**WATER TAXES: A SYSTEMATIC LITERATURE REVIEW WITH APPLICATION TO AUSTRALIA AND NEW ZEALAND**

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**ABSTRACT:** Water is a scarce resource in many parts of the world while other parts of the world have abundant water, but it is of relatively poor quality. In Australia there is strong competition for water, which was managed through engineering works to control its supply until water markets were adopted in the late 1990s. By way of contrast, water is abundant in many places in New Zealand, but there are issues with its quality. While there is significant professional and academic literature regarding these and other water issues, most of it ignores the effect of tax. This is notable given that water taxation affects the pricing on which water markets are based. Without an appropriate price for water, it can be misallocated, leading to inefficient use. However, research into water quality has not significantly considered the role of economics, let alone taxes. Furthermore, what research does exist appears to have had little influence in water policy in Australia and New Zealand.

Despite the relative paucity of water tax research and its apparent lack of impact, it has the potential to make a significant contribution to water issues such as efficiency and water quality. The purpose of this paper is to undertake a systematic review of the literature of water so that the research undertaken so far can be consolidated, lessons can be identified for New Zealand and Australia, and future directions for research can be recommended.

We find that the number of articles on water and taxation has increased markedly over the last 10 years, suggesting that the area is increasing in importance. Many of the articles are situated in developing countries, with only two in Australia and none in New Zealand. We observe that many articles are econometric studies that develop theoretical models of water taxes with the aim of achieving greater efficiency of water use and associated environmental benefits while others study real water taxes in the local context. We observe the breadth of topics covered in extant water tax research while equally noting an absence of depth. This is perhaps indicative of the infancy of the topic.

There is general support for water taxes in the literature, with regard to a taxes potential to both decrease water usage and improve water quality. However, this support is highly contingent on a range of factors, including design of the tax, how tax collected is used, and economic and social impacts. The review demonstrates that more studies are required to determine the impact of water taxes in actual environments, particularly in Australia and New Zealand. Furthermore, there needs to be more research on nature of the tax itself, how it is drafted and how it interacts with other taxes to ensure that benefits from water taxes are optimised.

# Introduction

Water has multiple characteristics that justify research attention on the subject. These characteristics include that it is essential for survival; it is unevenly distributed; and it is a key factor of production in many industries (Neal, Lukasiewicz and Syme, 2014). Unique and valuable habitats reside in water (European Commission, 2019). Globally, demand for water is increasing while water availability is decreasing due to ecosystem degradation, climate change, and increased extraction by the agriculture and industrial sectors (Zwarteveen and Boelens, 2014; Munguia-Lopez, Gonzalez-Bravo and Ponce-Ortega, 2019). Water shortages have wide ranging impacts from electricity provision (Radcliffe, 2018) to food security (Qureshi, Hanjra and Ward, 2013). There is the potential for much conflict in water allocation, where multiple competing objectives have the potential to result in inefficient or inequitable distribution.

Despite the importance of water, there has been relatively little research attention paid to the subject from a tax perspective. As water is arguably the most important natural resource that must be managed, research is needed to ensure that decisions on this management can be made using data generated from robust scientific methods.

There is no shortage of research on water quality. Indeed, an entire New Zealand-based journal has published four issues a year solely on marine and freshwater research since the late 1960s. However, the primary focus of research has been on broader aquatic science through a range of lenses, including ecology, biodiversity, physical oceanography, hydrology, aquatic chemistry and aquaculture, among others. Disciplines such as economics or taxes have not made a significant contribution to the academic debates in New Zealand. Significant amounts of water research also originate from Australia and while economics has informed this research in more recent times, a tax perspective is lacking.

There are many ways to try to control the use of water, including taxes, subsidies, quotas, market instruments such as tradeable permits, voluntary agreements or regulation (OECD, 2006; Esteban and Dinar, 2013). This study focuses on the first of these – the use of water taxes.

There are many ways in which tax is connected to water. Perhaps the most obvious is with regard to pricing. Taxes may be used to impact on price signals to attempt to change behaviours around water consumption or to encourage investment in water infrastructure. Taxes can be used as a sanction for inefficient or unsustainable use. Taxes can also be used where there is a market failure, such as externalities in the form of environmental costs. Economic theory proposes that a socially optimal level of harm, such as overuse of water, can be achieved by ensuring that economic participants pay the full cost of the harm generated by their actions (Coeck, S’jegers, Verbeke and Winkelmans, 1995).

In this article we undertake a systematic literature review to examine the extant scholarly literature on water taxes. A systematic review is a review of the literature that provides an account *“in a domain that is comprehensive, capable of replication, and transparent in its approach”* (Bryman, 2008). We adopt this method to compile, synthesise and critique extant literature with the aim of providing an assessment of the extent and quality of evidence relating to water taxes (Siddaway, Wood and Hedges, 2019). While our study is situated in Australia and New Zealand, we explore the international literature on water taxes to assess what may be learned for both our specific jurisdictions and as a more general contribution to knowledge.

We address three research questions in this study. First, what are the key tax and water issues that have been examined in the literature and where are the gaps? Second, what lessons may be learned by Australia and New Zealand from this literature? Third, what is the future for water tax research?

New Zealand and Australia are used in this study as they both have specific water issues and the tax system has not been used to address the issues in either country. In Australia, the primary issue is water shortages in certain locations. In New Zealand, the primary issue is poor and declining water quality.

The study is structured as follows. We commence in section two with a background of the particular water issues that exist in Australia and New Zealand. Section three follows, which outlines the systematic literature review method used in this article. Section four provides a synopsis of this literature, which is then analysed further in section five. Our conclusions are drawn in section six.

# Background

One of the primary issues pertaining to water is water quality. Water quality can be impacted by the presence of nutrients (e.g. nitrogen), which in turn is impacted by factors such as land usage and water networks (e.g. wastewater and stormwater networks). A further important issue is water scarcity and the need to encourage efficient and effective usage. This section will provide background with respect to these two issues and how they affect Australia and New Zealand respectively.

## 2.1 Australia

Australian water policy and associated research is most commonly driven by scarcity and variability with quality being an important, but secondary, consideration. While Australia is a relatively dry continent, problems arise from water being in the wrong place or coming at the wrong time (Musgrave 2008). Since the Murray-Darling Basin (MDB) contains Australia’s major river system, covers five mainland states and territories and produces one-third of Australia’s agricultural output (Crase, 2008; Wheeler, 2016), water policy tends to be focused on that region. The use of water in the MDB for competing agricultural, domestic and environmental purposes has been a contentious issue for some time with accusations that decisions on these matters are made on political rather than scientific grounds (Murray-Darling Basin Royal Commission, 2019).

British settlers brought with them riparian rights giving irrigators access to and the use of water associated with their land providing they did not interfere with other landowners (Musgrave, 2008). This situation existed for nearly 100 years until the Irrigation Act (1886) and subsequently the Water Act (1905) reduced riparian rights of individuals and placed more control of water with the States where water could be used by individuals under a licence (Musgrave, 2008). With water under the States’ control, irrigation spread throughout the MDB supported by major engineering and water storage works (Musgrave, 2008) The objective was to control water supply using supply side policy based on engineering, which led to the development of significant infrastructure such as dams to store and conserve water. The infrastructure was subsidised either directly, through grants, or indirectly, through advantageous tax treatment (Crase, 2008).

In the latter half of the 20th Century, the contribution of agriculture and irrigation to Australia’s overall prosperity came under increasing scrutiny (Crase, 2008; Musgrave, 2008) As the century wore on, it became increasingly clear that engineering-based solutions to water scarcity had reached the peak of their effectiveness and concerns about the sustainability of water extractions from the Murray River vis-à-vis the environment and degradation of the river’s water quality grew stronger (Crase, 2008; Cooper, Crase and Pawsey, 2014; Musgrave, 2008). Various reforms were implemented on a progressive basis to address these concerns. One major reform was the establishment of water property rights and the establishment of a water market with the aim of allowing water to be allocated towards its highest level use (Crase, 2008).

Australian water reforms have also impacted the domestic market, perhaps the most significant being the change from charging for water based on a person’s domestic property value to a charge based on cost of the water and its supply (Sibly, 2006). Debate remains regarding the appropriate structure of the tariff with equity considerations resulting in tiered tariffs where water is charged at progressive rates with two, three or four tiers (Crase, O’Keefe and Burston 2007; O’Keefe and Crase, 2009). In times of drought, consumers have been subject to water restrictions leading to issues with compliance, avoidance and enforcement (Cooper, Burton and Crase 2011).

While water markets and other reforms are generally regarded as a success (Crase, Pawsey and O’Keefe, 2013), further work must be done to improve their efficiency (Pawsey and Crase, 2013; Hughes, Gupta and Rathakumar, 2016) and evaluate the effectiveness of associated reforms that support water markets such as integrated water resources management. With respect to water markets, examples of this work, including removing or reducing transaction costs (Loch, Wheeler and Settre, 2016) and achieving best practice water pricing (Cooper, Crase and Pawsey, 2014) is ongoing. New systems and frameworks, such as Integrated Water Resources Management, are being adopted to facilitate these improvements and the effectiveness of these frameworks is being continuously evaluated (Crase and Cooper, 2015).

## 2.2 New Zealand

Unlike Australia, New Zealand in general does not have a shortage of fresh water.[[3]](#footnote-3) Instead, the primary issue with water is water quality. Water quality is important not only for usage and consumption by individuals, but also for the support of freshwater ecosystems. In New Zealand, many of the activities that support the tourism sector rely on good water quality (Ministry for the Environment, 2017).

Debate on issues relating to water quality has become more prevalent in New Zealand in recent years. The causes of poor water quality are multiple, and include: clearing of native vegetation, the draining of wetlands, farming, forestry and urbanisation (Ministry for the Environment, 2017). Research shows that nitrate pollution is worsening in New Zealand rivers (Ministry for the Environment, 2017).

A large proportion of water in New Zealand is used for irrigation. More than half of water allocated or consented to by councils is for irrigation (although this may not all be utilised) (Ministry for the Environment, 2017). Household consumption accounted for 14 per cent of water usage, while industry accounted for 13 per cent (Ministry for the Environment, 2017).

As noted by the Ministry for the Environment (2017), it is not possible to provide a New Zealand-wide explanation for water quality issues, as land usage differs widely across the country. However, there is a general trend of increasing river pollution, as measured by nitrate-nitrogen concentration. The most recent report in 2017 shows that nitrate-nitrogen concentration in rivers was 18 times higher in the urban land-cover class, and 10 times higher in the pastoral class, when compared with the native class for 2009-13 (Ministry for the Environment, 2017). The same report also shows that of 175 monitored river sites that were classified as pastoral, nitrate-nitrogen levels were worsening at 61 per cent. Nitrogen leaching from agricultural soils was estimated to have increased 29 per cent in the period from 1990 to 2012 (Ministry for the Environment, 2017).

The agricultural sector is frequently charged with practices that impact negatively on water quality. Research suggests that these accusations are not without merit (Joy, 2015; Monaghan et al, 2007; Quinn and Stroud, 2001; Wilcock et al, 1999). Agriculture has intensified since the late 1970s in New Zealand, which has contributed to diffuse pollution (Ministry for the Environment, 2017). However, in New Zealand there are no economic instruments in place to address this issue.

Examples include additional targeted taxes on inputs such as fertilisers, or taxes based on water usage or pollution. At the current time New Zealand has an Emissions Trading Scheme. All sectors of the New Zealand economy are required to report on their emissions, with the exception of biological emissions from agriculture.

While there are no water taxes in New Zealand, homeowners pay local “rates” that cover the cost of water infrastructure and supply. In some locations, households are charged water rates calculated by water usage and in other locations the amount is a proportion of the land and property value.

# Research Method

We undertake a systematic literature review to locate all relevant published work on water taxes. While all literature reviews need to be systematic, the term “systematic review” has a more technical meaning, as it refers to a particular approach to inquiry developed from the evidence-based movement in professional practice and policy (Punch, 2014). As such, a systematic review seeks to answer questions in its own right, rather than serving as the basis to establish the state of a body of knowledge or establish a knowledge gap.

While literature reviews are frequently used to help with the complexity of a substantial body of literature, in the case of water taxes the literature is sparse. Nevertheless, we compile research undertaken to date, identify the primary topics that have been the focus of research studies and draw conclusions on the issues that have warranted research. We also apply the results of the literature review to our two jurisdictions of interest, Australia and New Zealand, to identify and apply specific matters that are relevant to these two countries.

Systematic literature reviews have a number of benefits including their methodical and replicable methodology (Siddaway, Wood and Hedges 2019); minimisation of bias through a comprehensive search of studies (Massaro, Dumay and Guthrie, 2016); and the transparency associated with documented processes used. In this study, we follow the structured literature review approach adopted by Whait et al. (2018) and supplement this with insights from Massaro, Dumay and Guthrie (2016).

The literature review was undertaken between February and July 2019. We used a simple search protocol, using the term “water tax”. We limited our search to research articles written in English when both words were used as a phrase in the title, abstract or keyword of the article.

We used a two-phase review process. In the first review, one author examined the abstracts of all the research articles. At this first review, many studies were excluded as they did not directly relate to the topic of the study. For example, studies on sugar taxes, where drinking water is suggested as an alternative to sugar-sweetened beverages, were prevalent in the initial search.

Our study includes taxes that are intended to impact on water quality and water management, as well as water usage. As our focus is on studies that report on original research on taxes and water, we excluded studies that did not do this. For example, one article was a historical case study that included discussion on a water tax. Other studies were on the impact of a water tax on plastic consumption, e.g. introducing a tax on bottled water in order to change behaviour on purchases of beverages in plastic bottles. These are also not discussed further in this study.

We excluded seven studies from the 1970s that were published in German trade journals. We excluded these as we were not able to access the full articles. The articles all discussed the same topic, which was the introduction of a waste water tax. A further three articles had English titles but were written in German. These were also excluded. The total of articles resulting from the literature review was 40 articles. The majority of the journals focus on economics, engineering, environmental management or agriculture.

We used nine academic databases, with a final search through Google Scholar to ensure all relevant articles had been captured. The Google Scholar search produced one more article. Table 1 outlines details of these databases, together with the total number of research articles found in the search.

**Table 1: Number of Articles**

|  |  |  |
| --- | --- | --- |
| **Database** | **Total Number of Research Articles** | **Research Articles after Review** |
| Science Direct | 11 | 9 |
| Scopus | 40 | 13 |
| EBSCO Host | 20 | 3 |
| Emerald Insight | 1 | 1 |
| JSTOR | 1 | 0 |
| ProQuest | 20 | 0 |
| SpringerLink[[4]](#footnote-4) | 83 | 4 |
| Taylor and Francis Online | 2 | 1 |
| Wiley Online Library | 30 | 8 |
| Google Scholar1 | 3,640 | 1 |
| **Total** | **3,848** | **40** |

The 40 articles were read in full with relevant extracts transferred to a table (Whait et al (2018). As a further check, references from these articles were investigated to assess whether additional sources were relevant for inclusion in the review. This exercise resulted in a further 10 articles added to the total. This resulted in the 50 articles used in the analysis. Appendix 1 provides details of the 50 articles used in this study.

The 50 articles were coded in NVivo 12. Coding was undertaken by both researchers independently to minimise subjectivity. Following Whait et al. (2018) an inductive approach was adopted. The output of the coding facilitated identification of the themes. After separate coding, key themes were agreed by the authors, which were then used for analytical purposes. This process also allowed us to identify some gaps in the literature. Section five reports on these findings.

The recent increase of interest in the topic of water taxes is visible with reference to the years of publication of water tax articles. Figure 1 outlines this information, which shows that 24 articles (48%) were published in the period from 2010 to 2019.

**Figure 1: Dates of Article Publication**

Publications came from a wide range of journals, with 42 different journals contributing to the 50 publications.

Research on water taxes was undertaken in a range of regions. These are outlined in Figure 2. There are fewer locations shown in Figure 2 (35) than studies used in this review, as some articles were theoretical modelling studies and were not situated in a specific location.

**Figure 2: Locations of research**

The methodologies used in water tax research are shown in Figure 3. As is visible, the predominant method is economic modelling, either theoretical or empirical. There were a small number of other studies that included methods such as an experiments. Some articles were largely descriptive, including those that engaged in legal or policy analysis, or case studies. A small number of other approaches were coded as ‘other’ empirical studies such as surveys, a chemical study, trend analysis and other techniques. Most studies used only one method. However, 2 studies used multiple methods, which is reflected in Figure 3 (Articles 401 and 709).

**Figure 3: Methodologies used in water tax research**

# Literature

This section outlines the key themes that developed from our review of the literature. We include reference to the specific articles in these sections by including the numbers that we used as references to each article. Appendix 1 provides detail on these numbers. What is perhaps most evident from the range of literature examined, was the breadth of topics that are linked to water taxes. In general, there was support for water taxes (Articles 1, 3, 7, 139, 207, 209, 210, 304, 401, 502, 601, 705, 908, 909, 910). However, this support was highly contingent on a range of factors, including design of the tax, how tax collected was reinvested, and economic and social impacts.

We coded the 50 articles into their primary level of focus. Most studies permitted a single code, although seven are coded into two categories (Articles 1, 7, 13, 504, 902, 904 and 905). A number of high-level themes can be drawn from the studies examined. The three themes most frequently highlighted were tax design, effectiveness of policy instruments and water saving/water efficiency (each with 11 studies). A smaller number of studies had a primary theme of water quality (7 studies), pollution (7 studies), water pricing (4 studies), agriculture/food (4 studies) and other economic factors (3 studies). The high-level themes are outlined in Table 2 and the first eight of these themes are used to frame the following discussion.

**Table 2: Key themes from the literature**

|  |  |
| --- | --- |
| **Theme** | **Number of articles** |
| Tax design | 11 |
| Effectiveness of policy instruments / behavioural change | 11 |
| Water saving / water efficiency | 11 |
| Pollution / water quality | 7 |
| Food and agriculture | 4 |
| Water pricing | 4 |
| Other economic factors | 3 |
| Triple dividend | 2 |
| Benefit from water taxes | 2 |
| Electricity | 1 |
| Irrigation | 1 |

## 4.1 Tax design

The most common theme that arose from the studies examined was discussion on tax design. We discuss these below under the headings of the primary discussion topics, including: types of taxes; the size of the tax; incentives to invest in technology; hypothecation; sector design; information asymmetry; and practicalities associated with water taxes.

### Types of taxes

Articles discussed a range of tax types including user charges and property taxes (708), a waste control tax and a sanitary tax (12), a differential water tax (3), a lump sum tax (304), and a volumetric tax (703, 704, 707). Each tax has advantages and disadvantages. A waste control tax was argued to be lower than a sanitary tax but was found to not encourage investment in wastewater treatment and water savings. However, a sanitary tax encouraged investment in effluent decontamination and improved water quality (12). While a user charge based on a property tax was relatively simple, the tax burden would shift to those with higher value properties and not impact on incentives to change behaviour (708). A differential water tax(3) was described as the “most efficient” and superior to either a quota system or a uniform tax instrument. A lump sum tax was a concession to the practicalities associated with measurement and monitoring of a volumetric tax (304).

A further view is that property owners should pay for water based on the increased value of a property due to availability of water to that property (708). In effect, the tax would fund the capital cost of water and the property value would determine water taxes paid, rather than use of water. While a charge based on land size would be simple, it is likely to result in inefficient allocations (907). A further option is to tax inputs that lead to poor water quality, such as a tax on fertiliser (907).

A volumetric tax is essentially a user-pays tax. There was support for such a tax where a single volumetric price set at marginal cost was proposed to be the most efficient tax to result in optimal allocation of scarce water (703, 704, 707, 908). Moreover, the effectiveness of a tax was argued to be contingent on achieving the correct estimation of the marginal tax level (908). There was support for the suggestion that simple taxes, based on one variable such as water input, are reliable (211). Conversely, an argument was made that a differentiated tax was preferable to allow for local differences, such as different groundwater levels (908).

While the focus of our study was on water taxes, it was noted that some studies engaged in discussion on alternatives. Typically, it was reported that taxes perform better than alternatives, such as voluntary agreements, land zoning, subsidies or water allocations. However, one article found that reducing water allocations was a more cost-effective policy than a water tax (501). It was also reported that greater gains are available when a package of tools is implemented (3).

One study (801) related a less precise finding, reporting on water demand management policies collectively, including educational policies and domestic water-savings technologies, together with water taxes and tariffs. This research reports that demand management practices may be insufficient, due to other structural changes in urban development that are leading to increased demand on water (such as increased numbers of households).

The type of tax introduced will be contingent on the overall policy objective. Articles noted that if the only objective was to reduce water use, then specific sector taxes would be the most efficient policy tool to achieve this (8, 902). However, other factors, such as economic or social criteria may impact on policy decisions, as is highlighted in the following sub-sections.

### Size of the tax

Small taxes were found to have insignificant impact (204, 303) and may not cover the basic costs associated with providing water, such as monitoring supply or geological exploration (204). Thus, articles highlighted the importance of ensuring taxes were sufficiently high to result in behavioural change (204, 205, 207). However, the difficulty with determining the “right” rate was observed (3). Furthermore, taxes need to be sufficiently large that consumers are aware of the taxes (215).

One study, situated in Belgium, reported that taxes were not resulting in reduced pollution(709). The explanation provided for this was that the taxes may be too low to result in behavioural change.

### Investment in technology

Studies generally agreed that taxes were effective where they generated incentives for investment in new water saving technologies (10). Examples discussed included technologies for improving wastewater treatment (12) and having a non-uniform tax for farmers that is correlated to their irrigation technology to provide an incentive for adoption of more efficient technology (210).

### Hypothecation

Some articles discussed hypothecation, with general acceptance that greater environmental benefits would result where policy makers used water taxes collected to subsidise other tax saving mechanisms, or food when a water tax resulted in increases in food prices (7, 8, 216, 504, 901). There was also the suggestion that a water tax could be used to finance investment in water saving technologies (1) or invest in water-related research activity (908). Hypothecation could also assist with minimising the potential for producers to be driven out of business (909).

### Sector design

As will be noted below, multiple studies focused on the agricultural sector. However, a question was also raised as to whether all sectors could or should be included when a water tax is imposed. Studies were undecided on this. One suggestion was made that a focus on the sectors that are the heaviest users of water may be the most effective policy approach, such as a water tax on agriculture (213). However, there were also strong arguments made for why agriculture should be excluded, particularly where water is scarce and there is a need to ensure ongoing provision of agricultural products.

### Information asymmetry

The problem of imperfect information is a factor in the overall effectiveness of using any instrument, including a tax, to manage groundwater usage. Six studies discussed issues associated with information asymmetry, whereby it can be difficult for a regulator to accurately assess factors such as water usage or pollution, or it may be costly to collect information to accurately inform tax design (3, 210, 503, 707, 907, 911).

### Practicalities

A number of practicalities were noted in relation to adopting an effective tax scheme. Administrative and transaction costs were highlighted multiple times (3, 210, 907, 908). There is a high level of information required to implement an effective tax (907). Information asymmetry is noted above, but taxes such as volumetric taxes require a high level of monitoring (908, 910) and measurement may be difficult (304). Moreover, much of the information required to accurately price taxes is complex, such as quality of water, reserves, use, market price, social factors, impact on markets, impact on production and other hydrogeological factors (205).

Other practical matters raised that may impact on the effectiveness of a water tax include when there are issues with water usage rights (504); where there are clear problems with ability of users to pay such a tax (707); and where joint costs exist (707).

Coordination of policies between agencies was observed. For example, urban factors may impact on water demand, such as population growth (801). This points to the need for integration of policies, for example with urban development policies and environmental policies.

Alongside all the above-mentioned factors that introduce considerable complexity into water tax design, there is also a need for policy to be clear, precise and enforced (205).

Finally, articles observed the inherent political nature of taxes. While this is not part of the tax itself, politics is a component of practical tax design. Issues include a lack of political appetite to increase taxes that will impact on food prices, particularly basic food items when a tax will impact on profitability of domestic products on international markets (1).

## 4.2 Behavioural change

Behaviour change was mentioned in many of the articles reviewed. This behavioural change could take a number of forms, but it was mostly directed at the impact of taxes on water use. An important factor for consideration is the need for a sufficiently long period of time to generate change in behaviour that will result in positive economic impact (709).

In general, studies agreed that taxes on water usage would result in reductions in water extraction and water usage (2, 7, 8, 139, 211, 215). However, studies also reported that this change may be minor (709). In addition, there was general consensus that water quality would improve with the introduction of a water tax, as this would generate incentives for farmers to adopt more efficient irrigation techniques (210).

Some studies identified that a less than optimal outcome may result from the presence of a tax, such as when land use changes, which results in substitution that is not economically desirable (1). However, it was also suggested that when water is not free, land use change shifts to higher-value crops and increasing yields. Thus, it may be possible to tax water usage and improve water economy (705). Yields may also increase when investment is made in technologies that assist with effective irrigation or similar technologies (1).

A further advantage of a water tax, is that it may generate a signalling effect, which may reduce demand, particularly if users think future increases may be possible (908).

Unintended consequences may result from the introduction of a tax. For example, where the presence of a tax may result in discharge that is less environmentally preferred, such as into a river basin, rather than into a sanitary sewer network where the water will be treated before discharge (12). Of particular concern among studies was the potential for a water tax to increase farmers’ production costs and consequently reduce output (3, 905).

The above points are premised on the assumption that a water tax will change behaviour. However, it is possible that a water tax on industry may be considered as a traditional business tax increase, rather than generating an incentive to change behaviour (709).

## 4.3 Water saving

A key objective of water taxes is often to decrease water usage. Studies agreed that increasing the price of water through taxes would reduce water usage (1, 3, 7, 8, 12, 13, 139, 204, 207, 208, 209, 210, 213, 215, 301, 303, 502, 705, 801, 901, 902, 910). There was a range of estimates of the extent to which taxes would reduce consumption, generally determined by the size of the tax. Studies also noted the potential for increased prices to sufficiently reduce demand to the extent that further investment in infrastructure, such as desalination plants, is unnecessary (502). A further advantage of water taxes is that they may incentivise water savings not just from a reduction of demand, but also from ensuring water supply is improved, such as through reducing leakages (139) or increased investment in technologies, as noted above.

As previously mentioned, the overall policy objective is an important consideration, as the appropriate policy will be determined on whether water quality or water saving is paramount. Article 215 noted that taxes on water can be justified where environmental arguments take precedence, such as when water is a scarce resource.

Some articles were discursive, rather than analytical, and outlined detail of newly implemented water taxes. For example, Article 216, located in Brazil, discussed a tax introduced in 1991 on river water extraction used for industrial and agricultural use. One of the aims of the tax was to improve water quality.

## 4.4 Water quality

A further important theme that was paramount in the literature was the need to address pollution and improve water quality, with a water tax generating the potential incentive to achieve this (208, 210, 401, 503, 504, 701).

There were some outliers with regard to the extent that a water tax could assist with improving water quality. Article 10 suggested that a water tax makes the water supply system unsustainable and generates an indifferent attitude to water conservation. Article 709 reported that empirical research in Belgium did not confirm the expected relationship between an increase in tax and a decrease in pollution. This study reported a lack of a behavioural effect from environmental taxes, although this was partly explained by the time period over which pollution-reduction strategies are implemented. It was also reported that the tax may be too low to result in significant behavioural change. This study did not rule out the potential for reduced pollution in the long run.

As well as the ability of a water tax to improve water quality, another factor considered was the incentive created for development of new technologies to improve wastewater treatment (12). This study found that a waste control tax was not effective at creating a penalty that was correlated to the pollution generated. The study also found that the waste control tax would not incentivise investment in wastewater treatment or water saving.

One study from China reports that charges imposed were so low that a reduction of pollution could not be attributed to the charges (207). In addition, the charges were imposed only on pollution above a specified threshold, rather than on all polluting activity. Thus, the charges acted more as a form of fine, rather than a tax (207).

Water quality is also a factor with regards to willingness to pay a tax. One study, reporting on survey data from 500 households in India, found that households are prepared to pay a tax when water is provided of a desirable quality (401). This was aligned with other normative studies that reported that consumers should pay for water to reflect that it is a scarce resource (7).

## 4.5 Sector findings

Some studies focused on specific sectors. Agriculture was often an industry chosen for investigation as shown in Table 3, with one study reporting that taxes on water used in the agricultural sector drive most of the economic and welfare impacts (213). One study found that the greatest effect of water taxes was found when the tax was imposed on the agricultural industry (209). A similar finding was reported in Article 504, which found that taxation should focus on water intensive sectors to save water. Notwithstanding the focus on agriculture in these studies, Article 906 reports that government attempts to tax farmers’ use of water are rare.

**Table 3: Sector specific studies**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Sector** | | | | | |
| **Article No.** | **Agriculture / food** | **Textiles** | **Bottled water** | **Industry** | **Forestry** | **Mining** |
| 1 | Y |  |  |  |  |  |
| 3 | Y |  |  |  |  |  |
| 8 | Y |  |  |  | Y |  |
| 12 | Y |  |  |  |  |  |
| 204 |  |  |  |  |  | Y |
| 209 | Y | Y |  |  |  |  |
| 210 | Y |  |  |  |  |  |
| 212 | Y |  |  |  |  |  |
| 213 | Y |  |  |  |  |  |
| 303 | Y |  | Y |  |  |  |
| 502 | Y |  |  | Y |  |  |
| 503 | Y |  |  |  |  |  |
| 504 | Y |  |  | Y |  |  |
| 901 | Y |  |  | Y | Y | Y |
| 902 | Y |  |  |  | Y |  |
| 905 | Y |  |  |  |  |  |
| 907 | Y |  |  |  |  |  |
| 908 | Y |  |  |  |  |  |
| 911 | Y |  |  |  |  |  |

The particular problems associated with taxing agriculture are noted. There are political issues (discussed above), information asymmetry (discussed above), together with measurement of water usage and specific identification of water pollution. A further problem identified with creating tax policy for the agricultural sector include farmers’ heterogeneity (210).

It is also worth noting that while many of the articles focused on agriculture or industry, the need to change public behaviour was also noted (601).

## 4.6 Water pricing

The European Commission (2019) observed the importance of effective water pricing to encourage sustainable use of water resources. Perhaps unsurprisingly when the topic is water taxes, a number of studies addressed the issue of water pricing. The issue with regard to pricing is perhaps best captured by Article 208: “*[a] price directly linked to the water quantities used or pollution produced can ensure that pricing has a clear incentive function for consumers to improve water use efficiency and reduce pollution*”. These two factors are the main objective of water taxes in most countries (208).

The complexity of water valuations was noted (706, 907). The need to ensure that water was appropriately costed to minimise environmental damage was frequently observed (301, 303, 703, 907), as was the need to ensure efficient allocations (502). The observation was made that water taxes and tariffs do not cover the full cost of protection of water resources (303). Furthermore, incorrect pricing of water can result in externalities, such as over-utilisation or wastage (301, 304).

A range of factors were raised with regard to what components would need to be included within a tax for it to be effective, including the costs of water delivery/supply (703, 907); costs of desalination plants (502); wastewater treatment costs or biodegradability (12); the chemical components of discharged water (12); costs of control, monitoring, exploration and environmental programmes (205); or other operating and capital investment costs associated with water supply systems (708).

Discussions on the appropriate cost for water noted a preference for marginal cost, rather than average cost (703, 704, 907). Some studies queried whether a water tax should cover both fixed[[5]](#footnote-5) and variable costs (204), noting that in San Diego water service provision is financed by a user charge that covers both fixed and variable costs of delivery (708). One study found that consumers responded more to a change in the sum of variable and fixed costs (i.e. average costs) than the marginal price (215).

The observation was made that the price for irrigation water is considerably less than prices charged to households and industries, due to the common presence of subsidies to sectors such as agriculture (905), which may lead to water waste in regions where water is most scarce. This pricing can lead to distortions that result in non-optimal use of water. However, there is also an argument prefaced on the importance of agricultural output and most countries are reluctant to remove subsidies or add costs that would negatively impact on agricultural production. This stresses the importance of understanding the impact of pricing policies on the entire economy (905).

As well as what was included in the tax, a question arose as to what was not included. That is, should there be a threshold of water usage that may be consumed before a charge is introduced (207).

## 4.7 Economic and social factors

### Socio-economic

Studies were mixed on the impact of water taxes on socioeconomic factors. For example, Article 1 reported that a water tax may not be socioeconomically efficient to improve irrigation water productivity. However, this study was located in Serbia and was specific to potato production, therefore may have limited generalisability. Other studies reported trade-offs between economic, environmental and social objectives (139, 209, 213). Article 213 reports that globally, the world is worse off from the introduction of water taxes, although some countries gain as their competitive position improves. This result is amplified where it is difficult to improve water efficiency.

A variety of equity issues were raised in articles. Research was undecided on the impact on social factors, reporting both declines in household welfare (209) and increases in household welfare (502, 904). These included the potential for trade-offs, whereby water taxes can impact more on poorer households even where water prices decrease for those households (8, 215, 502). This outcome results because water taxes increase the price of agricultural products, as well as decreasing wages in the agricultural sector, which disproportionately employs people from poorer households (7, 8, 209, 502). Job losses are a further factor (905). Another issue raised was the potential for over-taxation, which is where an increase in taxation may not improve environmental quality; and instead only increases production costs, thereby reducing consumer welfare (701).

Further trade-offs identified in the literature include the potential for a tax on irrigated field crops to perform well in terms of water saving, but to reduce real GDP and consumption by poor households (7, 8, 209, 502, 901, 902). However, there is the suggestion that the impact on GDP can be minimised where taxes are reinvested in schemes that will help with water savings (7) or overall taxes reduce (502). Thus, it is possible to achieve a positive outcome overall from the introduction of a water tax.

Other articles report an overall increase in social welfare from the introduction of a water tax (3, 210, 304, 502) although noting that there are winners and losers depending on the tax design (904).

Sector-specific equity issues include the potential for increased water pricing to lower farm income as well as land values (907) and increases in electricity prices from a water tax (2). The link between energy and water is outlined in Article 139, where it is noted that water is necessary to produce and transport energy, and energy is needed to extract, treat and transport water.

### Economic impacts

Articles discussed the need to include international trade implications when considering water taxes. This is because water is implicitly traded on international markets, such as via food and textiles (213, 904). The water embedded in these products is called virtual water (904). Articles reported that the introduction of a tax would result in a decline in exports (7, 209) and domestic supply (209) and an improvement in the terms of trade in the long run (7).

In general, a decline in GDP is reported when a water tax was implemented (7, 209). A further consideration is when two countries share water aquifers. In this situation, Article 214 reports that a water tax in one country will reduce GDP in one country and increase GDP in the other. It is necessary for countries to implement a tax in cooperation in order to avoid both countries being made worse off (214).

Additional impacts include the effect that a water tax may have on business profits. Studies reported decreased profits, as businesses paid higher taxes than optimal (3, 203, 210).

Two articles discussed the potential for increased taxes to create incentives for investment in capital resources. These included the potential for increased taxes on water to create incentives for farmers to change to new technologies (1, 210, 213). Article 1 reports that a high water tax may make some investment profitable, where there is a low marginal price for water. A sanitary tax encourages companies to invest in water saving and improving the quality of discharged water in order to reduce tax charges and improve business efficiency (12).

Taxes can impact on the local market, the domestic market or the international market. Article 7 finds that water taxes have the potential to have different impacts on these markets. The example used is that as a water tax increases the cost of production, this will result in a decrease in international demand. Therefore, local producers reduce supply, which increases the domestic price and facilitates imports. Employment is a further factor in these considerations. Reinvestment of taxes collected into affected industries provides a mitigating influence on the negative outcomes. This example illustrates the importance of tax design, to ensure that unintended effects or negative economic impacts are not the result of the introduction of a water tax.

A range of additional economic factors were raised in the articles reviewed for this study. These were both negative: the impact of a water tax on trade (13, 209, 213, 904) or a decline in exports (209); and positive: reducing emissions (139) and employment creation (139). Also raised was the degree of substitution from water to other factors (such as labour and capital) with the introduction of an instrument that increases water prices (209). Water taxes have the potential to increase or decrease the demand for capital in some sectors (209). However, water taxes resulted in a reduced demand for labour, resulting in a decline in wages (7, 209).

An important factor is the potential for a water tax to impact negatively on production and consumption (3, 209, 213, 502, 504, 701) and potentially not achieve any environmental gains (701). This can occur when a tax is introduced but it does not generate an incentive to invest in water saving technologies. This is particularly the case in water intensive industries such as agriculture and textiles (209, 504).

Overall impact will depend on how any tax revenues collected are used. Studies indicate that reinvestment results in reduced negative impact (7). Article 905 also noted the importance of clearly understanding the impact of water taxes on all parts of the economy, due to the particular political sensitivity related to the tool.

### Efficiency

One of the key themes from the articles was the potential for a water tax to result in efficiency gains (1, 3, 13, 139, 203, 208, 209, 215, 502, 504). Efficiency gains reported from a water tax have already been noted above, such as reduced water extraction or usage. However, other efficiency gains are also reported, such as adoption of new technologies, preserving water resources, reducing emissions into water, encouraging environmentally sustainable supply chains, reallocation of water to the most efficient usage, and reducing demand so that greater capital investment was not needed.

Articles show that taxes generate incentives for investment in water saving technologies (13, 203, 210, 703). Articles also noted the potential for increased efficiency gains when farmers that adopt more efficient irrigation technology pay less tax than farmers using less efficient technology (210). Using a tax in this way has the potential to limit river emissions and encourage investment in technology. However, a water tax that achieved behavioural change may also mitigate the need for such investments.

Article 908 reports that the advantage of a tax is that it improves both economic and technical efficiency. Administrative costs are high with a water tax, as it can be complex to control and monitor. While the focus of the extant study is on taxes, rather than subsidies, it is worth noting that some studies also included reference to subsidies, generally observing that they are not economically efficient, they create distortions and do not provide incentives for investment in technologies (908).

Optimal water allocation is achieved when profit is maximised and economic, social and environmental impacts are minimised. Some studies reported that water taxes would help generate an optimal allocation of water (1, 3, 503). Article 503 reported that an optimal instrument mix is a water tax combined with an additional tax on emissions, which would impact on water use as well as water pollution. Other research presented how water tax schemes could assist with optimisation approaches for structures such as water distribution networks (139), managing water stocks (211), in agriculture (213, 911) or ground-water basins (909).

## 4.8 Double and triple dividends

A number of articles discussed the potential for a water tax to have a double or triple dividend. A triple dividend refers to environmental, economic and equity effects. A double dividend refers to two of these effects. For example, Article 7 observes that proponents of environmental taxes, including water taxes, claim that they are efficient for protecting the environment and generating economic benefits – hence a double dividend.

A study from South Africa (901) reports the potential for a double dividend (economic and environmental impacts), depending on the industry that was taxed and how the tax was utilised. The same article notes the potential for a triple dividend of reduced water use, increased growth and reduced poverty from the introduction of a water resource management charge on the quality of water used in certain sectors, such as agriculture, mining, and forestry. However, this outcome is contingent on reducing indirect taxes, particularly those on food (901).

A study from Israel (502) also finds a double dividend with environmental benefits in the form of water saving and increasing economic growth, with the potential for a triple dividend depending on the redistribution of taxes collected.

A further perspective was raised in Article 209, which noted that while there were environmental gains from the water tax, there was a negative economic impact in the form of reduced GDP and household welfare. However, when taxes collected are used to offset welfare losses to affected households, it is possible to achieve a double dividend. Notwithstanding this comment, Article 8 reports that GDP gains from reinvestment of taxes do not offset the GDP loss from the tax.

## 4.9 Other issues

### Food sufficiency

The potential reluctance to introduce water taxes in areas of water scarcity was noted (213). In some regions, water is subsidised to ensure food production can continue. There would be both popular and political resistance to taxes in these areas.

### Government revenue

Research was equivocal on the impact of a water tax on government revenue. Some studies reported that a small water tax provided minimal profitability to the government budget (204) and did not generate enough revenue to carry out minimal reparation work on water resources (204). Other studies report a moderate contribution to government revenue (215), proportionate to the level of the tax. Other studies did not attempt to quantify the gain made, instead noting that there would be an increase in government revenue (7, 8, 209, 215, 304, 502, 704, 705, 707, 708, 709, 902). One study reported the variables that would impact on this revenue, such as the customer’s ability to pay, demand management and control or urban development, among others (707).

An important factor with regard to the revenue collected from water taxes is the ability to fund activity that can counter the effects of pollution, such as water treatment (207). However, prior studies have reported that taxes in Europe that have been used for revenue raising for this purpose have not been sufficiently high to cover the damage.

# Findings

As noted in section one, our research has three primary objectives. The first of these is to identify the key tax and water issues that have been documented in the literature and where are the gaps. We address this topic first in section five.

## 5.1 Extant literature and gaps

There are three overriding themes that came through from our exploration of the literature. These are the importance of effective tax design; the effectiveness of taxes on changing behaviour; and environmental gains by way of water savings and improvement in water quality. In general, there was agreement that a tax is an effective policy tool to control levels of water usage and quality. However, there was no consensus on this.

Perhaps the most obvious observation from the exploration of the literature was the dearth of studies in general that are focused on water taxes. We found no areas that were over-researched, and indeed few studies that built on prior studies reporting empirical findings.

Some themes are clear. Water taxes have the potential to reduce demand on water resources and to improve the quality of water. However, myriad complex interacting variables will impact on the success and impact of taxes. Tax design is crucial, including the extent to which taxes are reinvested in water technologies or sectors that are high water consumers. Sectors such as agriculture have both the potential to change pollution and use from taxes, but are also susceptible to the greatest welfare losses where hypothecation does not protect the sector. Ideally taxes will result in behavioural changes, without generating welfare losses where they are not desired. All of these themes would benefit from greater focus and research attention to provide greater clarity and certainty on their outcomes.

There are considerable practical challenges in designing, implementing and monitoring a water tax. Information asymmetry is significant and costs of monitoring water usage or pollution are likely to be high. We found no studies that attempted to quantify the administrative and transaction costs associated with water taxes.

Many of the studies have limited generalisability, either because they relate to a specific type of agriculture (e.g. Article 1 on potato crops in Serbia) or region (e.g. Articles 901 and 902 in South Africa). More studies that are location- or industry-specific would add to the body of knowledge and allow lessons to be learned across jurisdictions. In addition, comparative studies, such as between countries with similar drought or water profiles, could provide useful opportunities for insights.

While there are currently limited studies, there is still the potential for research investigating how studies have changed over time as debates on environmental taxes have matured. Our observation is that the majority of the studies on water taxes have been undertaken in recent times. However, greater depth on how findings have evolved and how topics of study have changed would add to knowledge.

A criticism of behavioural change that arises from the literature is that historically it has focused strongly on economic criteria (709). Our review of the literature finds that this is a fair criticism. Thus, there are myriad opportunities for different theoretical lenses to provide insights into water taxes, such as psychological or institutional.

It was evident that even though the majority of studies explored were modelling studies, there are multiple modelling opportunities to add value to this subject. Extant models can be developed by adding variables that will contribute to knowledge on the impact of water taxes at an individual, household and economic level.

We observe that the European Union has had a water framework directive since 2000. However, there is no such equivalent instrument in New Zealand. River quality issues in New Zealand have been “addressed” by lowering the acceptable quality standards for rivers. While there are numerous water plans and initiatives related to the MDB, these mainly address scarcity rather than water quality. There is scope for research on appropriate water quality frameworks for these countries.

## 5.2 Lessons for Australia and New Zealand

The purpose of a systematic literature review is not only to document extant literature and identify gaps in scholarly knowledge. It is also necessary to draw broad theoretical conclusions about what the literature means, “*linking theory to evidence and evidence to theory*” (Siddaway, Wood and Hedges, 2018:747). Our second objective in this study is to outline lessons for New Zealand and Australia from the extant literature. We discuss Australia and New Zealand separately in this sub-section, as Australia and New Zealand face different water issues.

### New Zealand

In New Zealand the issue is water quality. Seasonal droughts occur. However, the primary discussions are focussed on water quality.

The literature indicates that water taxes are likely to be successful in improving water quality, as individuals are faced with the costs of externalities. In New Zealand, water taxes may expedite investment in new technologies that will result in improved water quality. In New Zealand, the need for a double dividend is clear: economic and environmental benefits are necessary before a water tax is likely to be politically acceptable. Therefore any taxes are likely to require at least some hypothecation.

While a volumetric tax appears to be the most appropriate instrument, a particular issue in New Zealand will be measurement and monitoring of water usage. Many farms draw water from rivers, which limits ability to monitor their usage. It also impacts on accurate records of water pollution. In New Zealand, only water takes in excess of 10 litres / second need to be measured and reported (Ministry for the Environment, 2018).

New Zealand has a large agricultural sector, which is typically considered to play a large part in poor water quality in rural areas of the country. Thus, ideally the agricultural sector would be included in a water tax. However, it is noted that while the agricultural sector contributes to nearly half of New Zealand’s overall emissions, they are excluded from the Emissions Trading Scheme. This reflects both the power of the agricultural sector in New Zealand, together with the importance of the sector to the economy. The situation with emissions may reflect the likely approach to the inclusion of the agricultural sector in New Zealand if a national water tax was proposed.

The research on international trade is also relevant to New Zealand. New Zealand competes in a global marketplace for its products and there may be limited appetite to introduce policy that will reduce the competitiveness of New Zealand goods. This also reaffirms the potential need for hypothecation of a water tax.

### Australia

The literature discussed above has relevance for Australia since much of it is concerned with water tax in an agricultural context and since the primary water issue in Australia is with respect to its scarcity, particularly in the MDB. Water markets were introduced in an attempt to have it allocated efficiently to its highest value use. While these markets have been successful, further work must be done to improve their efficiency (Hughes, Gupta and Rathakumar, 2016). The research discussed herein suggests that a water tax may help the market operate more efficiently. The efficient operation of water markets relies on water being pricing water appropriately. The research discussed above suggest that a water tax is a necessary part of any appropriate water pricing policy.

There are a number of challenges to be overcome if a water tax is to be introduced in Australia. As discussed above, primary producers have been given generous tax concessions including subsidies for water infrastructure. Despite recent criticism of this subsidisation and realisation that it leads to overinvestment in water infrastructure, it continues in the form of a rollover for the disposal of water entitlements and allocations. Introducing a water tax for irrigators potentially entails a reversal of this policy which will be met with stiff opposition politically for core constituent groups involved in primary production. Indeed, research suggests that the agricultural sector ought to be assessed on the water it uses. If a water tax is to be introduced, the design of the tax will be a crucial element that can be informed by research discussed herein.

Other challenges are social as well as political. The research indicates, unsurprisingly, that a water tax will increase costs to farmers which is likely to be passed on to customers. Furthermore, a water tax is often accompanied by a real decreases in GDP. Social welfare may be reduced as a result, especially as it impacts on the cost and availability of staple products. Profitability and sustainability of irrigators is of particular concern with water allocations decreasing in times of drought, an aspect that a water tax may exacerbate. With the price of water being a critical factor in irrigators’ decision to exit farms (Zuo et al., 2015), a water tax would likely shift the equation in favour of irrigators leaving by virtue of it increasing the price for water.

Water markets were also introduced in Australia with the hope of there being more water for the Murray River and the associated environment encompassing the surrounding natural environment and all forms of life that inhabit it. This is recognised in the water tax literature. Article 501 notes that storage and extraction of water in arid locations, such as in Australia, is causing environmental damage. This is impacting on the potential sustainability of river systems when users also have an objective of maximising their profits. Article 501 observes that the main issue is overallocation of water resources to users, resulting in insufficient water to provide for environmental flows. This appears to suggest the need for an instrument to balance these trade-offs. Broader water tax literature indicates that an appropriately designed water tax would help achieve more water for the environment and also lead to more efficient land use. Thus while GDP and social welfare may suffer, the literature suggests that a water tax can result in environmental benefits thereby helping to achieve a key goal of water markets.

Imposing water taxes presents challenges in measuring water flows and extractions. These challenges are partly responsible for the capital gains tax rollover on disposal of water allocations and entitlements as the tax that would be payable but for the rollover is regarded as a barrier to water trade (Sherry, 2009). While these challenges cannot be easily dismissed, there can be potential side benefits from monitoring water usage and extractions for tax purposes since the information that arises can be used to support Integrated Water Resources Management (mentioned in section 2.1).

Australia is a large country and different areas face different water issues. Western Australia’s water source is mainly groundwater and Tasmania has significant rainfall and dams for storage. Water tax design will need to take into account this heterogeneity.

## 5.3 The Future for Water Tax Research

The final topic in this section is our thoughts on the future of water tax research. We raise some issues that have not been canvassed in the literature to date, but we think are topical in the current climate.

Only one article raised the potential for corruption to occur with the presence of a water tax (204). This is an area that would appear to warrant some research attention, with the potential for water usage or water quality to be falsified in order that a lower tax is paid. This is particularly relevant for Australia in light of the Murray-Darling Basin Royal Commission which heard accusations of water theft by New South Wales irrigators and mismanagement of water by the Murray-Darling Basin Authority which led to water that was earmarked for the environment being used for agriculture instead (Murray-Darling Basin Royal Commission, 2019). A further study noted the potential in China for pollution taxes to not be collected, not well administered or not enforced (207). An absence of will to collect charges was noted in other studies (504). Thus, there is some indication that corruption may be prevalent in water tax policy or collection to warrant further research interest.

Instances of water theft in Australia suggest that compliance with water taxes is also a potential research area. While this would be an extension of extant tax compliance research, it presents a new context within which to study compliance. As discussed above, systems to monitor water use and extractions can help in water management. Any research that improves compliance can only benefit the environment and lead to more efficient use of water.

Another article raised the potential for groups to engage in collusion to exert political pressure to further self-interest (907). While not considered corruption, a concomitant topic is the potential for politics to influence the outcomes of a water tax. This is highly relevant in Australia and New Zealand, where the agricultural industry have historically had significant influence in politics (Castelyn, Hodgson and Marriott, 2019).

It is clear from the literature that there is no one best practice with regard to water taxes. Notwithstanding this comment, the literature suggests that improvements in water quality and usage can result from water taxes. Thus, it may be possible to develop guidelines that can help countries achieve double or triple dividends when implementing water taxes. However, this will require greater investigation and confirmation of double or triple dividends resulting from water taxes. To the extent that water taxes can protect the environment and yield other benefits for society, they are more likely to be politically palatable.

Any water taxes that are implemented, depending on their design, must operate side-by-side with existing taxes. Research concerning relationships of this nature is necessary to prevent unintended consequences such as double taxation or non-taxation through loopholes. Thus, before a water tax can be implemented, the tax treatment of water under existing rules need to be determined.

Water justice is a relatively new topic of research. Within this topic, issues such as water governance are paramount to ensure that water, as a scarce resource, is effectively managed. We suggest that water justice and water taxes provide a fruitful new area for researchers who are interested in sustainability.

The future of water cannot be discussed in the absence of consideration of cultural issues. In New Zealand water has particular cultural significance, reflecting unique ancestral relationships with rivers. For example, in 2017 the Whanganui River was granted the same legal rights as a living person. The rights provide for long-term protection of the river, by making it a person in the eyes of the law. Another example is the potential for Māori to retain native title in water, or whether there should be co-governance with the Crown (Waitangi Tribunal, 2019). Water and its surrounding environments and living organisms have similar cultural significance to Australia’s indigenous population (Escott, Beavis & Reeves, 2015). Thus, there is scope for research to take into account cultural dimensions of water alongside the economic dimensions of a water tax.

# Conclusion

The primary contribution of this study is the synthesis of the literature on water taxes. For a topic that has such global significance, it has attracted limited research attention and warrants significantly more. The systematic review has found that research originates from a wide selection of countries, encompassed a variety of methodologies and has increased in frequency since 2010. It also tends to be focused on the agricultural sector with concerns for tax design, changing behaviour, pricing, water savings and efficiency, water quality and a range of economic, social and environmental concerns. Numerous articles seek to achieve the so-called double or triple dividend where economic and social goals are achieved alongside environmental ones.

While there was an element of breadth of research, there is an absence of depth. This may reflect the relative infancy of the field, where we have not seen research issues developed in the same way that we have for other well canvassed tax topics, such as tax compliance. We would encourage research in this important field, either through engagement with some of the areas we have noted in section five, or through building on the research articles that we have identified in this literature review.

We have identified a range of topics that appear particularly fruitful for future research interest, some that expand on existing knowledge and those that will generate new knowledge. First and foremost is continued research on water tax design that marries with best practice water pricing and subsequent evaluation of the tax. This research must be tailored to the specific location. Since taxpayers are always hoping to avoid tax and water is a valued resource, research that attempts to understand the causes of corruption and collusion is required as well as the research to improve compliance with any tax implemented. Cultural aspects of water may also impact on the design of a water tax and compliance with it, therefore these aspects should be studied further.

Interestingly, little of the extant research is situated in Australia or New Zealand. Despite this, numerous lessons can be drawn for those two countries. While New Zealand appears unlikely to implement a water tax and Australia has often subsidised the irrigators and water infrastructure via the tax system, the potentials for implementing a water tax are evident. For New Zealand, this means improved water quality while Australia is likely to see more efficient water use, providing the challenges in designing and implementing a water tax can be overcome.

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# Appendix 1: Articles used in the study

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| Authors | Article Title | Journal and publication year | Location |
| 1. Orum, Boesen, Jovanovic and Pedersen | Farmers’ incentives to save water with new irrigation systems and water taxation—A case study of Serbian potato production | Agricultural Water Management, 2010 | Seria |
| 2. Nanduri, Saavedra-Antolinez | A competitive Markov decision process model for the energy water climate change nexus | Applied Energy, 2013 | N/A |
| 3. Esteban and Dinar | Modeling sustainable groundwater management: Packaging and sequencing of policy interventions | Journal of Environmental Management, 2013 | Spain |
| 7. Kilimani, van Heerden, Bohlmann | Water taxation and the double dividend hypothesis | Water resources and economics, 2015 | Uganda |
| 8. Van Heerden,  Blignaut,  Horridge | Integrated water and economic modelling of the impacts of water market instruments on the South African economy | Ecological Economics, 2008 | South Africa |
| 10. Chakraborti et al. | Arsenic in groundwater of the Kolkata Municipal Corporation (KMC), in India: Critical review and modes of mitigation | Chemosphere, 2017 | India |
| 12. Roman Sanchez, Ruiz, Lopez, Sanchez Perez | Effect of environmental regulation on the profitability of sustainable water use in the agro-food industry | Desalination, 2011 | Spain |
| 13. Dang, Konar, Reimer, Di Baldassarre, Lin, Zeng | A theoretical model of water and trade | Advances in Water Resources,  2016 | N/A |
| 139. Munguia-Lopez, Gonzalez-Bravo and Ponce-Ortega | Evaluation of carbon and water policies in the optimization of water distribution networks involving power-desalination plants | Applied Energy, 2019 | Mexico |
| 203. Tsolakis, Srai and Aivazidou | Blue water footprint management in a UK poultry supply chain under environmental regulatory constraints | Sustainability, 2018 | UK |
| 204. Golovina and Chileva | Key aspects in the field of state management of groundwater production for commercial use | ARPN Journal of Engineering and Applied Sciences, 2017 | Russia |
| 205. Golovina | Strategic issues groundwater extraction management in Russia | Journal of Ecological Engineering, 2018 | Russia |
| 207. Zhou, Khu, Xi, Su, Hao, Wu, Huo | Status and challenges of water pollution problems in China: Learning from the European experience | Environmental Earth Science,  2014 | China |
| 208.Gomez-Rua | Sharing a polluted river through environmental taxes | SERIEs, 2013 | N/A |
| 209. Qin, Jia, Su, Bressers, Wang | The economic impact of water tax charges in China: A static computable general equilibrium analysis | Water International, 2012 | China |
| 210. Esteban, Tapia, Martinez and Albiac | Pigouvian taxation to induce technological change and abate nonpoint pollution in the Ebro Basin, Spain | Spanish Journal of Agricultural Research, 2011 | Spain |
| 211. Legras, S. | Managing correlated stock externalities: Water taxes with a pinch of salt | Environment and Development Economics, 2010 | N/A |
| 212. Barton, Bergland | Valuing irrigation water using a choice experiment: An individual status quo modelling of farm specific water scarcity | Environment and Development Economics, 2010 | India |
| 213. Berittella, Rehdanz, Roson and Tol | The economic impact of water taxes: A computable general equilibrium analysis with an international data set | Water Policy, 2008 | N/A |
| 214. Roe and Diao | Water, externality and strategic interdependence: A general equilibrium analysis | Journal of International Development, 2000 | Middle East |
| 215. Hoglund | Household demand for water in Sweden with implications of a potential tax on water use | Water Resources Research, 1999 | Sweden / Denmark |
| 216.  Krusche et al | Spatial and temporal water quality variability in the Piracicaba River Basin, Brazil | Journal of the American Water Resources Association, 1997 | Brazil |
| 301. Ambarriani, Snarni, Raharjono | The Implementation of Green Accounting in Deciding the Amount of Tax in Using the Well Water as the Environment Conservation Fund: A Study on Hotel Industry in Yogyakarta Special Region | Review of Integrative Business and Economics Research, 2017 | Indonesia |
| 303. Bacal | Geographical and Economic Aspects of Water Use in the Dniester Basin (The Sector of the Republic of Moldova). | Journal of Settlements and Spatial Planning, 2014 | Eastern Europe |
| 304. De and Pal | Willingness to Pay for Domestic Water Use: A Study of Hilly Urban Area in North-East India | Asian-African Journal of Economics and Econometrics, 2011 | India |
| 401. Mjumdar and Gupta | The economic rationale of a municipal water tax: evidence from Kolkata, India | Indian Journal of Economics, 2008 | India |
| 501. Tisdell | Acquiring Water for Environmental Use in Australia: An Analysis of Policy Options | Water Resource Management,  2010 | Australia |
| 502. Luckmann, Flaig, Grethe and Siddig | Modelling Sectorally Differentiated Water Prices - Water Preservation and Welfare Gains Through Price Reform? | Water Resources Management, 2016 | Israel |
| 503. Dinar, Xepapadeas | Regulating water quantity and quality in irrigated agriculture: Learning by investing under asymmetric information | Environmental Modelling and Assessment, 2002 | N/A |
| 504. Sukhaparamate | National Water Footprint of Thailand and Tax Simulation | International Journal of Economic Policy Studies, 2013 | Thailand |
| 601. Saqqar | Potential Use of Economic Instruments in Waste Management in the Arab Countries | Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances & Environmental Engineering, 2004 | Jordan |
| 701. Bundgaard-Nielsen and Hwang | On Taxation and Firms Choice of Waste Water Treatment Technology | Journal of the American Water Resources Association, 1975 | N/A |
| 703. Freebairn | Some emerging issues in urban water supply and pricing | Economic Papers, 2008 | Australia |
| 704. Gaffney | Milliman on Urban Water Price and Tax Policy | The American Journal of Economics and Sociology, 1966 | N/A |
| 705. Gaffney | The taxable surplus in water resources | Contemporary Policy issues, 1992 | N/A |
| 706. Brewer | Taxation of Water Rights in California | American Water Works Association, 1966 | California |
| 707 Jack, Berubé and Demard | Water User Demand: Cost Allocation and Taxation | Journal of the American Water Works Association, 1979 | Canada |
| 708 Neuner, Popp and Sebold | User Charges vs Taxation as a Means of Funding a Water‐Supply System | Journal of the American Water Works Association, 1977 | San Diego |
| 709. Coeck, S’jegers, Verbeke, Winkelmans | The Effects of Environmental Taxes: An empirical study of water and solid waste levies in Flanders | Annals of Public and Cooperative Economics, 1995 | Belgium |
| 801. Saurii | Lights and Shadows of Urban Water Demand Management: The Case of the Metropolitan Region of Barcelona | European Planning Studies,  2003 | Spain |
| 901. A. Letsoalo, J. Blignaut, M. de Wit, S. Hess, R. Tol, | Triple dividends of water consumption charges in South Africa | Water Resour. Res. (2007) | South Africa |
| 902. J. Blignaut, J.H. Van Heerden, M. Horridge | Integrated water and economic modelling of the impacts of water market instruments on the South African economy | Ecol. Econ. (2008) | South Africa |
| 904. M. Berrittella, A.Y. Hoekstra, K. Rehdanz, R. Roson, R. Tol | The economic impact of restricted water supply: a computable general equilibrium analysis | Water Res. (2007) | N/A |
| 905. B. Decaluwé, A. Patry, L. Savard | When water is no longer heaven sent: Comparative pricing analysis in a AGE model | Working Paper 9908, CRE´FA 99-05, Départment d'économique, Université Laval, 1999 | Morocco |
| 906. OECD | Environment, Water Resources and Agricultural Policies: Lessons from China and OECD Countries | OECD, France, 2006. | OECD and China |
| 907. Tsur, Y., Dinar, A., | The relative efficiency and implementation costs of alternative for pricing irrigation water | World Bank Econ. Rev. (1997) | N/A |
| 908. Koundouri, P | Current issues in the economics of groundwater resource management | Journal of Economic Surveys (2004) | N/A |
| 909. Bredehoeft, J.D., Young, R.A. | The temporal allocation of ground water - a simulation approach | Water Resources (1970) | N/A |
| 910. Maddock, T., Haimes, Y.Y., | Tax system for groundwater management | Water Resources Research (1975) | N/A |
| 911. Lenouvel, V., Montginoul, M., Thoyer, S | From a Blind Truncheon to a One-eyed Stick: Testing in the Lab an Optional Target-based Mechanism Adapted to Groundwater Withdrawals | European Association of Environmental and Resource Economists, 18th Annual Conference, 29 June-2 July 2011, Rome | N/A |

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3. We do not suggest that New Zealand does not experience droughts. Seasonal droughts exist in parts of New Zealand. [↑](#footnote-ref-3)
4. Search was on full text, rather than title, abstract and keyword. [↑](#footnote-ref-4)
5. Fixed costs include costs such as water meters. [↑](#footnote-ref-5)