortwin 2002, ‘A New Approach to Risk Evaluation and Management: Risk-Based, Precaution-Based and Discourse-Based Strategies’, *Risk Analysis*, 22(6), 1071-1093

Knowles Adelaide 2016, ‘Managing Water Pollution in China with Social Media’, *Future Directions International*, http://www.futuredirections.org.au/publication/managing-water-pollution-china-social-media/ , accessed 03 October 2017

Koyasu Ryoji 2013, ‘Irrigation Water Management by a Land Improvement District’, https://www.jst.go.jp/kisoken/crest/en/areah21/4-06.html, accessed 18 August 2019

KPMG 2011, ‘Evaluation of the National Water Quality Management Strategy’, *Department of Sustainability, Environment, Water, Population and Communities*, December, Canberra

KPMG 2016, ‘The 13th Five-Year Plan – China’s transformation and integration with the world economy: Opportunities for Chinese and foreign businesses’, October, https://assets.kpmg.com/content/dam/kpmg/cn/pdf/en/2016/10/13fyp-opportunities-analysis-for-chinese-and-foreign-businesses.pdf , accessed 04 November 2017

Krien Anna 2017, ‘the Long Goodbye: Coal, Coral and Australia’s Climate Deadlock’, *Quarterly Essay*, No 66, 1-116

Kuhn Berthold M 2018, ‘China’s Commitment to the Sustainable Development Goals: An Analysis of Push and Pull Factors and Implementation Challenges’, *Chinese Political Science Review*, 3(4), 359-388

Kurmelovs Royce 2015, ‘Desalination plants key to Perth water security’, July, http://www.aljazeera.com/indepth/features/2015/07/desalination-plants-key-perth-water-security-150705074410141.html , accessed 27 July 2017

Land and Water Australia 2009, ‘National River Health Programme’, http://lwa.gov.au/programs/national-river-health-program, accessed 05 September 2018

Land and Water Australia 2010, 'Farm Dam Management', 09 March, http://lwa.gov.au/node/2640 , accessed 06 April 2018

Lansbury Hall Nina, Shannon Cindy and Jagais Paul 2016, 'It's a fallacy that all Australians have access to clean water, sanitation and hygiene', *The Conversation*, https://theconversation.com/its-a-fallacy-that-all-australians-have-access-to-clean-water-sanitation-and-hygiene-61436 , accessed 26 April 2018

Larsen Joshua, Gibbes Badin and Quiggin John 2014, 'Dam hard: water storage is a historic headache for Australia', *The Conservation*, https://www.google.com.au/search?source=hp&ei=hrXeWsuNA8PD0gSMpL3ABA&q=dam+hard+water+storage+is+a+historic+headache+for+australia&oq=dam+hard+water+storage&gs_l=psy-ab.1.0.0i22i30k1.1563.10346.0.12856.27.22.2.2.2.0.559.4691.2-9j3j1j2.15.0....0...1c.1.64.psy-ab..9.16.3772.0..0j46j35i39k1j0i131k1j0i46k1j0i10k1j0i22i10i30k1j33i22i29i30k1.0.yKuMYtuDq24 , accessed 05 April 2018

Lauber Sabina 1993, 'Japan and International Environmental Law – Economy over Environment', *Japanese Studies Bulletin*, 13(3), 37-54

Lee Sang-Min, Byun Hi-Ryong and Tanaka Hiroshi L 2012, 'Spatiotemporal Characteristics of Drought Occurrences over Japan', *Journal of Applied Meteorology and Climatology*, 51, 1087- 1098

Lehane Sinéad 2014, 'Australia's Water Security Part 1: Water Resources', *Future Directions International*, 16 September, http://www.futuredirections.org.au/publication/australia-s-water-security-part-1-water-resources/ , accessed 18 December 2016

Li Weizhen 2015, 'Progresses of China's Water Action Plan at Putting China's Water Pollution Action Plan into Action', *Woodrow Wilson Center*, 17 November, https://wilsoncenter.org/putting-chinas-water-pollution-action-plan-action , accessed 26 September 2017

Li Xiaolin, Zhang Xiaotao, Niu Jun, Tong Ling, Kang Shaozhong, Du Taisheng, Li Sien and Ding Risheng 2016, 'Irrigation water productivity is more influenced by agronomic practice factors than by climatic factors in Hexi Corridor, Northwest China,', *Scientific Reports*, 6, Article No 37971, http://www.nature.com/articles/srep37971 , accessed 10 January 2018

Li Zhifei and Wu Fengshi 2016, 'China's Shared Water Resources: Geopolitics, Domestic Institutions and Global Governance', later incorporated into Fengshi Wu and Hongzhou Zhang (eds.) *China's Global Quest for Resources: Energy, Food and Water*, Routledge, New York, https://www.researchgate.net/publication/315717308_China%27s_Global_Quest_for_Resources_Notes_for_Policy_Advocates , accessed 01 May 2018

Liao Yongsong, Gao Zhanyi, Bao Ziyun, Huang Qingwen, Feng Guangzhi, Xu Di, Cai Jiabin, Han Huijing and Wu Weifeng 2017, 'China's Water Pricing Reforms for Irrigation: Effectiveness and Impact', Comprehensive Assessment of Water Management in Agriculture Discussion Paper 6, *International Water Management Institute*, Colombo, http://ageconsearch.umn.edu/bitstream/91872/2/CADiscussionPaper6'pdf , accessed 02 November 2017

Lin George S 2017, 'Water, technology, society and the environment: interpreting the technopolitics of China's South-North Water Transfer Project', *Regional Studies*, 51(3), 383-388

Littleproud David 2019, 'Federal Government responds to independent report into fish deaths', Media Release 10 April, http://minister.agriculture.gov.au/littleproud/Pages/Media-Releases/vertessy-report.aspx, accessed 10 April 2019

Liverpool Plains Shire Council 2018, 'Regional Water Supply Strategy', https://www.lgnsw.org.au/files/imce-uploads/48/4.Rod_Batterham_Mark_Gebhard.pdf , accessed 02 August 2018

Loucks Daniel P 2000, 'Sustainable Water Resources Management', *Water International*, 25 (1), 3-10

Loussikian Kylar 2019, 'Minister attacks river experts', *Sydney Morning Herald*, 26 August

Lu Yihe, Fu Xiaoming, Zeng Yuan, Liu Yu, Chang Ruiying, Sun Ge and Wu Bingfang 2012, 'A Policy-Driven Large Scale Ecological Restoration: Quantifying Ecosystem Services Changes in the Loess Plateau of China, *PLoS ONE*, 7(2), e31782

Lowy Institute 2020, 'Lowy Institute Poll 2020', https://poll.lowyinstitute.org/report/, accessed 06 July 2020

Lum Stephanie 2009, *Sydney's Desalination Plant: Lessons for critical infrastructure under the NSW Environmental Planning and Assessment Act 1979,* https://www.be.unsw.edu.au/sites/default/files/upload/pdf/schools-and-engagement/resources/_notes/5A3_32.pdf , accessed 11 July 2017

Lynham 2017, 'Carmichael licences safeguard water', 06 April, http://statements.qld.gov.au/Statement/2017/4/6/carmichael-licences-safeguard-water , accessed 14 September 2017

Ma Anthony 2017, 'Toward Better Industrial Water Management', 17 August, *China Water Risk*, http://chinawaterrisk.org/interviews/toward-better-industrial-water-management/ , accessed 28 September 2017

McCormack Gavan 2001, 'Water Margins: Competing Paradigms in China', *Critical Asian Studies*, 33(1), 5-30

McCormack Michael 2019, 'National Water Grid Authority for the future', Press Release, 14 September, https://minister.infrastructure.gov.au/mccormack/media-release/national-water-grid-authority-future, accessed 20 September 2019

McCormick Bill 2007, 'The National Plan for Water Security', *Parliament of Australia*, http://www.aph.gov.au/About_Parliament/Parliamentary/Parliament_Departments/Parliamentary_Library/pubs/rp/BudgetReview_2007-_2008/Nationnal_Plan-for_Water_Security , accessed 16 March 2017

McCormick Bill 2013a, 'Murray-Darling Basin Management', *Parliament of Australia*, http://www.aph.gov.au/About_Parliament/Parliamentary/Parliament_Departments/Parliamentary_Library/pubs/BriefingBook44p/MurrayDarlingBasin , accessed 25 April 2017

McCormick Bill 2013b,'Water', *Commonwealth Budget Review 2013-14*, 81-83, Australian Government, Canberra

McGregor Richard 2019, 'Pulling the strings Xi steps up control', *Australian Financial Review*, Review Section, 12 July, 1-7

Mckenzie Michael 2009, 'Water Rights in NSW: Properly Property?' *Sydney Law Review* 17; 31(3); Sydney Law Review 443

Makarewicz Alicja 2017, 'Seven things you didn't know about farm dams', OzeWEX, October 10, www.ozewex.org/seven-things-you-didn't-know-about-farm-dams , accessed 05 April 2018

Maiolo Mario and Pantusa Daniela 2018, 'Infrastructure Vulnerability Index of drinking water systems to terrorist attacks', doi.org/10.1080/23311916.2018.1456710

Marques RC, Berg SV and Yane S 2011, 'Performance Benchmarking Analysis of Japanese Water Utilities', https://pdfs.semanticscholar.org/c90d/804f8f84e28a875649d4ada571b8b4ca4bec.pdf, accessed 11 October 2019

Marshall Graham R and Alexandra Jason 2016, 'Institutional Path Dependence and Environmental Recovery in Australia's Murray-Darling Basin', *Water Alternatives*, 9(3), 679-703

Marslen Tess 2014, 'Are China's Plans to Tackle Water Pollution Sufficient?' *Future Directions International*, http://www.futuredirections.org.au/publications/are-china-s-plans-to-tackle-water-pollution-sufficient/ , accessed 03 October 2017

Mathevet Raphaël, Bousquet François and Raymond Christopher M 2018, 'The concept of stewardship in sustainability science and conservation biology, *Biological Conservation*, 217, 363-370

Matsui Nozomi 2017, 'Management by Basic Policy and Planning: Case Study of Comprehensive Strategy and Comprehensive Plan', *Japanese Journal of Public Policy Studies*, 17, 40-51

Matthews Ken 2015, 'Water reform needs to be back on the national agenda', *ATSE Focus*, April, 3-4

Matthews Ken 2017, *Independent Investigation into NSW Water Management and Compliance, Interim Report*, 8 September, NSW Government, Sydney

Maywald Karlene 2015, 'Water in regional Australia: who's holding the baby?' *ATSE Focus*, April, 5-7

Mekong Research Group 2012, 'Catchment Management Frameworks and Issues of Scale', Working Paper #2, *Sydney University*, http://sydney.edu.au/mekong/documents/completed_projects/water_governance_in_context-wp2.pdf , accessed 06 February 2017

Mekong River Commission 2018, 'About MRC', http://www.mrcmekong.org/about-mrc/ , accessed 03 May 2018

Miao Xin, Tang Yanhong, Wong Christina WY and Zang Hongyu 2015, 'The latent causal chain of industrial water pollution in China', *Environmental Pollution*, 196, 473-477

Minerals Council of Australia (MCA) 2014, 'Water Accounting Framework for the Australian Minerals Industry', http://www.minerals.org.au/leading_practices/water_accounting_framework_for_australian_minerals_industry , accessed 13 September 2017

Minerals Council of Australia (MCA) 2017, 'Safeguarding the environment', http://www.minerals.org.au/resources/coal/safeguarding_the_environment , accessed 13 September 2017

Ministry of Ecology and Environment, China (MEE) 2018, '2017 Report on the State of the Ecology and Environment in China', http://www.greengrowthknowledge.org/sites/default/files/downloads/policy-database/CHINA%29%202017%20Report%20on%20the%20Ecology%20and%20the%20Environment%20in%20China.pdf, accessed 23 March 2019

Ministry of Environment, Japan (MOE) 2005, 'Environmental Impact Assessment in Japan', http://www.env.go.jp/en/policy/assess/pamph.pdf, accessed 03 October 2018

Ministry of Environment, Japan (MOE) 2014a, 'Environmental quality standards for water pollution', https://www.env.go.jp/en/water/wq/wp.pdf , accessed 11 October 2018

Ministry of Environment, Japan (MOE) 2014b, 'Establishment of Environmental Quality Standards for Groundwater Pollution', https://www.env.go.jp/en/water/gw/gwp.html , accessed 11 October 2018

Ministry of Environment, Japan (MOE) 2018a, 'Outline of the Fifth Basic Environment Plan', https://www.env.go.jp/policy/kihon_keikaku/plan/plan_5/attach/ref_en-02.pdf, accessed 14 March 2019

Ministry of Environment, Japan (MOE) 2018b, 'Environmental Impact Assessment in Japan', http://dcm06.gis.survey.ne.jp/files/1_seido/panph_e.pdf, accessed 04 October 2019

Ministry of Environment, Japan (MOE) 2019, 'The Basic Environment Law – Outline', https://www.env.go.jp/en/laws/policy/basic/leaflet2.html, accessed 03 March 2019

Ministry of Environmental Protection of China (MEP) 2017, 'The Water Pollution Prevention and Control Plan for Major River Basins (2016-2020)', http://english.mep.gov.cn/News_service/news_release/2017/10/t20171027_424220.shml , accessed 16 November 2017

Ministry of Foreign Affairs, China (MFR) 2016, 'China's National Plan on Implementation of the 2030 Agenda for Sustainable Development', https://www.fmprc.gov.cn/mfa_eng/zxxx_662805/W020161014332600482185.pdf, accessed 07 October 2019

Ministry of Health, Labour and Welfare, Japan (MHLW) 2013, 'Water Supply in Japan', Part 4, Water Quality, https://www.mhlw.go.jp/english/policy/health/water_supply/4.html , accessed 10 October 2018

Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) 1998, 'The 5th Comprehensive National Development Plan: Grand Design for the 21st Century', http://www.mlit.go.jp/kokudokeikaku/zs5-e/, accessed 09 March 2019

Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) 2008a, 'Organization and Legislation related to Water Resources Policy', http://www.mlit.go.jp/tochimizushigen/mizsei/water_resources/contents/policy.html, accessed 02 October 2018

Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) 2008b, 'Current State of Water Resources in Japan', http://www.mlit.go.jp/tochimizushigen/mizsei/water_resources/contents/current_state.html, accessed 02 October 2018

Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) 2008c, 'Issues on Water Resources', http://www.mlit.go.jp/tochimizushigen/mizsei/water_resources/contents/long-term_plans.html, accessed 02 October 2018

Ministry of Land, Infrastructure, Transport and Tourism (MLIT) 2008d,' Long-term Plans for Water Resources', http://www.mlit.go.jp/tochimizushigen/mizsei/water_resources/contents/long-term_plans.html, accessed 02 October 2018

Ministry of Land, Infrastructure, Transport and Tourism (MLIT) 2008e, 'Responding Properly to Issues on Water Resources', http://www.mlit.go.jp/tochimizushigen/mizsei/water_resources/contents/responding_properly.html#02, accessed 02 October 2018

Ministry of Land, Infrastructure, Transport and Tourism (MLIT) 2008f, 'Achieving Water Security in Japan and Worldwide', http://www.mlit.go.jp/tochimizushigen/mizsei/water_resources/contents/Achieving%20Water%20Security%20in%20Japan%20and%20Worldwide.pdf, accessed 21 September 2019

Ministry of Land, Infrastructure, Transport and Tourism (MLIT) 2008g, 'Climate Change Adaptation Strategies to Cope with Water-related Disasters due to Global Warming (Policy Report), https://www.mlit.go.jp/river/basic_info/english/climate.html, accessed 23 September 2019

Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) 2011, 'Japan's experience and technology regarding Water Resources Management', https://www.mlit.go.jp/common/001040490.pdf, accessed 26 September 2019

Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) 2012, 'Water and Disaster Management Bureau', http://210.248.150.32/en/mizukokudo/index.html, accessed 26 October 2019

Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) 2014, 'Water in Japan', http://www.mlit.go.jp/common/001044443.pdf, accessed 19 August 2019

Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) 2015, 'National Spatial Strategy Plan (National Plan)', http://www.mlit.go.jp/common/001127196.pdf, accessed 08 March 2019

Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) 2017, 'White Paper on Land, Infrastructure, Transport and Tourism in Japan 2017', http://www.mlit.go.jp/common/001269888.pdf, 08 March 2019

Ministry of Water Resources of China (MWR) 2016, 'Briefings on the Opinions of the State Council on Implementing the Strictest Water Resources Management', 17 February, http://www.china.org.cn/china/2012-02/17/content_24664350.htm , accessed 17 January 2018

Ministry of Water Resources of China (MWR) 2017, 'Press conference was held by Ministry of Water Resources on the assessment implementation of the most stringent water resources management system', 17 November, http://www.cjw.gov.en?English/CWRCNews/30306.html , accessed 07 January 2018

Miskelly Greg 2017, 'Drinking water repeatedly contaminated with pathogens in rural NSW towns', 6 September, https://www.abc.net.au/news/2017-09-06/drinking-water-contaminated-with-pathogens-in-nsw-towns/8875464, accessed 22 June 2018

Mogi Aiichiro 2011, 'The evolution of reservoir irrigation systems as commons in the dry climate region of contemporary Japan', https://www.researchgate.net/publication/49467148_The_Evolution_of_Reservoir_Irrigation_Systems_as_Commons_in_the_Dry_Climate_Region_of_Contemporary_Japan, accessed 17 September 2019

Mollinga Peter P 2008, 'Water, Politics and Development: Framing a Political Sociology of Water Resources Management', *Water Alternatives*, Vol 1(1), 7-23

Moore Scott 2014, 'Water Markets in China: Challenges, opportunities and constraints in the development of market-based mechanisms for water resource allocation in the People's Republic of China,' *Harvard Kennedy School Belfer Center*, Discussion Paper #2014-09, http://www.belfercenter.org/sites/default/files/legacy/files/Water%20Markets%20China%20Moore%20Belfer%20DP%202014.pdf , accessed 29 October 2017

Morelli John 2011, ‘Environmental Sustainability: A Definition for Environmental Professionals’, Environmental Manager, September, 19-27

Moriyama Hayato 2019, ‘Amakuradi (Japan)’, 26 July, http://www.in-formality.com/wiki/index.php?title=Amakudari_(Japan), accessed 12 September 2019

Morrison Scott 2020, ‘Address’, *CEDA’s State of the Nation Conference*, 15 June, https://www.pm.gov.au/media/address-%E2%80%93-ceda%E2%80%99s-state-nation-conference, accessed 18 June 2020

Mugishima Takeshi 2017: ‘National Level Strategy for Infrastructure Development in Japan’, http://pubdocs.worldbank.org/en/123701486602287702/20170209-National-Level-Strategy-for-Infrastructure-Development-in-Japan.pdf, accessed 08 March 2019

Murray-Darling Basin Authority (MDBA) 2013, ‘Handbook for Practitioners: Water resource plan requirements’, October, *MDBA*, https://www.mdba.gov.au/sites/default/files/pubs/WRP-Handbook-for-Practitioners_0.pdf , accessed 22 June 2018

Murray-Darling Basin Authority (MDBA) 2017a, ‘Environment’, *MDBA*, http://www.mdba.gov.au/discover-basin/environment , accessed 17 March 2017

Murray-Darling Basin Authority (MDBA) 2017b, ‘Climate variability’, *MDBA*, http://www.mdba.gov.au/basin-plan-roll-out/climate-change , accessed 17 March 2017

Murray Darling Basin Authority (MDBA) 2017c, ‘Running the River Murray’, *MDBA*, http://www.mdba.gov.au/river-information/running-river-murray , accessed 17 March 2017

Murray-Darling Basin Authority (MDBA) 2017d, ‘Groundwater Reviews and Amendments’, *MDBA*, http://www.mdba.gov.au/basin-plan-roll-out/groundwater-reviews-amendments , accessed 17 July 2017

Murray-Darling Basin Authority (MDBA) 2017e, ‘Approach to monitoring and compliance; Water resource plans’, *MDBA*, https://www.mdba.gov.au/sites/default/files/pubs/Water-resource-plan-regulatory-approach-statement_0.pdf , accessed 22 June 2018

Murray-Darling Basin Authority (MDBA) 2018a , *Murray-Darling Basin Authority Annual Report 2016-17*, MDBA, https://www.mdba.gov.au/sites/default/files/pubs/MDBA_Annual_Report_2016-17-1.pdf , accessed 14 June 2018

Murray-Darling Basin Authority (MDBA) 2018b, 'Basin-wide compliance and enforcement', *MDBA*, https://www.mdba.gov.au/basin-plan-roll-out/basin-wide-compliance-enforcement , accessed 14 June 2018

Murray-Darling Basin Authority (MDBA) 2018c, 'Climate variability and change', *MDBA*, https://www.mdba.gov.au/basin-plan-roll-out/climate-change , accessed 15 June 2018

Murray-Darling Basin Authority (MDBA) 2018d, 'Critical human water needs', *MDBA*, https://www.mdba.gov.au/river-information/water-sharing/critical-human-water-needs, accessed 15 June 2018

Murray-Darling Basin Authority (MDBA) 2018e, 'Salinity', *MDBA*, https://www.mdba.gov.au/managing-water/salinity , accessed 17 June 2018

Murray-Darling Basin Authority (MDBA) 2018f, 'Murray-Darling Compliance Compact, Interim Assurance Report', December, https://www.mdba.gov.au/sites/default/files/pubs/murray-darling-compliance-compact-assurance-report.pdf, accessed 16 January 2019

Mushtaq Shahbaz, Maraseni Tek N and Reardon-Smith Kathryn 2015, 'Trade-offs and synergies between water and energy use in rural Australia, in Jamie Pittock, Karen Hussey and Stephen Dovers (eds.), *Climate, Energy and Water: Managing trade-offs, seizing opportunities*, Cambridge University Press, Cambridge

Nakai Michitaro 2003, 'Introduction of Water Right System in Japan', *Asian Development Bank*, http://www.narbo.jp/event/materials/vnsm/vn_sm_2-1.pdf, accessed 01 May 2019

Narita Kentaro, Matsui Yoshihiko, Iwao Kensuke, Kamata Montovuki, Matsushita Taku and Shirasaki Nobutaka 2014, 'Selecting pesticides for inclusion in drinking water quality guidelines on the basis of detection probability and ranking', *Environment International*, 63, 114-120

National Centre for Groundwater Research and Training (NCGRT), 'Strategic Plan 2009 - 2014', *Australian Government*, Canberra

National Institute for Land and Infrastructure Management (Japan) 2009, 'Reliability assessment of facilities and establishment of river management technologies', Research

Projects, September 17, http://www.nilim.go.jp/lab/fbg/en/proj/index.html, accessed 27 September 2019

National Research Council (US) 2013, C*limate and Social Stress*, National Academies Press, Washington DC

National Water Commission (NWC) 2011, *Urban Water in Australia: future directions 2011*, NWC, Canberra

National Water Commission (NWC) 2013, *Australian Water Markets: trends and drivers 2007-8 to 2012-3*, NWC, Canberra

National Water Commission (NWC) 2014a, *The National Water Planning Report Card 2013*, NWC, Canberra

National Water Commission (NWC) 2014b, 'Monitoring and evaluation for adaptive water management: issues paper, Executive Summary', *NWC*, Canberra

National Water Commission (NWC) 2014c, *Urban Water Futures 2014*, NWC, Canberra

National Water Commission (NWC) 2014d, 'NWI and mining and unconventional gas', http://webarchive.nla.gov.au , accessed 17 September 2017

National Water Commission (NWC) 2014e, A review of indigenous involvement in water planning, 2013', https://healthinfonet.ecu.edu.au/uploads/resources/27638_27638.pdf, accessed 19 June 2018

National Water Quality Management Strategy (NWQMS) 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality: Volume 1,* October, Australian Government, Canberra, http://www.environment.gov.au/system/files/resources/53cda9ea-7ec2-49d4-af29-d1dde09ef/files/nwqms-guidelines-4-volume1.pdf , accessed 22 June 2017

National Water Quality Management Strategy (NWQMS) 2006a, *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1),* Natural Resource Ministerial Council, Environment Protection and Heritage Council and Australian Health Ministers Conference, https://www.awa.asn.au/Documents/water-recycling-guidelines-health-environmental-21.pdf, accessed 21 June 2017

National Water Quality Management Strategy (NWQMS) 2006b, *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2): Augmentation of Drinking Water Supplies*, Natural Resource Ministerial Council, Environment Protection and Heritage Council and Australian Health Ministers Conference, http://www.environment.gov.au/system/files/resources/9e4c2a10-fcee-48ab-a655-c4c045a615d0/files/water-recycling-guidelines-augmentation-drinking-2.2.pdf , accessed 21 June 2017

National Water Quality Management Strategy (NWQMS) 2016, *Australian Drinking Water Guidelines 6 2011, Version 3.3*, November, Australian Government, Canberra, https://www.nhmrc.gov.au/_files_nhmrc/file/publications/nhmrc_ndwg_6_version_3.3_2.pdf accessed 12 June 2017

Natural Resources Commission, NSW (NRC) 2013, ‘Upgrading Catchment Action Plans: Lessons for Local Land Services’, 14 June, *NRC*, Sydney

Natural Resources Commission, NSW (NRC) 2014, ‘Review of 2004 Water Sharing Plans’, NRC, June, *NRC*, Sydney

Natural Resources Commission, NSW (NRC) 2018, ‘2017-2018 Water Sharing Plan Reviews’, http://www.nrc.nsw.gov.au/2017-2018-wsp-reviews , accessed 26 July 2018

Natural Resources Commission, NSW (NRC) 2019, ‘Review of Water Sharing Plan for the Barwon-Darling Unregulated and Alluvial Water Sources 2012’,

Neave I, McLeod, Raisin G and Swirepik 2015, ‘Managing Water in the Murray-Darling Basin under Variable and Changing Climate’, *Water*, April, 102-107

Nickum James 2010, ‘Water Policy Reform in China’s Fragmented Hydraulic State: Focus on Self-funded/Managed Irrigation and Drainage Districts’, *Water Alternatives*, 3(3), 537-551

Nickum James E and Ogura Chisa 2010, ‘Agricultural Water Pricing: Japan and Korea’, Japan Office, Asian Water and Resources Institute, *OECD*, https://www.oecd.org/korea/45016191.pdf, accessed 29 April 2019

Nikkei Asian Review 2018, ‘Japan faces $2bn price tag for flood rebuilding’, 20 July, https://asia.nikkei.com/Politics/Japan-faces-2bn-price-tag-for-flood-rebuilding, accessed 09 February 2020

Nicolaou Nicolas, Eliades Demetrios G, Panayiotou Christos and Polycarpou Marios M 2018, ‘Reducing Vulnerability to Cyber-Physical Attacks in Water Distribution Networks’, International Workshop on Cyber-physical Systems for Smart Water Networks, Porto, 16-19, doi:10.1109/CySWater.2018.00011.

Niponica 2015, ‘Japan, Land of Water’, *Discovery Japan*, No 15, https://web-japan.org/niponica/pdf/niponica15/no15_en.pdf, accessed 05 April 2019

Noda Koji 2018, ‘Governance, rights and resource development costs of water: lessons from post-war Japan’, *Water Policy* (Oxford), 20, 189-201

Noda Keigo, Hamada Junya, Kimura Masaomi and Oki Kazuo 2018, ‘Debates over dam removal in Japan’, *Water and Environment Journal*, 32, 446-452

NSW Government (NSWG) 2011a, *NSW 2011: A Plan to Make NSW Number One*, NSWG, Sydney

NSW Government (NSWG) 2011b, ‘Drinking Water Monitoring Program’, Updated October 2011, http://www.health.nsw.gov.au/environment/water/Publications/october-2011-dwmp-booklet.pdf , accessed 26 April 2018

NSW Government (NSWG) 2015, ‘Restart NSW: Water Security for Regions’, Department of Primary Industries - Water NSW, Sydney

NSW Government (NSWG) 2016, ‘State Strategic Plan 2016-2026’, *Local Land Services*, http://www.lls.nsw.gov.au/_data/assets/pdf_file/0007/658492/state-strategic-plan.pdf , accessed 01 April 2017

NSW Government (NSWG) 2017a, ‘NSW submission on proposed Basin Plan amendments’, http://www.water.nsw.gov.au/_data/assets/pdf_file/0013/700501/nsw-submission-on-proposed-basin-plan-amendments.pdf , accessed 22 March 2017

NSW Government (NSWG) 2017b, ‘Climate Change Fund: Draft Strategic Plan, 2017 to 2022’, http://www.environment.nsw.gov.au/resources/climatechange/Environmentalfuturefundingpackage/draft-climate-change-fund-strategic-plan-20160438.pdf , accessed 09 March 2018

NSW Government (NSWG) 2017c, 'The 2017 Metropolitan Water Plan', https://www.metrowater.nsw.gov.au/sites/default/files/Securing%20water%20for%20the%20Greater%20Sydney%20region.pdf, accessed 14 August 2018

NSW Office of Water (NSWOW) 2010, 'Climate Change and its Impacts on Water Supply and Demand in Sydney', NSWOW (co-ordinator), https://www.metrowater.nsw/gov.au/sites/default/files/publicationdocuments/climate_impact_water_supply_summary.pdf , accessed 09 July 2017

NSW Office of Water (NSWOW) 2017, 'Harvestable rights – dams', http://www.water.nsw.gov.au/water-licensing/basic-water-rights/harvesting-runoff , accessed 08 April 2018

Northern Territory Government (NTG) 2015, 'Our Water Future, Discussion Paper: A Conversation with Territorians, https://denr.nt.gov.au/__data/assets/pdf_file/0006/269304/NT-Water-Strategic-Plan-Discussion-Paper.pdf, accessed 28 April 2018

OECD 2011, 'Towards green growth: A summary for policy makers, May 2011', https://www.oecd.org/greengrowth/48012345.pdf, accessed 18 September 2019

OECD 2013, 'Water Security for Better Lives, A Summary for Policy Makers', http://www.oecd.org/env/resources/Water%20Security%20for%20Better%20Lives-%20brochure.pdf , accessed 28 January 2017

OECD 2015a, 'OECD Principles on Water Governance', 4 June, *OECD*, Paris

OECD 2015b, 'Water Resources Allocation: China (People's Republic of)', *OECD*, Paris, https://www.oecd.org/china/Water-Resources-Allocation-China-People-Republic-of.pdf , accessed 10 November 2017

OECD 2015c, 'Water Resources Allocation: Japan, *OECD*, Paris, https://www.oecd.org/japan/Water-Resources-Allocation-Japan.pdf , accessed 07 October 2018

OECD 2016, 'OECD Territorial Reviews: Japan 2016, *OECD*, Paris, https://www.oecd.org/japan/oecd-territorial-reviews-japan-2016-9789264250543-en.htm, accessed 14 November 2019

OECD 2017, 'The Governance of Land Use: Country fact sheet Japan' *OECD*, Paris, http://www.gdrc.org/uem/observatory/jp-overview.html, accessed 09 August 2019

OECD 2018, 'Wastewater treatment', *OECD. Stat* https://stats.oecd.org/index.aspx?DataSetCode=water_treat, accessed 12 October 2018

OECD 2019, 'Food and Agricultural Review: Innovation, Agricultural Productivity and Sustainability in Japan', *OECD*, Paris, https://www.oecd-ilibrary.org/agriculture-and-food/innovation-agricultural-productivity-and-sustainability-in-japan_92b8dff7-en, accessed 11 June 2020

Ohmura Takashi 2014, 'Advances in the Water Environment in Japan', https://www.env.go.jp/en/focus/docs/files/20140902-90.pdf, accessed 12 April 2019

Okada Tomoyuki 2016, 'Integrated water resources management and drought risk management in Japan', *Water Policy* (Oxford), 18, 70 - 88

Okayama Kazuo and Maruoka Noboru 2003, 'Conservation and Restoration of River Environment', https://www.iwra.org/member/congress/resource/MADRID2003_Kazuo_Okayama_2_EN.pdf, accessed 22 March 2019

Oliver Greg and Hussey Karen 2015, 'Cross-sectoral governance of the climate, energy and water sectors: A "Rubik's cube" analysis of cross-sectoral co-ordination', in Jamie Pittock, Karen Hussey and Stephen Dovers (eds.), *Climate, Energy and Water: Managing trade-offs, seizing opportunities*, 172-197, Cambridge University Press, Cambridge

Osti Rabindra P 2017, 'Strengthening Flood Risk Management Policy and Practice in the People's Republic of China: Lessons Learned from the 2016 Yangtze River floods', *Asian Development Bank*, https://www.adb.org/publications/strengthening-flood-risk-management-prc-yangtze-river , accessed 09 May 2018

Ostrom Elinor 2010, 'Beyond Markets and States: polycentric governance of complex economic systems', *American Economic Review*, 100 (3), 641-672

Ozawa Hideaki and Umedo Shogo 2019, 'Environmental law and practice in Japan: overview', https://uk.practicallaw.thomsonreuters.com/6-502-

8920?transitionType=Default&contextData=(sc.Default)&firstPage=true&comp=pluk&bhcp=1#co_anchor_a881602, accessed 13 March 2019

Pahl-Wostl Claudia, Mostert Erik and Tàbara David 2008, ‘The Growing Importance of Social Learning in Water Resources Management and Sustainability Science’, *Ecology and Society*, 13(1), 24

Pahl-Wostl Claudia, Gupta Joyeeta and Bhaduri Anik 2016, ‘Water security: a popular but contested concept’, in Claudia Pahl-Wostl, Anik Bhaduri and Joyeeta Gupta (eds.), *Handbook on Water Security*, Edward Elgar Publishing, Massachusetts

Pannett Rachel 2019, ‘US wants to adopt a cap-and-trade plan for water that isn’t working well’, *The Australian*, 5 September

Parsons Melissa and Thoms Martin C 2017a, ‘Assessment of rivers as social-ecological systems: a response to “The imperative need for nationally coordinated bioassessment of rivers and streams”, by Susan J. Nichols *et al*.’, *Marine and Freshwater Research*, 68, 2179-2183

Parsons Melissa, Thoms Martin C and Flotemersch Joseph E 2017b, ‘Eight river principles for navigating the science-policy interface’, *Marine and Freshwater Research*, 68, 401-410

Pegram Guy, Yuanyuan Li, Le Quesne Tom, Speed Robert, Jianqiang Li and Fuxin Shen 2013, ‘River Basin Planning: Principles, Procedures and Approaches for Strategic Basin Planning, Collaboration between General Institute of Water Resources and Hydropower Planning and Design, *World Wildlife Fund for Nature and Ministry of Water Resources*, PRC, https://www.adb.org/publications/river-basin-planning-principles , accessed 15 November 2017

Pizzi Elise 2015, ‘Drinking Water Provision in Rural China’, *University of Colorado*, https://scholar.colorado.edu/cgi/viewcontent.cgi?referer=http://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=16&ved=0ahUKEwih57i2tLvbAhXHfLwKHeBYB4QQFghzMA8&url=http%3A%2F%2Fscholar.colorado.edu%2Fcgi%2Fviewcontent.cgi%3Farticle%3D1045%26context%3Dpsci_gradetds&usg=AOvVaw1xTfH5x8wj7IXC_XI9G3vV&httpsredir=1&article=1045&context=psci_gradetds , accessed 05 June 2018

Primary Facts 2013, ‘10 Three Gorges Facts’, 25 September, http://primaryfacts.com/2754/10-three-gorges-dam-facts/ , accessed 17 January 2018

Pohlner Huw 2019, 'Compensating for the socioeconomic costs of catchment protection: The case of China's South-to-North Water Transfer', *Water Security*, doi.org/10.1016/j.wasec.2019.100023

Prosser Ian (ed.) 2011, *Water: Science and Solutions for Australia*, CSIRO Publishing, Melbourne

Qian Mingkai and Wang Kai 2017, 'Flood Management in China: the Huaihe River Basin as a Case Study', 138-152, https://www.intechopen.com/books/flood-risk-management/flood-management-in-china-the-huaihe-river-basin-as-a-case-study , accessed 4May 2018

Qiting Suo, Liu Huan, Ma Junxia and Runfang Jin 2016, 'China calls for human-water harmony', *Water Policy* (Oxford), 18(2), 255-261

Queensland Country Life 2018, 'Galilee Basin coal mining will have larger impact on water reserves', https://www.queenslandcountrylife.com.au/story/5815288/impact-of-galilee-basin-coal-mines-greater-than-first-thought/ accessed 27 April 2019

Queensland Government (QG) 2016, *South East Queensland's Water Security program 2016-2046*, http://www.seqwater.com.au/sites/default/files/PDF%20Documents/Publications/Water%20Security%20Program%20Version%20%20-%20Summary.pdf , accessed 11 August 2017

Queensland Government (QG) 2017, 'Water Planning Science Plan 2014-2019'

Queensland Government (QG) 2018a, 'Water Planning Framework',

Queensland Government (QG) 2018b, 'Developing Water Plans'

Queensland Government (QG) 2018c, 'Water plan monitoring, reporting and review',

Queensland Government (QG) 2019, 'Galilee Basin State Development Area', https://www.statedevelopment.qld.gov.au/coordinator-general/galilee-basin-state-development-area.html, accessed 27 April 2019

Quiggin John 2012, 'Murray-Darling plan: a disastrous process, a sliver of hope', http://johnquiggin.com/2012/05/31/murray-darling-plan-a-disastrous-process-a-sliver-of-hope/, accessed 16 March 2017

Radio Free Asia (RFA) 2015, 'More Than One Million Lack Clean Water in Xinjiang's Hotan Prefecture', 4 February, https://www.rfa.org/english/news/uyghur/water-02042015152217.html , accessed 05 June 2018

Reading Kristy 2017, 'Murray-Darling Basin Plan: How much water is used to grow cotton', *ABC Rural*, 26 July, https://www.abc.net.au/news/rural/2017-07-25/murray-darling-basin-plan-how-much-water-to-grow-cotton/8742234, accessed 19 April 2018

Rechtschaffen Daniel 2017, 'How China's Growing Deserts are Choking the Country', Forbes, September 18

Reuters 2019, 'Parts of Japan hit by Storms Brace for More; 60,000 Advised to Evacuate', 25 October, https://www.voanews.com/east-asia-pacific/parts-japan-hit-storms-brace-more-60000-advised-evacuate, accessed 08 February 2020

Ricepedia 2019, 'Japan', http://ricepedia.org/japan, accessed 30 April 2019

Rist Lucy, Felton Adam, Samuelsson Lars, Sandström Camilla and Rosvall Ola 2013, 'A New Paradigm for Adaptive Management', *Ecology and Society*, 18(4), 63

Rogers Sarah and Crow-Miller Britt 2017, 'The politics of water: a review of hydropolitical frameworks and their application in China', *Wiley International Reviews (WIREs)*, 4e1239.doi: 10.1002/wat2.1239

Rogers Sarah, Chen Dan, Hong Jiang, Rutherfurd Ian, Wang Mark, Webber Michael, Crow-Miller Britt, Barnett Jon, Finlayson Brian, Jiang Min, Chenchen Shi and Wenjing Zhang 2020, 'An integrated assessment of China's South-North Water Transfer Project', *Geographical Research*, 58 (1), 49-63

Rohlen Thomas P 1989, 'Order in Japanese Society: Attachment, Authority and Routine', *Journal of Japanese Studies*, 15 (1), 5-40

Rose Matthew 2015, 'Comment: Connections between Australian politics and coal lobby run deep', *SBS News*, 14 September, http://www.sbs.com.au/news/article/2015/09/14/comment-connections-between-australian-politics-and-coal-lobby-run-deep , accessed 14 September 2017

Rubenstein Naomi, Wallis Philip J, Ison Raymond L and Godden Lee 2016, 'Critical Reflections on Building a Community Conversation about Water Governance in Australia', *Water Alternatives*, Vol 9(1), 81-98

Rubinsztein-Dunlop Sean, Fallon Mary, Carter Lucy and Slezak Michael 2019, 'How taxpayers are funding a huge corporate expansion in the Murray-Darling Basin', *ABC Four Corners*, News Release, 08 July https://www.abc.net.au/news/2019-07-08/taxpayers-helping-fund-murray-darling-basin-expansion/11279468, accessed 08 July 2019

Saich T 2015, *Governance and Politics of China*, 4th Edn, Palgrave, London

Saravanan VS, McDonald Geoffrey T and Mollinga Peter P 2008, 'Critical Review of Integrated Water Resources Management: Moving Beyond Polarised Discourse', ZEF Working Paper No. 29, *University of Bonn*, https://www.econstor.eu/bitstream/10419/88323/1/579201309.pdf , accessed 16 March 2018

Schreurs Miranda A 2013, 'The Ethics of Japan's Global Environmental Policy: The Conflict between Principles and Practice', Review, *Journal of Japanese Studies*, Vol. 39(2), 498-503

Senge Peter M 1993, *The Fifth Discipline: The Art and Practice of the Learning Organization*, Random House, Sydney

Serrao-Neumann Silvia, Schuch Gemma, Kenway Steven and Low Choy Darryl 2014, 'Water sensitive cities and regions: tackling threats to water resources in metropolitan areas', *Association of European Schools of Planning Annual Congress*, Utrecht, Netherlands, 9-12 July, http://www98.griffith.edu.au/dspace/bitstream/10072/65003/99421_pdf? , accessed 13 April 2017

Seymour Eloise, Pannell David, Ridley Anna, Marsh Sally and Wilkinson Roger 2007, 'Understanding the capacity of catchment organisations to make decisions about natural resource management in Australia', http://www.uwa.edu.au/_data/assets/rtf_file/000785840/Understanding_the_capacity_of_catchment_organisations_to_make_decisions_about_natural_resource_management_in_Australia.rtf , accessed 18 April 2017

Shen Dajun 2015, 'Groundwater management in China', *Water Policy*, 17, 61-82

Shen Dajun and Wu Juan 2017, 'State of the Art Review: Water pricing reform in China', *International Journal of Water Resources Development*, Vol 33(2), 198-232

Shepheard Mark 2018, 'Stewardship arrangements for water: An evaluation of reasonable use in sustainable catchment or watershed management systems', in Robyn Bartel, Louise Noble, Jacqueline Williams and Stephen Harris (eds.), *Water Policy, Imagination and Innovation: Interdisciplinary Approaches*, Routledge, New York, 127-148

Shin Kyoung 2017, 'Mission-driven Agency and Local Policy Innovation: Empirical Analysis from Baoding, China', *Journal of Chinese Political Science*, 22, 549-580

Shintani Kohei, Kurachi Yoshiyuki, Nishioka Shinichi and Okamoto Takashi 2016, 'Administered Prices in Japan: Institutional Comparisons with Europe and the United States', *Bank of Japan Review*, https://www.boj.or.jp/en/research/wps_rev/rev_2016/data/rev16e09.pdf, accessed 29 April 2019

Simons Margaret 2020, 'Murky Waters', *The Saturday Paper*, 4-10 July

Sinclair Knight Merz 2013, 'Characterising the Relationship between Water Quality and Water Quantity', *Department of Sustainability, Environment, Water, Population and Communities*, August, Canberra

Slattery Maryanne 2019, 'Problems with the Murray-Darling Basin can't be skimmed over', *The Australia Institute*, 13 July, https://www.tai.org.au/content/problems-murray-darling-basin-cant-be-skimmed-over, accessed 17 October 2019

Slezak Michael 2016, 'NSW land-clearing laws will let farmers clear native vegetation with no approval', 3 May, https://www.theguardian.com/australia-news/2016/may/03/nsw-land-clearing-law-will-let-farmers-clear-native-vegetation-with-no-approval , accessed 09 March 2018

Smith Carl 2014 (citing Karlene Maywald), 'National Water Commission releases final report, warns government not to backtrack on water reform', www.abc.net.au/2014-10-20/final-national-water-commission-report-advises-against-changes/5826790, accessed 11 March 2017

South Australian Government (SAG) 2010, 'Water for Good: A Plan to Ensure the Water Future to 2050, Executive Summary', *Department of Environment Water and Natural Resources*, https://www.environment.sa.gov.au/managing-natural-resources/water-resources/planning , accessed 14 March 2017

South Australian Government (SAG) 2013, 'Adelaide and Mt Lofty Ranges Natural Resource Management Plan, Summary', *Adelaide and Mt Lofty Ranges Natural Resource Management Board*, http://www.naturalresources.sa.gov.au/adelaidemtloftyranges/about-us/our-regions-plan , accessed 06 March 2017

South Australian Government (SAG) 2016, 'South East Water Security Plan', https://www.sawater.com.au/community-and-environment/environment-water-and-sewerage-systems/our-networks/regional-south-australia-supply/south-east-plan , accessed 11 August 2017

South Australian Government (SAG) 2017, 'Water planning', https://www.environment.sa.gov.au/topics/water/planning, accessed 21 January 2020

South Australian Government (SAG) 2018, 'Murray-Darling Basin Royal Commission', https://www.mdbrc.sa.gov.au/ , accessed 14 June 2018

South Australian Government (SAG) 2019, *Murray-Darling Basin Royal Commission Report*, 29 January, https://www.mdbrc.sa.gov.au/sites/default/files/murray-darling-basin-royal-commission-report.pdf?v=1548898371 , accessed 06 February 2019

South China Morning Post (SCMP) 2017, 'Southern China's million-tonne raw sewage problem', 15 April, http://www.scmp.com/news/china/policies-politics/article/2087815/southern-chinas-million-tonne-raw-sewage-problem , accessed 24 October 2017

Srinivas Hari 1997a, 'Japan: Overview of Planning', *Global Development Research Centre*, http://www.gdrc.org/uem/observatory/jp-overview.html, accessed 09 August 2019

Srinivas Hari 1997b, 'Chronology of Japanese Planning', *Global Development Research Centre*, http://www.gdrc.org/uem/observatory/jp-chrono.html, accessed 09 August 2019

State Council, People's Republic of China 2012, 'Opinions of the State Council on the implementation of the most stringent water resources management system', 16 February, http://english.gov.cn/zwgk/2012/02/16/content_2067664.htm , accessed 04 October 2017

State Council, People's Republic of China 2016a, 'China renews anti-pollution policy', 25 November, http://english.gov.cn/policies/policy_watch/2016/12/08/content_281475511187196.html , accessed 28 September 2017

State Council, People's Republic of China 2016b, 'China pins hopes on taxation for environmental protection', 8 December, http://english.gov.cn/policies/policy_watch/2016/11/25/content_281475499757679.html , accessed 28 September 2017

State Council, People's Republic of China 2016c, 'State Council rolls out big plans to improve environment during 2016-2020', 05 December, http://english.gov.cn/policies/latest_releases/2016/12/05/content_281475508633492.htm , accessed 04 October 2017

State Council, People's Republic of China 2016d, 'China's plan to promote modern agriculture', 20 October, http://english.gov.cn/policies/latest_releases/2016/10/20/content_281475470945910.htm , accessed 07 January 2018

State Council, People's Republic of China 2016e, 'State Council seeks to adjust agricultural water price', 29 January http://english.gov.cn/policies/latest_releases/2016/01/29/content_281475280730942.htm , accessed 07 January 2018

Statista 2016, 'Water consumption per capita by country', https://www.statista.com/statistics/263156/water-consumption-in-selected-countries/ , accessed 21 November 2018

Statista 2019, 'Annual water consumption world wide in 2017, by select country', https://www.statista.com/statistics/263156/water-consumption-in-selected-countries/, accessed 08 March 2020

Stratfor 2016, ‘Bridging the Gap between China’s Central and Local Governments’, *Stratfor Worldview*, https://worldview.stratfor.com/article/bridging-gap-betweeen-chinas-central-and-local-governments , accessed 19 November 2017

Stratfor 2017, ‘Consolidating China’s Industries, One Polluter at a Time’, *Stratfor* Worldview, October 25, https://worldview.stratfor.com/article/consolidating-chinas-industries-one-polluter-time , accessed 31 October 2018

Stockwin Arthur 2018, ‘Political transformation in Japan as a source of insight’, *Japan Forum*, 30(1), 132-147

Sun X, Warner T, Yang S and Liu M 2013, ‘Patterns of Authority and Governance in Rural China: Who’s in Charge? Why?’ *Journal of Contemporary China*, Vol 22, Issue 83, 733-54

Swainson Becky, de Loë Rob and Kreutzwiser Reid 2010, ‘Sharing Water with Nature: Insights on Environmental Water Allocation from a Case Study of the Murrumbidgee Catchment Australia’, *Water Alternatives*, Vol 4(1), 15-34

Sydney Desalination Plant (SDP) 2017, ‘Sydney Desalination Plant’, http://www.sydneydesal.com.au , accessed 10 July 2017

Sydney Water Corporation (SWC) 2006, ‘Preferred project report for Sydney’s desalination project, August, SWC, http://www.sydneydesal.com.au/media/1145/2006-preferred-project-report.pdf , accessed 11 July 2017

Sydney Water Corporation (SWC) 2012, ‘AdaptWater: Climate Change Adaptation Tool for the Australian Urban Water Sector’, https://www.sydneywater.com.au/web/groups/publicwebcontent/documents/document/zgrf/mdq0/~edisp/dd_044233.pdf , accessed 09 July 2017

Sydney Water Corporation (SWC) 2014, ‘Climate Change Adaptation, Program Summary – Sydney Water’, https://www.sydneywater.com.au/web/groups/publicwebcontent/documents/document/zgrf/mdq0/~edisp/dd_044229.pdf , accessed 09 July 2017

Sydney Water Corporation (SWC) 2018, ‘2017-18 Annual Report’, *SWC*, Sydney

Szalkai Kinga 2012, ‘Water Issues are What States Make of Them: A Constructivist Approach to Conflict and Cooperation over Trans-Boundary Waters’ http://www.etd.ceu.hu/2012/szalkai_kinga.pdf, accessed 05 December 2018

Takahashi Yutaka and Uitto Juha I 2004, ‘Evolution of river management in Japan: from focus on economic benefits to a comprehensive view’, *Global Environmental Change*, 14, 63-70

Takao Yasuo 2018, *Japan's Environmental Politics and Governance*, Routledge, New York

Takao Yuko 2019, ‘ECB and Japan linked by pitfalls in Abenomics’, *Japan Times*, 07 November 2019, https://www.japantimes.co.jp/news/2019/11/07/business/financial-markets/ecb-japan-linked-by-abenomics/#.XhrZI-R7mM8, accessed 12 January 2020

Tan Debra 2014, ‘China Water Investments: 3 Thoughts’, *China Water Risk*, 10 December, http://chinawaterrisk.org/opinion/china-water-investments-3-thoughts , accessed 26 September 2017

Tan Debra 2015a, ‘Water Ten: Comply or Else’, *China Water Risk*, 14 May, www.chinawaterrisk.org/resources/analysis-reviews/water-ten-comply-or-else/, accessed 26 September 2017

Tan Debra 2015b, ‘8-Game-changing Policy Paths’, *China Water Risk*, 10 February, http://chinawaterrisk.org/resources/analysis-reviews/8-game-changing-policy-paths , accessed 26 September 2017

Team Water Japan 2013, ‘Team Water Japan’, http://www.waterforum.jp/twj/eng/index.html, accessed 22 September 2019

Tembata Kaori and Takeuchi Kenji 2010, ‘Collective decision making under drought: An empirical study of water resource management in Japan’, *Water Resources and Economics*, 22, 19-31

The Australia Institute 2019, ‘Watergate’s water mates’, https://www.tai.org.au/content/watergate-s-water-mates, accessed 17 October 2019

The Business Times 2018, ‘Japan to ramp up public works spending to decade-high next year: Nikkei’, 05 December, https://www.businesstimes.com.sg/government-economy/japan-to-ramp-up-public-works-spending-to-decade-high-next-year-nikkei, accessed 15 September 2019

The Guardian 2020, 'China blows up dam on Yangtze river tributary to ease flooding', 20 July, https://www.theguardian.com/world/2020/jul/20/china-blows-up-dam-on-yangtze-river-tributary-to-ease-flooding, accessed 30 August 2020

The Headquarters for Water Cycle Policy, Cabinet Secretariat (HWCP) 2017, 'Trends of efforts based on the Basic Act on Water Cycle and Basic Plan on Water Cycle', *JWF Water Journal*, 1, 8-9, http://www.waterforum.jp/wp/wp-content/uploads/2017/06/Journal-1engs.pdf, 12 April 2019

The Japan Times 2014a, 'Protecting the water cycle', *The Japan Times,* 18 May, https://www.japantimes.co.jp/opinion/2014/05/18/editorials/protecting-the-water-cycle/#.XLUkE-R7mM8, accessed 12 April 2019

The Japan Times 2014b, 'Shameful waste of tax money', 29 November, https://www.japantimes.co.jp/opinion/2014/11/29/editorials/shameful-waste-tax-money/#.XYBfvuR7mM8, accessed 15 September 2019

Thieriot Hubert 2015, 'Water in Coal: Still Murky', *China Water Risk*, 14 May, http://chinawaterrisk.org/resources/water-in-coal-still-murky , accessed 06 November 2017

Thomas Garry 2007, 'Water Markets and Water Lessons in the United States: Lessons from Australia', *Macquarie Journal of International and Comparative Environmental Law*, Vol 4(2) http://www.auslii.edu.au/au/journals/MqJiiCenvLaw/2007/6.html , accessed 03 August 2017

Thompson Ross M 2017, 'Is the Murray-Darling Basin Plan broken?', *The Conversation*, 26 July, https://theconversation.com/is-the-murray-darling-basin-plan-broken-81613 , accessed 27 April 2018

Timms Wendy and Holley Cameron 2016, 'Mine site water-reporting practices, groundwater take and governance frameworks in the Hunter Valley coalfield, Australia', *Water International*, 41(3), 351-370

Tortajada Cecilia 2016, 'Policy dimensions of development and financing of water infrastructure: The cases of China and India', *Environmental Science and Policy*, 64, 177-187

Ueda Satoru and Benouahi Mohammed 2009, 'Accountable Water and Sanitation Governance: Japan's Experience', in Jagannathan N Vijay, Mohamed Ahmed Shawky and Kremer Alexander (Eds.) *Water in the Arab World: Management Perspectives and Innovations*, Middle East and North Africa Region, World Bank, http://siteresources.worldbank.org/INTMENA/Resources/Water_Arab_World_full.pdf, accessed 13 April 2019

Umeda Sayuri 2014, 'Japan: New Water Circulation Basic Act', *Law Library of Congress*, https://www.loc.gov/law/foreign-news/article/japan-new-water-circulation-basic-act/, accessed 12 April 2019

UN Water 2013, 'Water Security', http://www.unwater.org/topics/water-security/en/ , accessed 18 February 2017

UN 2015, 'Transforming our world: the 2030 Agenda for Sustainable Development', https://sustainabledevelopment.un.org/post2015/transformingourworld, 03 October 2018

UN Office of Counter-Terrorism and UN Counter-Terrorism Committee Executive Directorate 2018, 'The protection of critical infrastructure against terrorist attacks: Compendium of good practices', https://www.un.org/sc/ctc/wp-content/uploads/2018/06/Compendium-CIP-final-version-120618_new_fonts_18_june_2018_optimized.pdf, accessed 08 June 2020

United States Department of Agriculture (USDA) 2017, China's Annual Agricultural Policy Goals – The 2017 No. 1 Document of the CCP and the State Council, 15 February https://gain.fas.usda.gov/recent%20GAIN%20Publications/China's%202017%20Agricultural%20Policy%20Goals_Beijing_China%20-%20Peoples%20Repbulic%20of_2-15-2017.pdf , accessed 8 January 2018

Van der Zaag P and Savenije HHG 2006, 'Water as an Economic Good: The Value of Pricing and the Failure of Markets', UNESCO-IHE, http://www.waterfootprint.org/media/downloads/Report_19_Water_as_an_Econ_Good_1.pdf accessed 27 July 2017

Van Dijk Albert IJM 2015, 'Water resources, climate change and energy', in Jamie Pittock, Karen Hussey and Stephen Dovers (eds.), *Climate, Energy and Water: Managing trade-offs, seizing opportunities*, 6-27, Cambridge University Press, Cambridge

Varis Olli, Keskinen Marko and Kummu Matti 2017, ‘Four dimensions of water security with a case of the indirect role of water in global food security’, *Water Security*, 1(1), 36-45

Viala Eric 2017, ‘What is Water Security?’ *US AID: Sustainable Water Partnership,* https://www.swpwater.org/what-is-water-security/ , accessed 30 November 2017

Victorian Auditor-General’s Office 2019, ‘Security of Water Infrastructure Control Systems’, https://www.audit.vic.gov.au/sites/default/files/2019-05/29052019-Water-Control-Systems.pdf, accessed 08 June 2020

Victorian Catchment Management Council (VCMC) 2012, *Catchment Condition and Management Report 2012*, VCMC, http://www.vic.gov.au/PDF/CCMR.2012.pdf , accessed 18 April 2017

Victorian Catchment Management Council (VCMC) 2016, ‘Victorian Catchment Management Council, Fact Sheet 3’, DELWP/ VCMC, http://www.vic.gov.au/_data/assets/pdf_file/0003/328629/FINAL-FACT-SHEET-1_Overview-of-Victorias-CMF_Apr-2016_1.pdf.pdf , accessed 18 April 2017

Victorian Government 2014, ‘Water Bill 2014, Explanatory Memorandum’, *Victorian Government*, http://www.legislation.vic.gov.au/domino/web_notes/ldms/pubdocs_arch.nsf/5da7742d8f61e92bca256de50013d008/ca2570ce0018ac6dca257d0100294e82/SFILE/571407exi1.pdf , accessed 02 March 2017

Victorian Government 2016a, ‘Water Law Review’, *Department of Environment, Land, Water and Planning*’, http://www.depi.vic.gov.au/water/governing-water-resources/environmental-contribution/water-law-review , accessed 01 March, 2017

Victorian Government 2016b, *Water for Victoria, Water Plan*, Department of Environment, Land, Water and Planning, Melbourne

Victorian Government 2018, *Water for Victoria*, *Delivering Water for Victoria*, Department of Environment, Land, Water and Planning, https://www.water.vic.gov.au/water-for-victoria, accessed 21 January 2020

Vidot Anna 2016, ‘What is the Murray-Darling Basin Plan and why are we still talking about it?’ *ABC News*, 29 November, http://www.abc.net.au/news/2016-11-21/what-is-the-murray-darling-basin-plan/8043180 , accessed 15 March 2017

Visentin Lisa 2018, ‘Minister accused of political interference over illegal dam’, Sydney Morning Herald, News Section, 18 August

Vörösmarty CJ, McIntyre PB, Gessner MO, Dudgeon D, Prusevich A, Green P, Glidden S, Bunn SE, Sullivan CA, Reidy Liermann C and Davies PM 2010, ‘Global threats to human water security and river biodiversity’, *Nature*, 467, 555-561

Vosse William M 2019, ‘Rethinking Japan: The Politics of Contested Nationalism’, Book Review, *Social Science Japan Journal*, 22(2), 277-280

Voulvoulis Nikolaos, Arpon Karl Dominic and Giakoumis Theodoros 2017, ‘The EU Framework Directive: From great expectations to problems with implementation’, *Science of the Total Environment*, 575, 358-366

Walker Brian H and Salt David 2006, *Resilience Thinking – Sustaining ecosystems and people in a changing world*, Island Press, Washington DC

Walker Brian H, Abel Nick, Anderies John M and Ryan Paul 2009, ‘*R*esilience, Adaptability and Transformability in the Goulburn-Broken Catchment, Australia’, *Ecology and Society*, 14(1), Article 12, 1-24

Wang Xiao-jun, Zhang Jian-yun, Gao Juan, Shahid Shamsuddin, Xia Xing-hui, Geng Zhi and Tang Li 2018, ‘The new concept of water resources management in China: ensuring water security in a changing environment’, *Environment, Development and Sustainability*, 20(2), 897-909, doi.org/10.1007/s10668-017-9918-8

Wang Xin and Yang Shizhong 2018, ‘Research on Status Quo of Water Trading in China’, *Earth and Environmental Science*, 171, 01233; doi: 10.1088/1755-1315/171/1/012033

Wang Yahua 2017, *Water Resources Development and Management: Assessing Water Rights in China*, Springer, New York

Wang Yahua, Wan Tingting and Biswas Asit K 2018, ‘Structuring water rights in China: a hierarchical framework’, *International Journal of Water Resources Development*, 34(3), 418-433, doi:10.1080/07900627.2017.138627

Wang Yan 2018, ‘Mekong River Commission reaches out to China to avert dam damage’, https://www.chinadialogue.net/article/show/single/en/10619-Mekong-River-Commission-reaches-out-to-China-to-avert-dam-damage- , accessed 07 May 2018

Wang Zhengxu, Liu Jainxiong and Pavlićevic Dragan 2018, ‘Democratic Localism: The Case of Grassroots Self-Governance in Urban China’, *Chinese Political Science Review*, 3(3), 129-153

Water and Wastewater International (WWI) 2017, ‘China’s desalination project tally tops 130’, 20 July, https://www.waterworld.com/articles/wwi/2017/07/china-s-desalination-project-tally-tops-130.html , accessed 26 May 2018

Water Corporation of Western Australia (WCWA) 2009, *Water Forever: Towards Climate Resilience*, WCWA, Perth, http://watercorporation.com.au/-/media/files/about-us/planning-for-the-future/water-forever-50-year-plan.pdf , accessed 27 July 2017

Water Corporation of Western Australia (WCWA) 2016, *Annual Report 2016*, WCWA, Perth

Water Environment Partnership in Asia (WEPA) 2015, ‘State of Water: Japan’, http://www.wepa-db.net/policies/state/japan/japan.htm , accessed 11 October 2018

Water Environment Partnership in Asia (WEPA) 2018, WEPA Outlook on Water Environmental Management in Asia 2018, http://wepa-db.net/3rd/en/publication/2018_outlook/wepa_outlook_report_2018_en.pdf, accessed 22 March 2019

WaterNSW 2017, ‘Farm Dams”, https://www.waternsw.com.au/water-quality/catchment/living/managing-land/farm-dams , accessed 06 April 2018

Water Politics 2017, ‘The Thirsty Dragon: New Investment Flows into China’s Water Industry’, 8 August, http://www.waterpolitics.com/2017/08/08/the-thirsty-dragon-new-investment-flows-into-chinas-water-industry/ , accessed 02 October 2017

Water Services Association of Australia (WSAA) 2016, *Climate Change Adaptation Guidelines – Project Report*, February 2016, WSAA, Melbourne

Watson Nigel 2004, ‘Integrated river basin management: a case for collaboration’, *International Journal for River Basin Management*, 2(4), 243-257

Webber Michael and Han Xiao 2017, 'Corporations, Governments, and Socioenvironmental Policy in China: China's Water Machine Assemblage', *Annals of the American Association of Geographers*, 107(6), 1444-1460

Webber Michael, Crow-Miller Britt and Rogers Sarah 2017, 'The South-North Water Transfer Project: Remaking the Geography of China', *Regional Studies*, 51(3), 370-382

Weng Lida cited in Deng Qualun 2012, 'Floods test Three Gorges Dam', 15 August, 3, https://www.chinadialogue.net/article/5108-Floods-test-Three-Gorges-Dam , accessed 13 January 2018

Wentworth Group of Concerned Scientists 2012, 'Once Again the Taxpayer Pays, Individuals Benefit and the River Loses, Plan Evaluation', *Wentworth Group*, http://wentworthgroup.org/wp-content/uploads/2013/10/Wentworth-Group-Evaluation-of-Proposed-Basin-Plan.pdf , accessed 16 March 2017

Western Australian Government (WAG) 2016, *Water for Growth: Urban*, Department of Water, http://www.wa.gov.au/_data/assets/pdf_file/0016/8521/110200.pdf , accessed 11 August 2017

Western Australian Government (WAG) 2017a, 'New water resources management legislation', *Department of Water*, http://www.wa.gov.au/legislation/water/water-resource-managemnt-legislation , accessed 09 March 2017

Western Australian Government (WAG) 2017b, 'Why we need reform', *Department of Water*, http://www.wa.gov.au/legislation/water/water-resource-management-legislation/why-we-need-reform , accessed 09 March 2017

Western Catchment Management Authority 2007, *Western Catchment Action Plan 2006-2016*, http://www.archive.lls.nsw.gov.au/_data/assets/pdf_file/0005/496697/arachive-westerm-catchment-action-plan.pdf , accessed 01 April 2017

White Phillip 2015, 'Japan's 2012 National Debate on Energy and Environmental Policy: Unprecedented but Short-Lived Public Influence', *Electronic Journal of Contemporary Japanese Studies*, 15(2), 1-20

WHO 2017, *Financing Universal Water Sanitation and Hygiene under the Sustainable Development Goals, UN-Water Global Analysis and Assessment of Sanitation and Drinking-*

Water, GLASS 2017 Report, http://apps.who.int/iris/bitstream/handle/10665/254999/9789241512190-eng.pdf , accessed 12 February 2018

WHO/UNICEF 2017a, *Progress on Drinking Water, Sanitation and Hygiene 2017*, WHO/UNICEF JMP, https://washdata.org/sites/default/files/documents/reports/2018-01/JMP-2017-report-final.pdf, accessed 11 February 2018

WHO/UNICEF 2017b, 'Water Supply Statistics – Japan', https://knoema.com/WHOWSS2018/who-unicef-water-supply-statistics?location=1001060-japan , accessed 14 October 2018

Williams John 2011, 'Coastal catchment management: the future of catchment action plans in New South Wales', *Coastal Conference 2011*, http://www.coastalconference.com/2011/papers2011/John%20Willimas%20Full%20Paper.pdf , accessed 15 March 2017

Williams John 2017, 'Turning the Tide of Water Reform', *APPS Policy Forum*, https://www.policyforum.net/turning-the -tide-water-reform/ , accessed 11 August 2017

Williams John and Grafton R Quentin 2019, 'Missing in action: possible effects of water recovery on stream and river flows in the Murray-Darling Basin, Australia, *Australasian Journal of Water Resources*, 04 March, doi:10.1080/13241583.2019.1579965

Wilson Maxwell C, Li Xiao-Lin, Ma Yu-Jun, Smith Andrew T and Wu Jianguo 2017, 'A Review of the Economic, Social and Environmental Impacts of China's South-North Water Transfer Project: A Sustainability Perspective', *Sustainability*, 9, 1489; doi: 3390/su9081489

Wilson Thomas, 'Toll Rising as Historic Rains Hit Tokyo' 2018, *The Sydney Morning Herald*, 07 August

World Bank 1994, *Governance: The World Bank's Experience*, World Bank, Washington

World Bank 2006, 'Water Resources Management in Japan: Policy, Institutional and Legal Issues', Analytical and Advisory Assistance Program, http://documents.worldbank.org/curated/en/558331468051297615/pdf/377430ENGLISH011experience01PUBLIC1.pdf , accessed 17 October 2018

World Bank 2015, *Country Opinion Survey 2015: China*, http://www.worldbank.org/en/country/china , accessed 10 February 2018

World Bank 2016, 'Empowering Farmers and Implementing Modern Irrigation Helps China Reduce Water Consumption', 18 November, http://www.worldbank.org/en/news/feature/2016/11/18/empowering-farmers-and-implementing-modern-irrigation-helps-china-reduce-water-consumption , accessed 06 November 2017

World Bank 2017, 'Water Productivity', *World Data Atlas*, http://data.worldbank.org/indicator/ER.GDP.FTWL.M3.KD , accessed 09 January 2018

World Bank 2018, 'Resilient Water Supply and Sanitation Services: The Case of Japan', https://reliefweb.int/sites/reliefweb.int/files/resources/ResilientWaterSupply-JapanCase_0.pdf accessed 08 October 2018

World Bank Global Facility for Disaster Risk and Recovery (GFDRR) 2016, 'Modernization of Meteorological Services in Japan and Lessons for Developing Countries, https://www.gfdrr.org/sites/default/files/publication/Met%20report.pdf, accessed 22 September 2019

World Commission on Dams (WCD) 2000, 'Dams and Development: A New framework for Decision-Making', https://www.internationalrivers.org/sites/default/files/attached-files/world_commission_on_dams_final_report.pdf, accessed 27 March 2019

World Commission on Environment and Development (WCED) 1987, *Our Common Future*, Oxford University Press, Oxford

World Economic Forum (WEF) 2012, *Water Security: The Water-Food-Economic-Climate Nexus*, WEF, Island Press, Washington

World Economic Forum (WEF) 2019, 'The Global Risks Report 2019, 14th Edition', http://www3.weforum.org/docs/WEF_Global_Risks_Report_2019.pdf, accessed 04 October 2019

World Water Council (WWC) 2015, 'A New Water Politics: 2010-2012 Strategy', http://www.worldwatercouncil.org/fileadmin/wwc/library/Publications_and_reports/New_Water-Politics.pdf , accessed 22 August 2017

World Water Forum 2017, ‘15th Meeting of the Committee for Basic Policy of the Water Security Council of Japan (WSCJ), 10 March, http://www.waterforum.jp/en/2017/0310/?p=4698, accessed 23 September 2019

World Water Forum 2019, ‘16th Meeting of the Committee for Basic Policy of the Water Security Council of Japan (WSCJ), 9 January, http://www.waterforum.jp/all/policy_recommendations/twj/2019/0109/?p=10552, accessed 23 September, 2019

Worrell Richard and Appleby Michael C 2000, ‘Stewardship of Natural Resources: Definition, Ethical and Practical Aspects’, *Journal of Agricultural and Environmental Ethics*, 12(3), 263-277

Wu Zhiyong, Xiao Heng, Lu Guihua and Chen Jinming 2015, ‘Assessment of Climate Change Effects on Water Resources in the Yellow River Basin, China’, *Advances in Meteorology*, http://dx.doi.org/10.1155/2015/816532

Xi Jinping 2015, ‘Speech to National Committee on U.S. China Relations’, September, http://www.chinadaily.com.cn/world/2015xivisitus/2015-09/24/content_21964069_2.htm, accessed 08 June 2018

Xia Li 2017, ‘Thirsty Power: Measuring the Water Risk of China’s Coal Industry with Mingxuan Wang’, *NewSecurityBeat*, 6 July, https://www.newsecuritybeat.org/2017/07/thirsty-power-measuring-water-risk-chinas-coal-industry-mingxuan-wang/ , accessed 06 November 2017

Xinhuanet 2017a, ‘China revises law on water pollution prevention and control’, 27 June, http://news.xinhuanet.com/english/2017-06/27/c_136399271.htm , accessed 20 October 2017

Xinhuanet 2017b, China Focus: China expands water conservation through tax reform, 30 November, http://www.xinhuanet.com//english/2017-11/30/c_136791296.htm , accessed 14 January 2021

Xu Guanghua, Xu Xianli, Tang Wanbin, Liu Wen, Shi Jing, Liu Meixian and Wang Kelin 2016, ‘Fighting against water crisis in China – A glimpse of water regime shift at county level’, *Environmental Science and Policy*, 61, 33-41

Xu Yuanchao 2017, 'China's River Chiefs: Who Are They?' *China Water Risk*, 17 October, http://www.chinawaterrisk.org/resources/analysis-reviews/chinas-river-chiefs-who-are-they/ , accessed 21 February 2019

Xu Yuanchao 2018, 'China's Water Resource Tax Expansion', *China Water Risk,* 14 February 2018, https://www.chinawaterrisk.org/resources/analysis-reviews/chinas-water-resource-tax-expansion/ , accessed 14 January 2021

Xu Yuanchao and Chan Woody 2018, 'Ministry Reform: 9 Dragons To 2', *China Water Risk,* 18 April, http://www.chinawaterrisk.org/resources/analysis-reviews/ministry-reform-9-dragons-to-2/ , accessed 21 February 2019

Xu Yuanchao, Tan Debra and Chan Woody 2018, 'Two Sessions, Five Highlights for Water', *China Water Risk,* http://www.chinawaterrisk.org/resources/analysis-reviews/two-sessions-five-highlights-for-water/ , accessed 21 February 2019

Yamaoka Kazumi 2016, 'Importance of Institution and Organization for Sustaining Irrigation and Drainage System Management in the Future – Lesson Learned from Practice in Japan', https://www.icid.org/ppts/wgioa_ppts_3.pdf, accessed 17 September 2019

Yang Xiankun and Lu Xixi 2014, 'Drastic change in China's lakes and reservoirs over the past decades', *Scientific Reports*, 4, Article no 6041; doi: 10.1038/srep06041

Yao Liuyang, Zhao Minjuan and Xu Tao 2017, 'China's Water-Saving Irrigation System: Policy, Implementation and Challenge', *Sustainability*, 9(12), 2339 doi:10.3390/su9122339

Young Bill and Prosser Ian 2011, 'Introduction' in Ian Prosser (ed.), *Water: Science and Solutions for Australia*, ix-xiv, CSIRO, Collingwood

Young Mike 2011, 'Longevity of basin key to success', *Australian Financial Review*, 28 November, 61

Young Mike 2013, 'Designing water entitlement regimes for an ever-changing and ever-varying future', *SEPIO Conference*, Paris, 18 June, http://laep.univ-paris.fr/SEPIO/SEPIO130618Young.pdf , accessed 22 August 2017

Yu Keping 2014, ‘Restructuring the Relations between State, Market and Society in China’, *China/US Focus*, October 29, https://www.chinausfocus.com/political-social-development/restructuring-the-relationship-between-the-state-the-market-and-society-in-china , accessed 19 November 2017

Yu Lili, Ding Yueyuan, Chen Fei, Hou Jie, Liu Guojun *et al* 2018, ‘Groundwater resources protection and management in China’, *Water Policy* (Oxford), 20(3), 447-460

Yu Xiaoman, Geng Yong, Heck Peter and Xue Bing 2015, ‘A Review of China’s Rural Water Management’, *Sustainability*, 7, 5773-5792

Zeitoun Mark 2011, ‘The global web of national water security’, *Global Policy*, 2(3), 286-296

Zeitoun Mark, Lankford Bruce, Krueger Tobias, Forsyth Tim, Carter Richard, Hoekstra Arjen Y, Taylor Richard, Varis Olli, Cleaver Frances, Boelens Rutgerd, Swatuk Larry, Tickner David, Scott Christopher A, Mirumachi Naho and Matthews Nathaniel 2016, ‘Reductionist and integrative research approaches to complex water security policy challenges, *Global Environmental Change*, 39, 143-154, doi: 10.1016/j.gloenvcha.2016.04.010

Zhang Chunman 2017, ‘Review Essay: How to Merge Western theories and Chinese Indigenous Theories to Study Chinese Politics? *Journal of Chinese Political Science*, 22, 283-294

Zhang Hongzhou 2015, ‘China-India: Revisiting the Water Wars Narrative’, 30 June, https://thediplomat.com/2015/06/china-india-revisiting-the-water-wars-narrative/, accessed 03 May 2018

Zhang Hongzhou 2016, ‘Sino-Indian water disputes: the coming water wars?’ *WIREs Water*, 3, 155-166

Zhang Hongzhou and Li Mingjiang 2017, ‘Thirsty China and its transboundary waters’, in Hongzhou Zhang and Mingjiang Li (eds.) *China and Transboundary Water Politics in Asia*, Routledge, New York, 3-24

Zhang Qingfeng, Kobayashi Yoshiaki, Howell Melissa and Zheng Yong 2012, ‘Drying Up: What to do about droughts in the People’s Republic of China’, *Asian Development Bank*, https://www.adb.org/publications/drying-what-do-about-droughts-peoples-republic-china , accessed 08 May 2018

Zhong Ma 2014, 'Fundamental Issues: Industrial Wastewater', March 12, *China Water Risk*, http://chinawaterrisk.org/interviews/fundamental-issues-industrial-wastewater/ , accessed 28 September 2017

Zhou Gangyan 2010, 'Water Resources Management in Yangtze River Basin', *1st Mekong River Commission Summit*, http://www.mrcsummit.org/1stmrcsummit/Presentations/3-6_Zhou-Gangyan-Water-Mgt-in-Yangtze-River-Basin.pdf , accessed 14 November 2017

Zhu Yongnan, Lin Zhaohui, Wang Jianhua, Zhao Yong and He Fan 2016, 'Impacts of climate changes on water resources in Yellow River Basin, China', *Procedia Engineering*, 154, 687-695

Zuo Qiting, Liu Huan, Ma Junxia and Jin Runfang 2016, 'China calls for human-water harmony', *Water Policy* (Oxford), 18(2), 255-61

APPENDIX

WATER PLANNING IN AUSTRALIAN JURISDICTIONS

1.0 New South Wales (NWC 2014a: 6-12; NRC 2014: 1-20)

The State *Water Act 2000* establishes the statutory framework for managing more than 95% of the state's water and the development of water sharing plans. These plans cover regulated and unregulated rivers and groundwater and span one or more water management areas. Later plans aggregate water management areas into macro-plans. Water sharing plans were first developed in NSW in 2004, though many were revised in the period 2004-2013. By 2013, water sharing plans covered 95% of the state's regulated and unregulated rivers and groundwater. The plans involved stakeholder consultation in their development and drew, to varying degrees, on scientific and socio-economic studies and public consultation. The plans establish the rules for licensing, water allocation including for environmental water, management and accounting and trade. The plans are audited every 5 years and extended or replaced after a 10 year review.

The period 2014-2016 has seen replacements developed, notably for major regulated river system; incorporation of smaller plans into existing plans for large water sources; and, the introduction of new water sharing plans (Office of Water 2016: 2-4). Priorities have been revisited and water modelling updated. The changes are directed at improving 'operational efficiencies', assuring 'consistency across plans', providing greater certainty for consumptive users, and at simplifying and improving the implementation of water plans (Office of Water 2016: 2-4). In 2019, some plans had been replaced or extended but many had not been audited after 5 years as required.

1.0.1 Catchment Planning and Management in NSW

NSW has a regional model for natural resource management which comprehends all natural resources including water. Catchment Management Authorities were established under the *Catchment Management Act 2003* and were charged with the responsibility of developing Catchment Action Plans to guide management of each region's natural resources. The plans were assessed by the state Natural Resources Commission (NRC) and further refined both as a result of those assessments and new requirements under 'NSW 2021' (NSWG: 2011a), a whole of state plan for the years 2011-2021. The catchment action plans represented a shared vision of regional priorities and values, focused on maintaining landscape health, whole system resilience and adaptive management (Williams 2011: 2-3). As part of plan development, the community was encouraged to become heavily involved in improved land and natural resource stewardship in their region. The plans included strategies to deal with surface and groundwater systems and wetlands and their various ecosystems.

In January 2014 the Catchment Management Authorities were merged with other functions, to become Local Land Services and the catchment action plans were amalgamated and revised. Under a new State Strategic Plan 2016-2026 (NSWG 2016), the focus of the revised catchment action plans became sustainability of primary production and sound natural resource management, still designed to deliver 'productive landscapes and resilient communities' NSWG (2016: 6-10). While, the NRC continued as the agent of independent assessment of performance and advice under this new regime, the state focus tended to emphasise land over water. The combined land services do not operate within catchment boundaries (NSWG 2016: 6-10). The APC (2017: 151) considers the change to have weakened water-related natural resource management goals associated with water planning.

1.1 Queensland (NWC 2014a: 265-274)

Queensland is responsible for 20% of the nation's water use. In the south-east water resource systems are highly developed while in the far north they remain essentially in their natural state (NWC 2014a: 265). The Queensland *Water Act 2000* provides the management and planning framework for most of the state's water resources, while some river resources are covered by *Wild Rivers Declarations*. There are two types of water plans developed under the provisions of the Act, namely resource operation plans, usually at the catchment level, and subordinate water resource plans (NWC 2014a: 266). The former specify strategies, outcomes and operational and trading rules, while the latter guide water management and implementation of specified requirements. These plans have been developed drawing on some hydrological, environmental and socio-economic studies and public consultation. The plans and are generally subject to review every ten years (NWC 2014a: 267). In the same time frame the government has developed a 30 year strategy to address the challenges associated with significant population growth and the associated increased demand for water (AWA 2016: 11).

In the period 2014-2017, the Queensland Government introduced the *Water Reform and Other Legislation Amendment Act 2014,* the Water Regulation 2016 and new requirements involving Water Management Protocols and Operating Manuals (DNRM 2017: 1-4). A prime objective is to replace water resource plans with water plans that are capable of providing more efficient, flexible and responsive water planning frameworks. The new plans draw on scientific and technical assessments and broad community consultation. From the standpoint of water security for the environment, the objective is to ensure all water is allocated strictly within sustainable limits. Rules have been established aimed at securing ecological and social outcomes and at providing guidance to managers as to how to achieve these outcomes. Water security for industry has involved clear definition of the amount of water available for consumptive purposes by town water supply, primary and secondary industry. Rules have also been developed and specified for water sharing, water trading, future water allocations, water release from dams and trading zones. The effectiveness of each plan is to be assessed in terms of specified outcomes during its 10 year life-span. Water entitlements have been converted into ‘water entitlement notices’ with provision for conversion, grant, amendment, refusal or cancellation of these notices. It is too soon to gauge the effects of these extensive changes on planning effectiveness and water security.

1.1.1 Catchment Planning in Queensland

In Queensland, water plans for each of that states 23 river catchments must meet new requirements (Queensland Government 2017: 3-4; 2018a: 1; 2018b: 1-2; 2018c: 1). Each plan must be underpinned by a good understanding of the river system, its physical attributes, hydrology, geomorphology, environment and ecosystems. Economic and social assessments are called for and catchment threats, including from human use, are to be assessed and ranked. Stakeholders, Aboriginal peoples, conservationists, local government and industry are all to be consulted and draft plans circulated for public comment before finalisation. It is too soon to judge the outcomes of these requirements.

1.2 Victoria (NWC 2014a: 206 – 214)

Victoria accounts for some 20% of water usage in the nation (NWC 2014a: 206). It has a complex, but sophisticated approach to water resource management and planning under several statutes. The *Water Act 1989* creates the broad framework for management and allocation of the state’s water resources. The state confers priority on the ‘resource security’ of ‘existing rights and entitlements’ (NWC 2014a: 207). Victoria has developed statutory plans at multiple levels that collectively guide water planning, as opposed to a single instrument that meets NWI criteria. The statutory hierarchy of planning involves, *inter alia*, state water strategies that deal with risks to the state’s water resources; bulk water allocation instruments providing authority and entitlements to major water suppliers; and, local management plans that control water allocations from unregulated rivers and groundwater resources. Plans have been developed in a consultative manner with stakeholders and communities, supported by environmental and socio-economic studies leading to assignment of consumptive and bulk water entitlements. Proposed changes to the act, water planning and management did not proceed in the period 2014-2016 (Victorian Government 2016a: 1). Later, the Victorian Government (2018) announced that it had embarked on a long-term assessment of water available in Victoria, waterway deterioration and the impacts of climate change, including on existing planning.

1.2.1 Catchment Planning and Management in Victoria

The Victorian catchment management Council (VCMC) is an independent body established under the *Catchment Land and Protection Act 1994* (VCMC 2016: 1). Under the Act 10 Catchment Management Authorities (CMAs) must prepare strategies to accord with VCMC guidelines. Each CMA is in principle governed by concepts of sustainable development, integrated, whole-of-catchment management, community empowerment, securing targeted investment and meeting tests of accountability and administrative efficiency (DELWP 2016: 3). Every five years the VCMC must prepare a report on the condition, quality and management of land and water resources in Victoria (VCMC 2016: 2). In 2012 the Council found that it was not able fully to assess what condition catchment resources needed to be in in order to deliver both land productivity and environmental sustainability (VCMC 2012: 6). In practice most Victorian CMAs are confronted by the pressing problem of achieving a balance between catchment productivity, on one hand, and protection and restoration of aspects of catchment land and water systems, on the other. There is as a consequence little emphasis on systemic and integrated catchment management underpinning improved water security for all users and for the health of the hydrological cycle.

1.3 South Australia (NWC 2014a: 337-343)

'South Australia is the driest of the Australian States and Territories' (NWC 2014a: 337). Most of the state's scarce and highly developed water resources lie in the south of the state. The state has a hierarchy of plans, established under the *Natural Resources Management Act 2004*, which affect water planning, through a natural resources management plan, regional resource management plans, and statutory water allocation plans. The latter plans provide the framework for management of extractive limits, allocations, approvals, environmental water, monitoring and reporting. The plans have been established through stakeholder and public consultation with scientific inputs on key water resource variables and must be reviewed and amended, if necessary, every 10 years.

The state has developed several overarching plans including a natural resources management plan for 2012-2017, ‘Water for Good: A Plan to Ensure the Water Future to 2050’ and a Five Year Work Plan for Water Resource Management, which is updated annually since its inception in 2014 (South Australian Government 2010, 2017). The focus in water resources planning lies on the need for the state to deal with CSIRO projected declines in state rainfall by 15 to 30%, less rainfall run-off from the Mount Lofty Ranges and national over-allocation of River Murray water. A mix of responses are anticipated including greater reuse of stormwater and wastewater, desalination and better domestic demand management.

1.4 Western Australia (NWC 2014a: 395-400)

Much of the population and the primary industry of Western Australia are located in the south-west coastal belt, whereas most of the mining and petroleum developments lie in the north-west. The state is primarily dependent on groundwater availability. The limited available surface water is accessible and used in the state’s ‘developed regions’ (NWC 2014a: 395-396). Water resources are proclaimed under the *Rights and Irrigation Acts 1914*; *2000*. They provide the primary legislative basis for administration of proclaimed water resources, water rights and entitlements and for implementation of water allocation plans (NWC 2014a: 396). The extraction of water from proclaimed water resources and artesian aquifers is statutorily licensed, though licensing is guided by non-statutory water allocation plans. These plans are prepared if the government gives the resource priority, if demand is projected to increase rapidly and if at least 30% of the resource has been allocated (NWC 2014a: 399). The complexity of scientific assessments and risk identification varies, as does stakeholder, public and indigenous community consultation.

The state government has assessed urban water demand to 2050 and set out principles to improve demand management and efficiency, while calling on the three tiers of government to work with the private sector to build the state’s ‘future water security’ (Western Australian Government 2016: 3). The government has begun drafting a Water Resources Management Bill, based in part on a position paper aimed at securing the state’s water future under which six acts would eventually be consolidated into one (Western Australian Government 2017a: 1; 2017b: 2).

1.5 Tasmania (NWC 2014a: 458-462)

Tasmania occupies less than 1% of the nation's land mass but has 12% of its fresh water resources (NWC 2014a: 458). Given its small and rather dispersed population and heavy reliance on agriculture, Tasmania has, through all levels of government, been provided with considerable funding for municipal water and wastewater treatment and irrigation infrastructure (AWA 2016: 10). Water availability is under most pressure in the state's more developed central and eastern regions. The statutory basis for planning, management, allocation, regulation and protection of water resources is provided by the *Water Management Act 1999*. Under the Act, the preparation of water plans is discretionary. Water is largely extracted from surface water systems for primary industry, irrigation, power generation and domestic supply. Allocation and extraction of water are managed under plans which have been developed in consultation with stakeholders and the community for those priority areas where there is greatest competition and demand, often for new irrigation. Water plans must take account of the State Policy on Water Quality Management 1997, the state's sustainable development objectives, and Standard Operating Procedures 2010 (NWC 2014a: 459). Socio-economic assessments have been made for some plans.

1.6 Northern Territory (NWC 2014a: 509-514)

In the north of the Northern Territory there are dramatic changes in climate from wet, when water for consumptive use is extracted from both surface and groundwater and dry when groundwater is the principal source. The state has an arid centre and while there are sporadic flows in the south, groundwater is the source for consumptive uses. The territory's water resources are 'under relatively little pressure', and none of the water sources are regulated (NWC 2014a: 509). The primary instrument for water management is the *Water Act 1992* under which investigations and assessments are made, entitlements and allocations secured and controls introduced. Water for mining and petroleum development is managed under separate legislation though a measure of integration is achieved in water management. Water allocation plans have been developed for water control districts, at Ministerial discretion, which 'establish the area and water resource to which a plan applies' (WMC 2014a: 510). Plans must be reviewed within 5 years and licences to extract water commonly have a period of 10 years. Consultation occurs though the medium of water advisory committees reflecting governmental, industrial, environmental and community and indigenous interests. A number of further plans existed in draft form in 2013. In 2015 the government released a Discussion

Paper for public review dealing with pressures on water as a result of projected population growth and economic development and setting out draft objectives, priorities and principles (NTG 2015: 1-7).

1.7 Australian Capital Territory (NWC 2014a: 498-506)

Surface water resources in the ACT are mostly shared with NSW and have been highly modified by land use, dams, and water discharges. In fact, the ACT lies wholly within the catchment of the Murrumbidgee River. The climate is variable leading to long dry period and occasional flooding (NWC 2014a: 498). Water resources are allocated for consumptive use and the environment under the *Water Resources Act 2007*. Water security for the ACT is guided by a policy document entitled ‘Think water, act water (2004)’. It guides public consultation, supply security, urban amenity and improved ecological values (NWC 2014a: 499). Water sharing plans, developed under subordinate legislation to the above Act, detail extractive volumes for surface and groundwater in specified areas. Environmental flows are determined in accordance with the Environmental Flow Guidelines 2013.

In 2014 the ACT government released a long term water strategy directed at maintaining healthy water sources and catchments, assuring sustainable water supply, maintaining water quality and water-based ecosystems in the same or better quality after water passes through the territory and protecting the water cycle through better urban management (ACT 2014: 2). The strategy addresses both projected population growth and climate change and is subject to review every 5 years.