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Abstract

Global water systems are under increasing pressure due to global warming and rising population. Strong inequalities exist in the access to freshwater between regions and countries but also within them, geographically and economically. Water is a lever for development: its absence has dramatic consequences on a human and economic perspective. Several governance modes can be used to manage the resource. Water markets are a tool to enable efficient allocation of water, through the trade of water rights. As of today, formal ones are only present in six countries: Argentina, Australia, Chile, the United States, Mexico, and Spain. Being a quite recent implementation (less than 20 years in their most evolved form, water markets mechanisms are still changing and the literature on the topic is growing every year.

Calls were made around the world to assess water as a human right, which became a UN resolution, but it didn't get much impact. International water governance was widely developed in the last decades but remains too weak to address water complex challenges. This research aims to identify factors explaining (or not) the presence of formal water markets. For this purpose, a quantitative empirical methodology was used, which consisted of several statistics analysis and a logistic regression. This aimed to test the hypothesis that a relationship exists between the presence of water markets and the indicators selected. The predictors we used were water stress, freshwater withdrawals for agriculture, WJP Rule of Law index, type of political regime, votes to the UN resolution 64/292, existence of a constitutional right to water, HDI index, Gini coefficient and Atkinson index.

The model explored in this research was overall significant but could not fully explain the presence of formal water markets. Water markets are deeply influenced by a country's legal and institutional frameworks, but these alone do not determine its existence and importance. Some of our variables, like water stress, do not seem to bring a meaningful contribution to the prediction and should be replaced, or completed, in further research, by other political, social, and cultural indicators. The outcome shows the importance of the concept of embeddedness when studying water markets, highlighting the need for a polycentric approach.

List of abbreviations

CPR = Common-pool resource

EU = European Union

FAO = Food and Agriculture Organization

GNI = Gross National Income

HDI = Human Development Index

ICWE = International Conference on Water and the Environment

IDWSSD = International Drinking Water Supply and Sanitation Decade

IMF = International Monetary Fund

IWRM = Integrated Water Resources Management

NASDAQ = National Association of Securities Dealers Automated Quotations

NGO = Non-Governmental Organization

NQH2O = Nasdaq Veles California Water Index

OECD = Organization for Economic Cooperation and Development

PPP = Purchasing Power Parity

SEC = Security and Exchange Commission

SDG = Sustainable Development Goals

UN = United Nations

UNDP = United Nations Development Programme

UNGA = United Nations General Assembly

WFD = Water Framework Directory

WJP = World Justice Project

WMRA = Water Market Readiness Assessment

WRI = World Resources Institute

WSI = Water Stress Index

For words with an asterisk (*), refer to the list of abbreviations.

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Introduction

1. Background

Water is life. The human body is made of around 60% of water[1] and we cannot possibly live without it. Throughout history, populations have always settled around the most fertile areas, i.e. close to watercourses. The first civilizations were all located next to a river: the ancient Egyptians based themselves on the Nile, the Mesopotamians in the Fertile Crescent on the Tigris/Euphrates, the ancient Chinese on the Yellow River, and the ancient Indians on the Indus. More generally, water is also essential to agriculture and livestock farming: plants, animals and people cannot do without the precious liquid. As a result, even the most recent settlements have systematically taken place in naturally irrigated areas, as is the case in Australia, around the Murrey Basin, at the end of the eighteenth century.

Although water is essential to life, the access to this resource is not a right acquired by all, and there are many inequalities in this respect around the globe. Indeed, one in four people in the world do not have access to safe drinking water, which constitutes a major health risk. In 2010, Ban Ki-MOON, then Secretary General of the **UN***, declared "Unsafe water kills more people than war"[2]. In 2024, unhealthy water is still one of the main life-threatening risks, responsible for over one million deaths each year, according to the *Global Burden of Disease*, the major global study published every four years by the world-renowned medical journal *The Lancet*.[3] The quality of water matters as much as the quantity. Today, many freshwater courses are polluted by fertilizers, pesticides, and herbicides due to agriculture (Carpenter and al., 1998[4]; Chaudhry and Malik, 2017[5]) but also industrial discharges, untreated or

[1] Jéquier, E., Constant, F. Water as an essential nutrient: the physiological basis of hydration. *European Journal of Clinical Nutrition* **64**, 115–123 (2010). https://doi.org/10.1038/ejcn.2009.111

[2] *Unsafe water kills more people than war, Ban says on World Day*. (2010, 22 mars). *UN News*. https://news.un.org/en/story/2010/03/333182

[3] Wolf, J., Johnston & al. (2023). Burden of disease attributable to unsafe drinking water, sanitation, and hygiene in domestic settings: a global analysis for selected adverse health outcomes. *The Lancet*, *401*(10393), 2060–2071. https://doi.org/10.1016/s0140-6736(23)00458-0

[4] Carpenter, S. R., et al. (1998). "Nonpoint pollution of surface waters with phosphorus and nitrogen." Ecological Applications, 8(3), 559-568. https://doi.org/10.1890/1051-0761(1998)008[0559:NPOSWW]2.0.CO;2

[5] Chaudhry, F. N., & Malik, M. F. (2017). Factors affecting water pollution: a review. Journal of Ecosystem & Ecography, 07(01). https://doi.org/10.4172/2157-7625.1000225

inadequately treated sewage and wastewater, chemicals, mining activities, pollutants brought by urban runoff, microplastics, and many others.

Water is unevenly distributed across the globe, with some regions naturally endowed with larger natural reserves of freshwater than others. Climate and precipitation levels also play a critical role in determining the amount of water available in a given region. According to a World Resources Institute study, a quarter of the world's population lives under extreme water stress in 2023.[6] And the situation is set to worsen in the coming years because of global warming. Indeed, climate change and rising temperatures are leading to an intensification of droughts, with more irregular and extreme rainfall (World Bank, 2023)[7]. In Africa, migrations are already starting to take place due to the lack of water resources. In some places, it has become impossible to cultivate the land, and people often lack the resources to access deeper water reserves.

Water is a major environmental, social, and economic issue, but also a geopolitical one. Indeed, water is a common natural resource that must be shared: more than 260 transboundary rivers involve at least two countries sharing their watersheds. Yet it is also a major source of tension: according to a Pacific Institute database update from 2022, 831 conflicts related to water were registered since 2010, mainly in Asia and Africa. The increasing scarcity of this resource due to climate change does not seem to be improving the situation: from 122 conflicts in 2021, the number has risen to 231 in 2022, before reaching a record of 347 water-related armed conflicts in 2023.

2. Problem statement

Being the object of much covetousness, water is nicknamed ‘blue gold’ because of its necessity and relative scarcity: less than 3% of the water available on Earth is fresh water. More importantly, water is a finite resource; hence, the need to learn how to share it and

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[6] Kuzma, S. (August 16th, 2023). *25 countries, housing one-quarter of the population, face extremely high-water stress*. World Resources Institute. https://www.wri.org/insights/highest-water-stressed-countries

[7] Zaveri, E. D., Damania, R., & Engle, N. L. (2023). Droughts and Deficits - Summary Evidence of the Global Impact on Economic Growth. *World Bank*. http://documents.worldbank.org/curated/en/099640306142317412/IDU03b9849a60d86404b600bc480bef6082a760a

manage it collectively. To provide a framework and organize its sharing, a wide range of institutions and legislative tools have gradually been built up around water, at various levels. Given the importance of the issues raised by water, the regulation surrounding the resource is consequent and complex. It seems essential to look back, in the literature review, at the way in which this regulation has been constructed, both through the international governance that accompanies it, and through the range of national, regional, and local strategies that have been put in place, across different geographical areas and over different periods of time. Finally, water and the issues surrounding it are intrinsically linked to the survival of a state and therefore, in a way, to its sovereignty. Its control, the source of numerous conflicts, is also an issue of intra-state power, particularly in authoritarian regimes, and a way to assess authority over a population (Strang, 2016)[8].

After a wave of privatizations in the 80s and 90s, promoted by the World Bank and the **IMF***, many countries reversed course and returned to public water management, remunicipalizing their water. Remunicipalization can be defined as "the process by which the provision of public services, once outsourced to private entities, is transferred back to public ownership or management, typically with the goal of improving accountability and service delivery" (Pigeon & al., 2012)[9]. Citizens have also played a strong role in the water remunicipalization movement, fighting against the commercial nature of water: in Bolivia, during the Cochabamba water wars, but also in Europe, with, for example, the 2011 referendum on water in Italy. Paradoxically, privatization remains strong, with powerful private players in the water sector. Numerous public-private partnerships of varying degrees and forms are also in charge of water distribution around the world.

Charles W. Howe (1986) discusses, for the first time, the potential for water markets as an innovative approach to water allocation. It became reality in Australia, in the Murray-Darling Basin, which is now one of the most developed and studied water markets in the world, where water rights can be traded between users to ensure more efficient allocation of water resources. Water markets remain rare but also exist in other countries, such as Chile, the

[8] Strang, V. & Institute of Advanced Study, Durham University, Durham, UK. (2016). Infrastructural relations: water, political power and the rise of a new "Despotic regime" [Academic]. *Water Alternatives*, *9*(2), 292–318. https://www.water-alternatives.org/index.php/alldoc/articles/vol9/v9issue2/317-a9-2-7/file

[9] Pigeon, M., McDonald, D. A., Hoedeman, O., & Kishimoto, S. (Eds.). (2012). *Remunicipalisation: Putting Water Back into Public Hands*. https://www.tni.org/files/download/remunicipalisation_book_final_for_web_0.pdf

United States and Spain (though only in certain regions). Can these economic models improve resource allocation in terms of both efficiency and equity? What challenges do they pose?

Furthermore, since December 2020, investors can trade water futures: the Chicago Mercantile Exchange (**CME***) launched the Nasdaq Veles California Water Index (**NQH2O***). On the Nasdaq website, we can read that the NQH2O seeks "to track the spot rate price of water rights in the state of California." Many water-related **NGO**s* pointed it out as a further step in the financialization and commodification of water whereas proponents argue that, with careful regulation, futures contracts can serve as effective hedging tools.

Because of its special status regarding ecosystems and human life, water is a non-substitutable resource whose management and governance are unique in the world. The issues surrounding it are complex, multi-faceted and receive relatively little media coverage in relation to what is at stake. Climate change is going to lead to a rarefaction of the resource, questioning the viability of the water management strategies and the water governance in place, both at an international, national, and local level.

3. Research question

The aim of this research is to look for factors that could explain the presence of formal water markets in some places and not in others. We will look for indicators that might justify why certain governments and countries have chosen to implement water markets, when others don't. The research question will be the following: *To what extent selected water-related, legal, and socio-economic indicators can explain the presence of formal water markets?*

The several variables will be explained in the methodology section. The hypothesis we draw is that there will be a relationship between the presence of water markets and the selected indicators.

4. Structure

First, a literature review will enable us to go through the existing knowledge around water markets. We will define better the concepts around water and delve into water scarcity, the

existing solutions, and the up-to-date situation. We will then look at the international governance of water through time and the status the resource has on a legal perspective. Next, on a more conceptual level, we will explore the theories around markets and common goods, such as water, to finally explore the characteristics and goals of water markets, as well as their assessment.

After explaining the methodology followed for this research, we will perform descriptive statistics as well as a correlation and regression analysis. The next chapter will be a discussion of the results obtained, followed by the conclusion.

Literature review

1. Water-related definitions and water scarcity challenges

"When the well is dry, we know the worth of water." Benjamin Franklin, Poor Richard's Almanac, 1746. Before going further, it appears important to outline some important concepts when we are referring to water issues and topics.

Blue water refers to "the liquid water available in rivers, lakes, and aquifers, i.e., water that can be technically manipulated."[10] Green water is "that fraction of rainfall that infiltrates into the soil and is available to plants. It includes soil water holding capacity and the continual replenishment of reserves by rainfall." (Ringersma & al., 2003)[11]. The same authors explain that green water is the largest freshwater resource even though it has received less attention than blue water. Surface water is defined as "water that flows or rests on land and is open to the atmosphere. Ocean, lakes, ponds, lagoons, wetlands, rivers, streams, ditches, and man-made impoundments are bodies of surface water." (Popek, 2018).[12] Groundwater is "water that exists in the pore spaces and fractures in rocks and sediments beneath the Earth's surface, playing a vital role in the hydrological cycle and supporting ecosystems, agriculture, and human consumption" (Alley et al., 1999).[13] It flows in water tables and underground aquifers in large quantities. Nevertheless, groundwater is extremely slow to replenish, taking decades or even centuries, particularly in arid zones, which are very reliant on its supply. Research showed that in many places, natural groundwater recharge is much slower than current extraction rates (Richey and al., 2015[14]; Shamsudduha & Taylor, 2020[15]).

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[10] Lundqvist, J. (2009). Water as a human resource. In *Elsevier eBooks* (pp. 31–42). https://doi.org/10.1016/b978-012370626-3.00006-5

[11] Ringersma J, Batjes NH, Dent DL, 2003. Green Water: definitions and data for assessment. Report 2003/2. ISRIC – World Soil Information, Wageningen. https://www.researchgate.net/publication/40120223_Green_Water_Definitions_and_Data_for_Assessment#:~:text=Green%20water%20is%20that%20fraction,replenishment%20of%20reserves%20by%20rainfall. Page 3

[12] Popek, E. (2018). Practical approach to sampling. In *Elsevier eBooks* (pp. 145–225). https://doi.org/10.1016/b978-0-12-803202-2.00004-5

[13] Alley, W. M., Reilly, T. E., & Franke, O. L. (1999). Sustainability of ground-water resources. *U.S. Geological Survey Circular/U.S. Geological Survey Circular*. https://doi.org/10.3133/cir1186

[14] Richey, A. S., Thomas, B. F., Lo, M., Reager, J. T., Famiglietti, J. S., Voss, K., Swenson, S., & Rodell, M. (2015). Quantifying renewable groundwater stress with GRACE. *Water Resources Research*, *51*(7), 5217–5238. https://doi.org/10.1002/2015wr017349

Water scarcity can be defined as "a shortage in the availability of freshwater relative to demand" (Taylor, 2009)[16]. It is determined by three main factors: water demand and consumption, climatic conditions, landscape and geological. Four billion people live under conditions of water scarcity at least one month of the year, with nearly half of those people living in India and China (Mekonnen & Hoekstra, 2016)[17]. The authors defend the idea that "previous global water scarcity assessments have underestimated experienced water scarcity by failing to capture the seasonal fluctuations in water consumption and availability". Peter H. Gleick outlined the minimum water requirements necessary for various human activities, leading to the amount of water needed to meet human basic needs, including drinking, personal hygiene, and other domestic uses. The total is around 50 liters of water per day and per person (Gleick, 2006)[18].

Most of the literature identifies two primary causes of water scarcity:

- Physical scarcity, which occurs in desert or arid regions, where limited water availability is dictated by environmental factors. Additionally, inadequate water management and distribution upstream can contribute to downstream shortages.
- Economic scarcity, by contrast, occurs when water remains unavailable due to insufficient resources, poor management, or the inability to afford access to water.

To address water scarcity issues, there are two main categories of actions: demand-side management and supply augmentation.

Water supply augmentation would encompass all the "hard" infrastructures or engineering solutions and can be achieved through dams, weir constructions or substitution (desalinization). This has traditionally been the most promoted alternative because it can be

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[15] Shamsudduha, M., & Taylor, R. G. (2020). Groundwater storage dynamics in the world's large aquifer systems from GRACE: uncertainty and role of extreme precipitation. *Earth System Dynamics*, *11*(3), 755–774. https://doi.org/10.5194/esd-11-755-2020

[16] Taylor, R. (2009). Rethinking Water Scarcity: The Role of Storage. *Eos*, 90(28), p. 237-238. https://doi.org/10.1029/2009eo280001

[17] Mekonnen, M. M., & Hoekstra, A. Y. (2016). Four billion people facing severe water scarcity. *Science Advances,* 2(2). https://doi.org/10.1126/sciadv.1500323

[18] Gleick, P. H. (1996). Basic water requirements for human activities: Meeting basic needs. *Water International, 21*(2), 83-92. https://doi.org/10.1080/02508069608686494

implemented relatively quickly and is "occasionally efficient where there are low marginal costs" (Wheeler and Garrick, 2020).[19] On the other hand, water demand-side management encompasses "soft" infrastructure and governance. It takes the form of educational measures (information, awareness campaigns about water and environmental topics), regulation and planning processes through legislation and economic incentives (pricing, subsidies, and/or property right changes that allow water markets) (Wheeler and Garrick, 2020)[20]. While both demand and supply responses should be integrated when designing solutions to ensure water security, this is often not the case (Sadoff and al., 2015; Barbier, 2019[21]).

To visualize water resources vulnerability on a global scale, water stress indices are commonly used. The most widely use is the Falkenmark indicator, also called Falkenmark Water Stress Indicator, or Water Stress Index (**WSI)*.** It helps quantify how much stress a region is experiencing in terms of water scarcity, often expressed as a ratio between the amount of water withdrawn and the renewable freshwater resources available (Falkenmark, 1989)[22]. The water exploitation index plus, also referred as WEI+, is another water scarcity index and was introduced by the Water Scarcity and Drought Expert Group of the European Commission.

According to data from the World Resources Institute (**WRI***), in 2023, 25 countries were facing extremely high-water stress, using almost all their entire available water supply each year.[23] Those encountering the worst water-stress situations are Bahrain, Cyprus, Kuwait, Lebanon, Oman, and Qatar. Regionally speaking, the Middle East and North Africa are naturally more arid: up to 83% of the population in those regions is exposed to extremely high water-stress, followed by South Asia, where 74% of the population is concerned by the same problems. In Europe, only two countries are facing extremely high water-stress: Belgium and

[19] Wheeler, S. A., & Garrick, D. E. (2020). A tale of two water markets in Australia: lessons for understanding participation in formal water markets. *Oxford Review of Economic Policy*, *36*(1), 132–153. https://doi.org/10.1093/oxrep/grz032

[20] *Ibid*

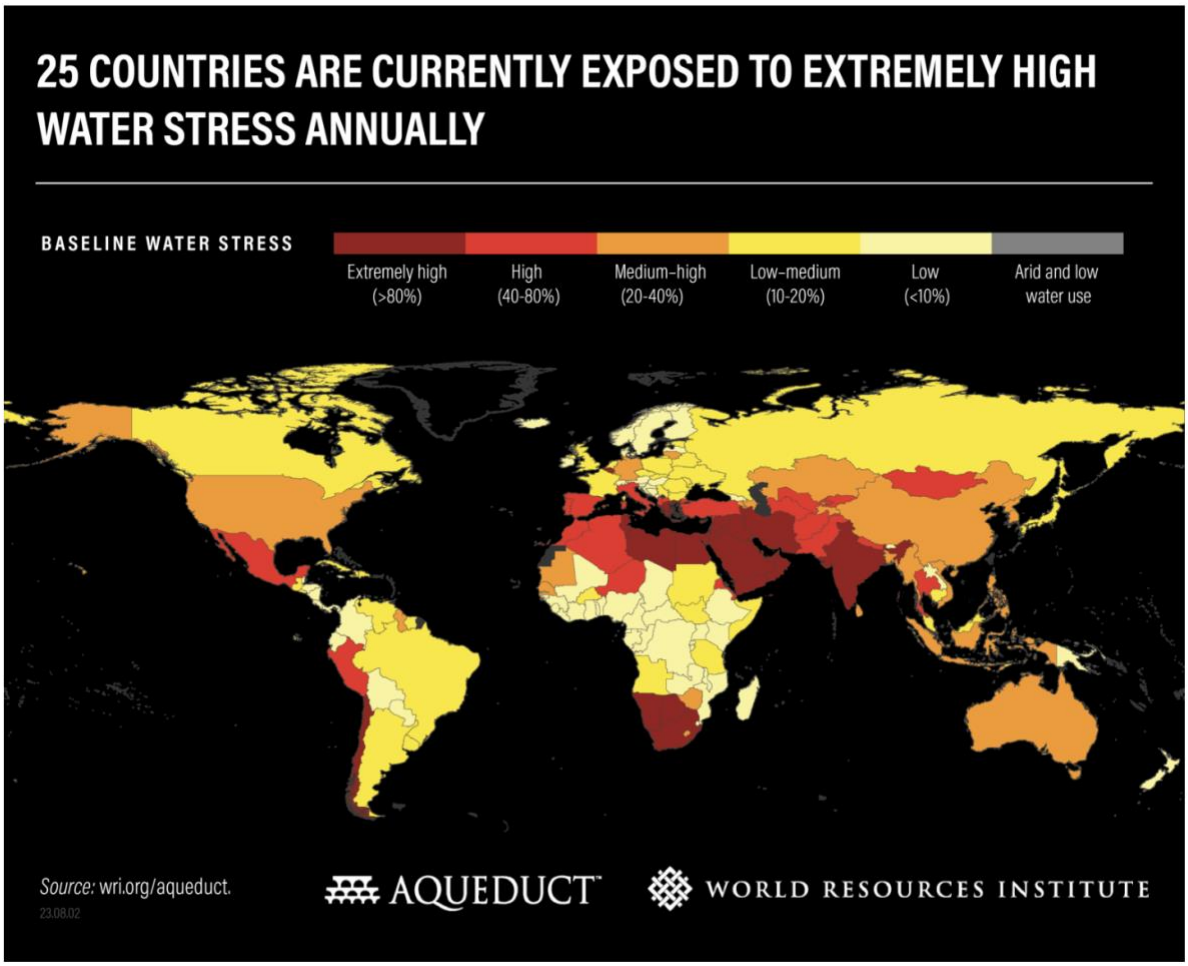
[21] Barbier, R., Barraqué, B., & Tindon, C. (2019). L'eau potable pourrait-elle devenir un bien commun ? *Développement Durable et Territoires*, *Vol. 10, n°1*. https://doi.org/10.4000/developpementdurable.13231

[22] Falkenmark, M. (1989). The massive water scarcity now threatening Africa: Why isn't it being addressed? *Ambio*, *18*(2), 112–118. https://www.jstor.org/stable/4313541

[23] Kuzma, S. (2023). *25 countries, housing one-quarter of the population, face extremely high water stress*. World Resources Institute. https://www.wri.org/insights/highest-water-stressed-countries

Greece, but the southern regions are increasingly being confronted to water scarcity, becoming drier every year.

Figure 1 - Water stress per country



Source: World Resources Institute. (2023). https://www.wri.org/insights/highest-water-stressed-countries

A strong link can be made between freshwater availability and development. Indeed, droughts are particularly harmful for economic growth in developing countries. According to a World Bank report from 2023, extreme rainfall shocks, meaning below-average precipitation, have increased by 233% in certain regions over the past fifty years. Poor countries experience more droughts, being often in drier areas, and are also more vulnerable to them. Moreover, "compared to normal conditions, moderate drought reduces growth in developing countries,

on average, by around 0.39 percentage points, while extreme drought reduces growth by around 0.85 percentage points." (Zaveri and al., 2023).[24]

2. International water governance and laws

Regulation through law plays a major role in water markets and water governance. More than 250 hundred watercourses are shared by at least two states, which imposes for an international legal framework. Nevertheless, international water governance only started in the last 50 years and isn't that strong, in regard of the vital challenges related to water.

Hammurabi's code, one of the first set of laws ever written (around 1755 BC), already mentions laws to regulate water usage (Kornfeld, 2009)[25]. In Antiquity, Roman law defined water as a natural resource, essential to the proper functioning of society and the protection of the Empire's strategic interests (Maslen, 2020)[26]. A whole series of laws regulated the management of public aqueducts and access to water. Fast forward in history, the 19th century has been the theater of the first modern national water laws in countries such as Spain, United States and Australia (Spain's Water Law of 1866 then 1879; California Supreme Court case of Irwin v. Philipps in 1855; New South Wales Water Act of 1896 in Australia). Around the world, the twentieth century saw the acceleration of national legislation to regulate water use and governance. The second half of the twentieth century also witnessed the organization of the Mar de Plata conference, the first step towards international cooperation in the water sector.

The Mar del Plata Conference held in Argentina in 1977 was the first world water forum but also the first conference of the United Nations addressing water. The conference was attended by 116 governments and for most of them, it was the ministry in charge of water that was leading the delegation. According to Biswas (2004), Mar del Plata can be considered as a

[24] Zaveri, E., Damania, R., Engle, N., World Bank Group, & Global Water Security & Sanitation Partnership. (2023). *Droughts and Deficits: Summary Evidence of the Global Impact on Economic growth*. International Bank for Reconstruction and Development / The World Bank. https://documents1.worldbank.org/curated/en/099640306142317412/pdf/IDU03b9849a60d86404b600bc480bef6082a760a.pdf?_gl=1*12lz79f*_gcl_au*MTk4MTMwNzU3My4xNzI2NTg4MTcz

[25] Kornfeld, I.E. (2009). Mesopotamia: A History of Water and Law. In: Dellapenna, J.W., Gupta, J. (eds) The Evolution of the Law and Politics of Water. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-9867-3_2

[26] Maslen, M. (2020). Roman, Historical and Contemporary Legal Access to Water as Object of Public Relations. Societas et iurisprudentia. https://doi.org/10.31262/1339-5467/2020/8/2/51-71.

milestone in water governance and its future development[27]. Hence, during this conference, water was referred for the first time as a "common good" by the international community. Even more important, Mar del Plata managed to put water firmly in the international political agenda of that time[28] (Biswas & Tortajada, 2023). An impressive amount of research and knowledge was amassed in preparation for the summit. Numerous analyses were carried out by developing countries on the availability and use of water resources. At the time, water-related issues had not yet been brought to the fore as they are today. Following the conference, many developing countries continued to monitor and assess their water resources, as well as current and future demand.

In addition, a major consequence of the Mar de Plata conference was the definition of the period 1981-1990 as the International Drinking Water Supply and Sanitation Decade (**IDWSSD***). The IDWSSD aimed to ensure that by 1990, all human beings would have access to sufficient quantities and quality of drinking water, as well as basic sanitation facilities. While it accelerated the investments needed to facilitate access to drinking water for all, and significantly improved the lives of hundreds of millions of people in developed countries, the primary goal wasn't achieved.

Shortly after the IDWSSD, a United Nations Global Consultation met in New Delhi to take stock of the past decade in terms of access to drinking water and sanitation. According to the resulting evaluation, an additional 449 million urban dwellers and 1.141 billion rural dwellers in developing countries have been provided with an adequate supply of safe water[29]. Coverage rates in urban areas rose from 76% to 88% between 1980 and 1990, and from 29% to 68% in rural areas[30]. The small percentage increase in absolute values for urban dwellers can be explained by the very strong growth in the urban population in developing countries

[27] Biswas, A. K. (2004). From Mar del Plata to Kyoto: an analysis of global water policy dialogue. Global Environmental Change, 14, 81-88. https://doi.org/10.1016/j.gloenvcha.2003.11.003

[28] Biswas, A. K., & Tortajada, C. (2023). United Nations water conferences: reflections and expectations. International Journal Of Water Resources Development, 39(2), 177-183. https://doi.org/10.1080/07900627.2023.2176655

[29] UNDP-New York. (1992). Global Consultation on Safe Water and Sanitation for the 1990s, New Delhi, India, September 10-14, 1990: Background document (A45/15). *Secretariat for the Global Consultation on Safe Water and Sanitation for the '90*. Consulted on July 28th 2024, on https://iris.who.int/bitstream/handle/10665/198356/WHA45_15_fre.pdf

[30] *Ibid*

over the decade. Moreover, although the gap between rural and urban areas has narrowed, inequalities remain.

The report's conclusions identify several major needs that foreshadow the new dominant model, as Petitjean (2009): "low-cost, easily adaptable technologies; decentralized management methods adapted to the new urban spaces of the South; new financial approaches, including the need not to consider water as a free good, and to recover at least part of the costs from users."[31]

In January 1992, was held the International Conference on Water and the Environment (**ICWE***) in Dublin, Ireland, also referred as Dublin conference. The conference was a preparatory meeting for the Rio Earth Summit which took place the same year in Brazil. The ICWE gathered around five hundred participants from government experts to international, intergovernmental, and nongovernmental organizations' representatives. It closed with the adoption of the Dublin Statement, encompassing four main guiding principles[32]:

- "Principle number 1 – Fresh water is a finite and vulnerable resource, essential to sustain life, development, and the environment.
- Principle number 2 – Water development and management should be based on a participatory approach, involving users, planners, and policymakers at all levels.
- Principle number 3 – Women play a central part in the provision, management and safeguarding of water.
- Principle number 4 – Water has an economic value in all its competing uses and should be recognized as an economic good."

In addition, for the first time, the notion of Integrated Water Resources Management (**IWRM***) appeared on the international scene during the Dublin conference. IWRM can be defined as "a process which promotes the coordinated development and management of water, land, and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the

[31] Petitjean, O. (2009, May 20). Water Governance: the evolution of models at the international level: From Mar del Plata to Istanbul, the role of conferences. *Partage Des Eaux*. https://www.partagedeseaux.info/Gouvernance-de-l-eau-l-evolution-des-modeles-au-niveau-international

[32] Secretariat, ICWE. (1992). The Dublin statement on water and sustainable development. In *International Conference on Water and the Environment, Dublin, Ireland.*

environment“ (Rahaman & Varis, 2005)[33]. It also implies that “water should be managed in a basin-wide context, under the principles of good governance and public participation.”

Nevertheless, the Dublin principles have been quite controversial, especially for recognizing officially water as an economic good for the first time. Indeed, critics argue that it constituted a step towards privatization, commodification and financialization of water (Bakker, 2011[34]; Lane & Jarman, 1998[35]). This goes hand in hand with the wave of privatizations in the water sector that began in the late 80s/early 90s, spurred on by the **IMF*** and World Bank. The privatization movement fits in perfectly with the context of the end of the Cold War, when the Washington Consensus played an important role in shaping development policies. The Washington Consensus is a tacit agreement to promote “good governance” practices in developing countries. Adherence to these recommendations, which are strongly neo-liberal in inspiration, was a condition for the payment of financial aid to the countries in question. These “good practices” were defined by John Williamson in 1989 and include notably economic deregulation and privatization.[36]

In the years that followed, the number of international bodies overseeing the governance and management of water resources multiplied. The creation of the World Water Council in 1995, a parallel multi-stakeholder body operating outside the United Nations, was followed by that of the Global Water Partnership in 1996. In parallel, international law was strengthened by a major step forward. The Convention on the Law of the Non-Navigational Uses of International Watercourses, adopted in 1997 by the United Nations General Assembly (resolution 51/229), provides a legal framework for the management of shared water resources, although it only came into force on August 17, 2014. In 2000, the Second World Water Forum in The Hague coincided with the adoption of the Water Framework Directive (**WFD***) in Europe. The International Conference on Freshwater in Bonn in 2001 brought

[33] Rahaman, M. M., & Varis, O. (2005). Integrated water resources management : evolution, prospects and future challenges. *Sustainability Science Practice And Policy*, *1*(1), 15-21. https://doi.org/10.1080/15487733.2005.11907961

[34] Bakker, K. (2011). Commons versus commodities : Debating the human right to water. In The Right to Water (1st ed.). Routledge. https://doi.org/10.4324/9780203152102-2

[35] Lane, J., & Jarman, J. (1998). Six years on - what happened to the Dublin principles ? Dans *WATERLINES : Vol. VOL. 16–NO. 3*. https://www.ircwash.org/sites/default/files/Lane-1998-Six.pdf

[36] Williamson, J. (1993). Democracy and the “Washington consensus.” *World Development*, *21*(8), 1329–1336. https://doi.org/10.1016/0305-750x(93)90046-c

stakeholders together to discuss freshwater resource management, shortly followed by the Third World Water Forum in Kyoto in 2003. The International Decade for Action "Water for Life" (2005-2015) then highlighted the importance of water in sustainable development and human rights.

In resolution 64/292 of July 28, 2010, the UN General Assembly recognized "access to clean and safe drinking water as a fundamental human right"[37]. In detail, 122 countries voted in favor of the resolution and 41 abstained, including the United States, Great Britain, and Australia, three countries at the forefront of turning water into a commodity and a financial investment. The resolution was put forward by Bolivia, which was heavily involved in defending access to water as a fundamental right following the Cochambaba "water wars" in 2000. Following this episode, the Bolivian government, led by Evo Morales, the country's first indigenous president, nationalized the country's water services and took a firm stance against the commodification of natural resources.

The 2023 UN Water Conference (22-24 March 2023) was the first UN conference on water since Mar del Plata in 1977, almost 50 years ago. This testifies to the lack of visibility and importance accorded to water challenges in the international agenda. The 2023 UN Water Conference was unfortunately carried out with limited objectives and considering mainly water as a scarcity issue and located in developing countries, when the reality is way more complex and deeply political (Biswas & Tortajada, 2023).[38]

Additionally, the One Water Summit, a UN event whose International Steering Committee is chaired by France and Kazakhstan, was due to take place in September 2024 in New York. The aim of the meeting was to accelerate action on SDG 6 and discuss solutions to the issues posed by water sharing, management, and scarcity. The summit was intended to serve as a preparatory meeting for the 2026 UN Water Conference, but has unfortunately been postponed to a later date, not yet set, underestimating the urgency of the water problem.

[37] United Nations. (2010). *Resolution 64/292: The human right to water and sanitation*. United Nations General Assembly. https://undocs.org/en/A/RES/64/292

[38] Biswas, A. K., & Tortajada, C. (2023). Global crisis in water management: Can a second UN Water Conference help? *River*, *2*(2), 143–148. https://doi.org/10.1002/rvr2.40

As a result, water does not seem to be a priority in the international agenda, while the world's population continues to grow, and global warming reduces available water resources year after year. Although international cooperation does exist, the lack of a common strategy between the various agencies and bodies governing water-related issues contributes to reducing the effectiveness of the actions taken. The UN-Water agency has the merit of existing, but currently lacks the strong leadership needed to make its voice heard and carry weight. To conclude, international regulations on drinking water remain very limited. However, measures are being taken at national and local level to legislate and attempt to regulate the use of this resource. A small number of countries, discussed in the next chapter, have enshrined the right to water in their constitutions, which has a significant impact on the governance of the resource. We will now examine, in the next section, how markets organized themselves, and especially water markets organized themselves along time.

3. Markets and market governance of public and common goods

The first definition of the market concept comes from Adam Smith (1776), who describes a market as a place where individuals, driven by self-interest, exchange goods and services. He also introduced the concept of the Invisible Hand, stating individual pursuits lead to the efficient allocation of resources and collective economic benefit.

From the earliest forms of exchange back to the Upper Paleolithic to now, the evolution of human societies has been accompanied by the institutionalization of markets (not necessarily always in a linear way). After the appearance of minted money, which standardized exchanges to a certain extent, rules appeared on the agora market in Athens and on the Forum Romanum to regulate transactions. In the Middle Ages, as early as the 11th century, the first medieval stock exchanges were created in Europe, bringing together merchants from different countries to exchange goods. In the 12th century, the fairs of Champagne set up special regulations to govern trade: strict rules between local lords and merchants defined the quality of goods, tax obligations and the manner of exchange (contracts, credits, etc.). Later, in 1801, the creation of the London Stock Exchange formalized financial markets (Michie, 1999)[39], before commodities markets were institutionalized in the 1850s with exchanges such as the Chicago Board of Trade, which introduced standardized futures contracts.

[39] Michie, R. C. (1999). *The London Stock Exchange: A history* (pp. 48-72). Oxford University Press.

In neoclassical economic theory, Walras (1874) defended the idea that markets are in equilibrium when supply equals demand for all goods and services simultaneously, and that this equilibrium is achieved through price mechanisms[40]. Prices signal scarcity conditions to economic agents and play a central role in coordinating their economic decisions. In the decades that followed, Pareto made important contributions to neoclassical theory, in particular the conditions necessary for Welfare Theorems to hold perfect competition, perfect symmetric information, complete markets, and price flexibility. In 1890, the Sherman Act guaranteed the right to competition in the United States by prohibiting monopolies. These were the first antitrust laws[41]. After the financial and economic crisis of 1929 and the Great Depression, the United States created the Security and Exchange Commission (SEC). In 1971, the **NASDAQ*** was the world's first electronic stock market, being able to promote and facilitate faster and more efficient trading.

Along with the institutionalization of markets and their transformation on many aspects, the definitions of what is a market and how it should be managed/governed has evolved. Markets are multiform and multidimensional, representing numerous realities that can be studied from a wide variety of angles. Polanyi (1944) viewed markets not as natural or self-regulating systems but as socially embedded institutions, shaped by cultural, political, and historical factors. He argued that unregulated markets, disembedded from usual social constraints, lead to social disruption. Indeed, markets can be seen as trade arenas of price uniformity, institutions, networks, value-creating systems, consumers' cognitive frames or outcomes of performative practices (Ruiz, 2012)[42].

Markets are intrinsically linked not only to the societies in which they evolve, but also to the types of products they concern. In the case of water, the issue is relatively complex. At the UN 2023 Water Conference, UN experts declared that "Water should be managed as a

[40] Walras, L. (1874). *Elements of pure economics.* Routledge.

[41] Stigler, G. J. (1985). The origin of the Sherman Act. *The Journal of Legal Studies*, 14(1), 1-12.

[42] Riuz, C. D. (2012). Theories of markets: Insights from marketing and the sociology of markets. *The Marketing Review*, *12*(1). https://doi.org/10.1362/146934712x13286274424316

common good, not a commodity."[43] It appears important to explain what is a "common good" and what are the differences between the later and a "public good" since their markets, management and governance can be quite different.

In his theory of public goods, Paul Samuelson (1954) provides a framework for understanding the provision and consumption of goods that are non-rivalrous and non-excludable. [44] He presents a classification of goods following two dimensions. First, we are exposed to the notion of jointness of use/consumption or rivalry: a good can either be rival or non-rival. Consumption of a rival good means that the quantity available for others is reduced. The second dimension is exclusion: it is difficult or impossible to prevent individuals from consuming a public good, even if they have not pay for it. Therefore, a public good is non-excludable and non-rivalrous when a common good is non-excludable but rivalrous. In situations where a good is non-excludable and non-rivalrous (public good), arises the problem of the free rider. It occurs when individuals or entities benefit from resources, goods, or services without paying for their fair share of the cost. Since people can benefit of public goods with contributing, they have a rationale incentive to expect other to cover the costs. This situation can lead consumers to deplete a resource or underfund it; hence, the free-rider problem complicates efforts to organize communities and groups, especially large ones, for common goals (Olson, 1965)[45].

In his book *The Tragedy of the Commons* (1968), Hardin describes a situation in which individuals, acting independently and rationally according to their self-interest, overexploit a shared resource (common good), ultimately depleting it and causing harm to the entire group[46]. In other words, the book's eponym theory refers to "a general class of situations where a common resource is overused by individuals who do not, when making their decisions, internalize the negative impact of their decisions on others' interests." (Bezin &

[43] OHCHR. (2023). Water is a common good not a commodity: UN experts. https://www.ohchr.org/en/statements-and-speeches/2023/03/water-common-good-not-commodity-un-experts. Accessed on July 28th, 2024.

[44] Samuelson, P. A. (1954). The pure theory of public expenditure. *The Review of Economics and Statistics, 36(4)*, 387. https://doi.org/10.2307/1925895

[45] Olson, M. (1965). *The logic of collective action : Public goods and the theory of groups*. Harvard University Press. http://commres.net/wiki/_media/olson.pdf

[46] Hardin, G. (1968). The tragedy of the Commons. *Science, New Series*, *162*(3859), 1243–1248. https://www.jstor.org/stable/1724745

Ponthière, 2019)[47]. Hardin argued that people couldn't be trusted to regulate themselves since their primary "rational thought" would be to maximize their own use of the resource and that the best way to tackle those kinds of situations was to put in place coercive measures. The main solutions were, in his opinion, privatization or government regulation. Privatization would enable individuals to be more responsible by having personal incentives to manage the resource sustainably: overexploitation leading to depletion would affect them directly. On the other hand, government regulation would involve external authorities enforcing rules to control access and usage, thereby preventing overexploitation by imposing penalties or restrictions to ensure the resource is preserved for the collective good.

A decade later, Ostrom & Ostrom (1977) challenged Hardin's theory and brought a new perspective on the "tragedy of the commons" concept while expanding the work of Samuelson's. While Samuelson primarily focused on the role of government in providing public goods, the Ostrom's introduced a new perspective: the potential for communities to self-organize and sustainably manage shared resources. Indeed, they underlined that local communities could create their own institutions and regulations, frequently more successfully than outside authorities. Their research highlighted that the successful management of common-pool resources (**CPRs***) depends on several factors such as clearly defined boundaries, collective-choice arrangements, monitoring, and graduated sanctions. The importance of social capital, trust and community engagement in their view can be linked to the notion of IWRM that will only emerge at the beginning of the 90s.

Tap water has a price almost everywhere in the world, meaning that you need to pay according to your consumption a certain sum per liter or cube meters. In some places, the price per liter (or cube meters) is linked to the quantity consumed: when the household uses more than a set amount of water (considered as covering their essential needs), they will need to pay extra. In the case of public water management, public subsidies are often introduced to guarantee universal access to the resource. In this way, the price charged to users can be lower than the real costs supported by the public authorities (Bel, 2020).[48] Furthermore, temporary restrictions may be imposed on the permitted uses of water (e.g. prohibiting filling a

[47] Bezin, E., & Ponthière, G. (2019). The tragedy of the commons and socialization: Theory and policy. *Journal of Environmental Economics and Management*, *98*, 102260. https://doi.org/10.1016/j.jeem.2019.102260

[48] Bel, G. (2020). Public versus private water delivery, remunicipalization and water tariffs. *Utilities Policy*, *62*, 100982. https://doi.org/10.1016/j.jup.2019.100982

swimming pool, washing a car, etc.), or on the quantity of water allocated to each household, adding extra regulations, for example, when there is a heatwave and supply is limited.

4. Definition and typology of water markets

A water market can be defined as "an institutional framework which allows water right holders, under certain established rules, to transfer their rights to other economic agents or water users, receiving an economic compensation in exchange." (Rey and al., 2018)[49]. Water markets are presented as an economic tool to better allocate water resources in water-scarce areas. Water trading occurs on water markets and refers to "the voluntary buying and selling of water in some quantifiable form; either in the present or the future." (Wheeler & al., 2017)[50]. It is also referred as "the process of buying and selling water licenses (also called entitlements or rights)" (Wheeler & Xu, 2021)[51].

Three different categories of water trading can be identified (Wheeler and Garrick, 2020)[52]. The first type is water allocation trade, which consists of short-term or temporary transfers. Secondly, water leasing is defined by "medium-term leasing of water allocations to secure access to water for a period of time specified in a contract". Finally, the third category is permanent transfers of water entitlements, which can be "the ongoing property right to either a proportion or fixed quantity of the available water at a given source (also known as water entitlement trading)" and water delivery rights (Wheeler & Xu, 2021)[53]. Water markets can be formal or informal depending on the legal framework that determines how they operate (Hadjigeorgalis, 2009)[54].

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[49] Rey, D., Pérez-Blanco, C. D., Escriva-Bou, A., Girard, C., & Veldkamp, T. I. E. (2018). Role of economic instruments in water allocation reform: lessons from Europe. *International Journal of Water Resources Development*, *35*(2), 206–239. https://doi.org/10.1080/07900627.2017.1422702

[50] Wheeler, S. A., Loch, A., Crase, L., Young, M., Grafton, R. Q. (2017). Developing a water market readiness assessment framework. *Journal of Hydrology*, 552, 807–820. https://doi.org/10.1016/j.jhydrol.2017.07.010

[51] Wheeler, S. A., & Xu, Y. (2021). "Chapter 1: Introduction to Water Markets: an overview and systematic literature review". In *Water Markets*. Cheltenham, UK: Edward Elgar Publishing. https://doi.org/10.4337/9781788976930.00010

[52] Wheeler, S. A., & Garrick, D. E. (2020). A tale of two water markets in Australia : lessons for understanding participation in formal water markets. *Oxford Review Of Economic Policy*, *36*(1), 132-153. https://doi.org/10.1093/oxrep/grz032

[53] *Ibid.*

[54] Hadjigeorgalis, E. (2009). A Place for Water Markets: Performance and challenges. *Review of Agricultural Economics*, 31 (1), 50–67. https://doi.org/10.2307/30224846

Informal water markets are made from arrangements between users with a framework that is operational rather than legal. Users need drive the framework that can widely vary; most of the time the transfer of water rights is temporary and does not change the ownership of the resource (Bjornlund &McKay, 2002)[55]. Informal water markets can be found in China, India, Thailand, and Pakistan. Tsiarapas & Mallios (2022) state that "in general, informal water markets have been established in areas where governments have failed to address water-related challenges"[56].

Furthermore, another distinction of water markets is between decentralized and centralized ones, depending on their structure. While in a decentralized system, users (buyers and sellers) directly trade with each other, in a centralized system, "water allocation is based on the willingness to pay and the willingness to accept of market participants through a double auction mechanism implemented by a central authority […]" (Tsiarapas & Mallios, 2022)[57].

Wheeler and al. (2017) developed a water market readiness assessment (WRMA) framework, which aims to "evaluate the practical benefits and institutional bases for the implementation and sustainability of water markets to address scarcity issues"[58]. The authors define three main institutional factors as a prerequisite for establishing water markets: enabling institutions, facilitating gains from trade, and monitoring and assessment. This highlights the importance of strong institutions and regulation enforcement to have efficient water markets. However, Griffin and al. (2013) highlights that "water market failures may mean a net cost for society"[59]. This might be an explanatory factor of the reluctance of some countries to adopt a water market approach.

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[55] Bjornlund, H., & McKAY, J. (2002). Aspects of water markets for developing countries: experiences from Australia, Chile, and the US. *Environment and Development Economics*, *7*(4), 769–795. https://www.jstor.org/stable/44379449

[56] Tsiarapas, A., & Mallios, Z. (2022). A Study on Water Markets and the International Experience Gained from their Establishment. *Environmental Research Engineering and Management*, *78*(1), 6–30. https://doi.org/10.5755/j01.erem.78.1.30133

[57] *Ibid.*

[58] Wheeler, S. A., Loch, A., Crase, L., Young, M., & Grafton, R. Q. (2017). Developing a water market readiness assessment framework. *Journal of Hydrology*, *552*, 807–820. https://doi.org/10.1016/j.jhydrol.2017.07.010

[59] Griffin, R. C., Peck, D. E., & Maetsu, J. (2013). Introduction: myths, principles and issues in water trading. In *Water Trading and Global Water Scarcity | International Experiences* (pp. 1–14). RFF Press Water Policy

Data and methodology

1. Introduction

This empirical study involved all the Member States of the UN, which comprises 193 sovereign states as of September 2024. The aim of this research is to compare countries with presence of formal water markets with the rest of the world to confirm the hypothesis that we drew. The presence of formal water markets is our dependent variable, and the other ones are independent variables.

Formal and informal water markets intervene in different contexts and have a fundamentally different relationship to the institutions and law. We will focus our research, in the following section, on formal water markets since data on informal water markets is more limited. Furthermore, research on informal water markets would rely on different indicators and probably imply a different approach.

The variables that we will be looking into are intended per country and include scarcity measures through freshwater withdrawals as a share of internal resources and annual freshwater withdrawals for agriculture as a share of total freshwater withdrawals. In addition, several legal and political components will enable us to better understand the ties between water markets, law, and institutions thanks to the following variables: voting data from resolution 64/292 of July 28, 2010, which recognized water as a human right, type of political regime, existence of a constitutional right to water and WJP Rule of Law Index. Furthermore, we will investigate socio-economic indicators, namely Human Development Index (HDI), Gini coefficient and Atkinson Index.

Data was unfortunately not available for all the 193 Member States of the UN for every indicator that we will be using in this research. Small countries and island nations were particularly impacted by the lack of information. Freshwater withdrawals (as a share of internal resources) and freshwater withdrawals for agriculture (as a share of total freshwater withdrawals) comprises 175 observations, the detail can be found in the datasets provided in the references' section. The dataset regarding the types of political regimes includes 172 countries, the WJP Rule of Law Index encompasses 126 countries, the Human Development

Series. https://www.taylorfrancis.com/books/edit/10.4324/9780203084151/water-trading-global-water-scarcity-josefina-maestu

Index 190, and the Atkinson one 169. The lowest data availability was for the Gini Index, for which we have only 64 observations. Details can also be found in the datasets provided in the references' section. Additionally, we decided to focus on the year 2020, due to data availability, to have more uniformity in our results.

2. Natural resources components

The "total freshwater withdrawals, as a share of internal renewable resources" data are from the Food and Agriculture Organization of the United Nations (**FAO***) AQUASTAT Database. This measure represents the water stress of a country and is expressed in %. The total water withdrawals are defined by the FAO as: "Annual quantity of water withdrawn for agricultural, industrial, and municipal purposes. It can include water from primary renewable and secondary freshwater resources, as well as water from over-abstraction of renewable groundwater or withdrawal from fossil groundwater, direct use of agricultural drainage water, direct use of (treated) wastewater, and desalinated water. It does not include in-stream uses, which are characterized by a very low net consumption rate, such as recreation, navigation, hydropower, inland capture fisheries, etc." The Food and Agriculture Organization of the United Nations categorizes water stress in the following ways: "if withdrawals are less than 25 percent of resources, then a country has no water stress; 25-50 percent is low stress; 50-75 percent is medium; 75-100 percent high stress; and greater than 100 percent is critical stress." Furthermore, it is explained that "withdrawals can exceed 100% of total renewable resources where extraction from non-renewable aquifers or desalination plants is considerable." Nevertheless, national-level data often overlooks local variations, which can be crucial when assessing the sustainability of specific groundwater aquifers or surface water basins.

The annual freshwater withdrawals for agriculture as a share of total freshwater withdrawals are the "annual quantity of self-supplied water withdrawn for irrigation, livestock and aquaculture purposes. It can include water from primary renewable and secondary freshwater resources, as well as water from over-abstraction of renewable groundwater or withdrawal from fossil groundwater, direct use of agricultural drainage water, direct use of (treated) wastewater, and desalinated water. Water for the dairy and meat industries and industrial processing of harvested agricultural products is included under industrial water withdrawal." The data was also extracted from the FAO Aquastat Database and is expressed in %.

3. Legal and political components

The **WJP*** Rule of Law Index is made by the World Justice Project, which is an independent, multidisciplinary organization. The dataset can be found on its website. They define rule of law as "a durable system of laws, institutions, norms, and community commitment that delivers four universal principles: accountability, just law, open government, and accessible and impartial justice". Its value can be between 0 and 1 (1 meaning a strong adherence to the rule of law). It is based on 8 factors: constraints on government powers, absence of corruption, open government, fundamental rights, order and security, regulatory enforcement, civil justice, and criminal justice. In the first place, we thought about isolating the sixth criteria (regulatory enforcement) but since they are all interconnected, we decided that it was better to take the index as a whole.

The detailed votes to the resolution 64/292 of July 28, 2010, of the UN General Assembly, were found in the UN Digital Library. The aim of this resolution was to recognize "water as a human right". Countries were classified in three categories: in favor, abstention, or non-voting. The results were 122 in favor to none against, with 41 abstentions and 29 non-voting countries. South Sudan which is the last country to become a Member State, wasn't recognized back in 2010. This vote reveals the perspective and position of countries towards water.

The type of political regime indicator is based on the classification by Lührmann and al. (2018) which distinguishes 4 types of political regimes: closed autocracy, electoral autocracy, electoral democracy, and liberal democracy. Closed autocracy can be defined as a regime in which "citizens do not have the right to choose either the chief executive of the government or the legislature through multi-party elections". Electoral autocracy is a form of political governance in which "citizens have the right to choose the chief executive and the legislature through multi-party elections; but they lack some freedoms, such as the freedoms of association or expression that make the elections meaningful, free, and fair." Electoral democracy corresponds to a situation in which "citizens have the right to choose the chief executive and the legislature in meaningful, free and fair, and multi-party elections." Finally, liberal democracy is "an electoral democracy and citizens enjoy individual and minority rights, are equal before the law, and the actions of the executive are constrained by the legislative and the courts."

The existence of a constitutional right to water is the official recognition in the constitution of a country of a right to water. This variable is binary; for federal states, we considered that if at least one state, province or regional entities disposes of a constitutional right to water in their constitutional or provincial constitution, we could count it as a yes to the question of the existence of a constitutional right to water in the country. The list of the countries can be found in ***Table 1*** below.

Table 1 - Countries with a constitutional right to water

Countries with a constitutional right to water	
Argentina	*Nicaragua*
Bolivia	*Niger*
Colombia	*Panama*
Democratic Republic of Congo	*Paraguay*
Ecuador	*Peru*
Egypt	*Slovenia*
Ethiopia	*South Africa*
Kenya	*Uruguay*
Morocco	*Venezuela*
Mexico	

4. Social and economic components

The income groups are from a classification of the World Bank and are made based on the **GNI*** per capita. The countries are divided in four categories: low-income, lower-middle-income, upper-middle-income, and high-income countries. The groups are made based on the following: low-income countries have a GNI per capita of $1,145 or less; lower-middle between $1,146 and $4,515, upper-middle between $4,516 and $14,005 and high-income above $14,005.

The Human Development Index (HDI) is a measure created by the United Nations Development Programme (UNDP). The aim of this indicator is to evaluate a country overall's development, taking into consideration both social and economic development. The HDI is

expressed on a scale from 0 to 1 (1 is the maximum, meaning a high human development). HDI formula relies on three key factors: life expectancy, education (average studies duration for adults being more than 25 years old and expected years of schooling for children entering school) and standard of living (based on GNI per capita, adjusted for purchasing power parity).

The Gini Coefficient is a metric quantifying the disparity in income distribution within a nation. It operates on a scale from 0 to 1, where 0 signifies perfect equality (every individual has the same income) and 1 indicates extreme inequality.

The Atkinson Index is also an indicator measuring income inequality in a country, but it is adjusted to reflect societal preferences for equality. It was developed by the economist Anthony Atkinson in 1970. It ranges from 0 to 1 but the lower it is, the more the country is close to perfect equality (0 is perfect equality). It incorporates an "inequality aversion parameter", thus assessing not only the income inequality but the behavior and attitude of a population towards inequality.

5. Model

The outcome of the dependent variable, presence of water markets, is binary: 0 = "Absence of water markets" and 1 = "Presence of water markets". Therefore, it appeared more appropriate to perform a logistic regression.

To obtain a higher number of observations (n = 113), we removed the Gini index when doing the regression. Due to high multicollinearity, we also removed the income category variable that was too strongly correlated to human development index, rule of law and inequalities.

The model can be expressed as followed:

$$logit(Y_i) = \ln\frac{P(Y_i = 1)}{P\ (Y_i = 0)} = \beta_0 + \beta_1 FWW\_agriculture_i + \beta_2 total\_FWW_i + \beta_3 Constitutional\_right_i + \beta_4 Political\_regime_i + \beta_5 WJP\_index_i + \beta_6 HDI\_index_i + \beta_7 Atkinson\_index_i + \beta_8 Votes\_resolution_i$$

Where:

- Y_i is the binary outcome for country i
- $P(Y_i = 1)$ is the probability that country i has a water market.
- $P(Y_i = 0)$ is the probability that country i does not have a water market.
- β_0 is the intercept.
- β_1 is the coefficient for the annual freshwater withdrawals for agriculture.
- β_2 is the coefficient for the annual total freshwater withdrawals.
- β_3 is the coefficient for the existence of a constitutional right to water in country i.
- β_4 is the coefficient for the type of political regime in country i.
- β_5 is the coefficient for the WJP Rule of Law Index in country i.
- β_6 is the coefficient for the Human Development Index in country i.
- β_7 is the coefficient for the Atkinson index in country i.
- β_8 is the coefficient for the vote of country i regarding the UN resolution 64/292.

To answer the research question, we will test the following null hypothesis that we expect to reject:

H_0 = There is no relationship between the presence of water markets and the selected indicators.

Results

1. Descriptive statistics

Formal water markets are only present in six countries as of 2024: Argentina, Australia, Chile, United States of America, Mexico, and Spain. Only around 3.11% of the countries in our sample have instituted formal water markets. Half of the water markets countries are liberal democracies: Australia, United States of America, and Spain. The other half (Argentina, Chile, and Mexico) are electoral democracies. The WJP Rule of Law Index has a mean of 0.656 among the water market countries, for 0.706 for the high-income countries and 0.555 overall.

The freshwater withdrawals for agriculture are, on average, 52.9% of total freshwater withdrawals per country. The standard deviation of 32.88 shows strong variations between countries with value ranging from 0% to 99.48%. The gap is even wider for the total of freshwater withdrawals as a share of internal renewable freshwater, with a standard deviation of 682.75 for a mean of 129.04%. On average, countries use more water than the internal renewable amount they have available, meaning they are under a water-stress situation. Some countries have extremely high withdrawals with a maximum of 7750%. High-income countries tend to have a lower percentage of freshwater withdrawals with agriculture (31.4% for high-income against 70.62% for middle-income, lower bracket). Nevertheless, the percentage of freshwater withdrawals seems to be significantly high in water markets countries (mean = 67.98 and standard deviation = 17.10). Hence, the mean is more than double the average one of high-income countries and higher than the one of all countries together. On the other hand, the freshwater withdrawals as a share of internal renewable freshwater are way lower for the water markets countries than for the rest (13.74% vs 129.04%), similarly regarding the high-income countries (13.74% vs 149.26%).

Regarding the constitutional right to water, 18 countries out of the 193 countries have recognized the right to water in their Constitution, explaining the low mean of 0.0885. Among the water market countries, Mexico and Argentina wrote down the right to water in their constitution. The proportion of countries to have a constitutional right to water is significantly lower in the high-income category (4,76% of the high-income countries for around 11% in the other income categories).

Out of the countries that have a constitutional right to water, all of them voted for the resolution 64/292 of the UN, except Ethiopia and Kenya. The average of countries that voted for the recognition of water as a human right is the lowest in the high-income category (mean = 0.4921 and standard deviation = 0.504); the standard deviation is also slightly higher than in the other income categories.

The Human Development Index is on average at 0.7207, with a standard deviation of 0.15, a minimum of 0.386 and a maximum of 0.963. Among the water markets countries, the HDI mean reaches 0.8687, varying from 0.757 and 0.948, a relatively small interval confirmed by a standard deviation of 0.0686. Therefore, water markets countries have a higher HDI. Nevertheless, the Gini coefficient is also higher in the water markets countries (mean = 40.53 vs 35.), meaning more inequalities are present in those countries' societies. Parallelly, Atkinson index within water markets countries is around 0.26, slightly lower than on average (mean = 0.2841).

Furthermore, means and medians of the water market countries were quite close for the various independent variables.

2. Correlation analysis

Freshwater withdrawals for agriculture have a strong negative correlation with the income category of countries (-0.4397, p = 0.00) and positive correlation with the Gini coefficient (0.5351, p = 0.00). Countries in higher income tend to have lower or more efficient freshwater withdrawals as a share of total withdrawals as we highlighted above. Countries with higher agricultural withdrawals are therefore on average poorer, which explains the higher income inequality and the negative correlation with the WJP Rule of Law Index (-0.4868, p = 0.00).

There is a strong positive correlation of political regime with the income category (0.5415), hence higher income countries tend to have more democratic political regimes. Naturally, democratic countries also have stronger adherence to the rule of law (0.6995) and higher human development (0.5006). Similarly, the human development index has the stronger correlation of this dataset, with income category (0.9180, p = 0.00). Higher human

development is also associated with lower income inequality (Gini: -0.3991 and Atkinson: -0.6441).

In addition, countries with stronger rule of law tend to have lower levels of inequality:
Gini: -0.4560 and Atkinson: -0.4650. The votes to the UN resolution have non-significant negative correlation with the income category but moderate positive correlation with the Gini coefficient (0.3990).

Table 2 - Correlation analysis

Variables	FWW Agri.	Total FWW	Consti-Tutional right	Political regime	WJP Rule of Law	HDI	Gini coeff.	Atkinson Index	Votes	Income category
FWW Agri.	1.0000									
Total FWW	0.0676 (0.3771)	1.0000								
Consti-tutional right	0.1868 (0.0128)	0.1566 (0.0385)	1.0000							
Political regime	-0.3622 (0.0000)	-0.1854 (0.0165)	0.0044 (0.9539)	1.0000						
WJP Rule of Law	-0.4868 (0.0000)	-0.1235 (0.1701)	-0.2356 (0.0079)	0.6995 (0.0000)	1.0000					
HDI	-0.3811 (0.0000)	0.0605 (0.4294)	-0.0557 (0.4449)	0.5006 (0.0000)	0.7564 (0.0000)	1.0000				
Gini coeff.	0.5351 (0.0000)	-0.1430 (0.2635)	0.4431 (0.0002)	-0.1741 (0.1690)	-0.4560 (0.0008)	-0.3991 (0.0011)	1.0000			
Atkinson Index	0.2851 (0.0003)	-0.0859 (0.2877)	0.1104 (0.1530)	-0.3251 (0.0000)	-0.4650 (0.0000)	-0.6441 (0.0000)	0.8441 (0.0000)	1.0000		
Votes	0.1763 (0.0189)	0.0843 (0.2674)	0.1708 (0.0176)	-0.2847 (0.0002)	-0.1874 (0.0357)	-0.0964 (0.1860)	0.3990 (0.0011)	0.0891 (0.2495)	1.0000	
Income category	-0.4397 (0.0000)	0.0125 (0.8697)	-0.0799 (0.2707)	0.5415 (0.0000)	0.7316 (0.0000)	0.9180 (0.0000)	-0.3520 (0.0043)	-0.5841 (0.0000)	-0.1284 (0.0758)	1.0000

3. Regression analysis

As explained above, because of the binarity of our dependent variable, it appeared more appropriate to perform a logistic regression. The detailed results can be found in the table below.

Table 3 - Logistic regression

Logistic regression — Number of obs = 113
LR chi2(8) = 27.56
Prob > chi2 = 0.0006
Log likelihood = -9.6691837 — Pseudo R2 = 0.5877

watermarket	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
fwwagri	.1142624	.0555285	2.06	0.040	.0054285	.2230962
totalfww	-.0016728	.0091355	-0.18	0.855	-.019578	.0162324
consti	4.696188	3.052886	1.54	0.124	-1.287358	10.67973
political	1.539266	1.714233	0.90	0.369	-1.820568	4.899101
wjp	-27.01548	15.9083	-1.70	0.089	-58.19518	4.164219
hdi	128.2199	62.75672	2.04	0.041	5.218944	251.2208
atkinson	24.84123	14.96959	1.66	0.097	-4.498614	54.18108
votes	3.295199	2.041697	1.61	0.107	-.7064546	7.296852
_cons	-115.6108	55.9495	-2.07	0.039	-225.2698	-5.951826

Note: 48 failures and 0 successes completely determined.

The two most significant predictors are the freshwater withdrawals for agriculture (p-value of 0.04) and the Human Development Index (p-value of 0.041), both significant at the 5% level. Hence, agricultural freshwater withdrawals and high HDI influence the presence of water markets. The low intercept value (0.039) suggests that without the presence of significant predictors, the odds of a country having a water market are close to 0.

Even with most of the predictors appearing to not be significant at a 5% level, the overall model seems to potentially be statistically significant (p-value of the chi-square statistic = 0.0006). The pseudo-R-squared could indicate the proportion of the variance explained by the model. Here, the pseudo-R-squared of 0.5877 suggests that approximately 58.77% of the variation in the presence of water markets can be explained by the model.

Nevertheless, when running a joint significance test (Wald test), we obtain a p-value of 0.7630. This indicates that the variables do not all provide meaningful contribution. While some appear to have a statistically significant impact on their own, the combination of all the variables may not enhance the model's ability to predict water markets effectively.

Discussion

The results need to be mitigated with the small number of countries that possessed a formal water market: only six countries out of the full sample. Out of those six countries, we can identify two groups with closer similarities: the Latin American countries (Argentina, Chile, and Mexico) on one side and the Global North countries on the other side (Australia, United States of America and Spain). Being in presence of a small sample of water market countries, the differences might have been exacerbated in the results.

Spain, Australia, and the United States have the older water markets, which are also the more formalized and "advanced". Those three countries were at the forefront of water regulation, implementing the first modern water laws in the nineteenth century. As suggested in the literature, those countries have a solid legal framework and strong institutions that can enable formal water markets. The WJP Rule of Law Index is higher in the water markets countries, being a necessary tool for successful implementation but it is even higher in the three countries mentioned above than in the three Latin American ones.

The water used for agriculture is often around 70% of the total consumption and many formal water markets allow water rights to big consumers (mostly farmers). Agricultural freshwater withdrawals are higher in the water markets countries but probably because all those countries seem to have an important agricultural export sector, which might be one of the reasons they decided to implement water markets.

To function effectively, water markets need to be implemented in places where the demand for water is higher than the supply; if it is not the case, there would be no need for the users to trade their rights, and no demand. However, freshwater withdrawals as a share of internal renewable resources are lower in the water markets countries than in the rest. It could be

explained by the fact that this calculation is made at the scale of the country and while some areas (often the ones where the water markets are located) are under a lot of water stress: South of Spain, Diamond Valley in the US, Murray-Darling Basin in Australia; others might not be as vulnerable, balancing the number at a country-scale. Ultimately, the water stress didn't appear to be a statistically significant variable to determine the presence of water stress markets because the most-water stressed regions are mainly in Middle East and North Africa. The lack of water has a significant impact on countries development and those countries do not have strong institutions and high adherence to the rule of law that could enable formal water markets.

As explained above, the two most significant predictors are the freshwater withdrawals for agriculture (p-value of 0.04) and the Human Development Index (p-value of 0.041), both significant at the 5% level. For the overall model, we can reject the hypothesis that there is no link between the predictors and the presence of water markets. However, the variables that we have chosen are not all meaningful to the model.

Nevertheless, the model was able to predict 48 failures, highlighting where we know that there won't be water markets. Prior literature highlights what is needed for a formal water market to be implemented and the absence of some of our predictors is indeed strong evidence that water markets won't be implemented because they would be set for failure. The pseudo-R-squared of 0.5877 can be explained by the fact that many countries share the same characteristics than the water markets countries: high HDI, freshwater withdrawals for agriculture relatively high, strong institutions and high rule of Law index; but did not chose to implement water markets. They theoretically could implement a water market according to the WMRA but decided not to. The model that we built didn't manage to grasp that dimension that is crucial when it comes to water, strongly linked with values and power. Furthermore, citizens movements play an increasingly important role in water governance since 2010 and many are against water markets that they consider as a tool to commodify and financialize water.

Conclusion

Water markets can be an effective tool for a more efficient allocation of water. However, they rise several ethical concerns for their opponents and their potential failure can have dramatic social cost for societies. Two main visions are opposed: water as a common good and water as an economic good. Rising water scarcity due to growing population and rarefaction through climate change is questioning current water governance all over the world. Awareness is growing around water challenges and water begins to move up the international agenda.

Formal water markets are highly political because deeply rooted in the institutional and legal framework of a country. However, the institutions and legal perspectives/positions cannot predict the presence of water markets by themselves, nor can water stress and inequalities indexes. It appears essential to adopt a polycentric approach when assessing water-related topics because water is multidimensional, deeply cultural, symbolic and political. Some countries that implemented water markets also have a constitutional right to water and voted in favor of the recognition of water as human right, which imply that they might consider water both as an economic and common good. Hence, water markets cannot be studied only on an economic or legal perspective but to be fully understand, require an interdisciplinary approach, as suggested by Macpherson and al. (2024). The concept of "embeddedness" seems to make sense more than ever in the case of water markets.

We identified several further research paths to complete and deepen this research. New indicators could bring a stronger explanatory power through a refinement of this model. Several calls have been made in the literature for more transdisciplinary research with integration across spatial spaces. Since water is highly political, the exploration of the political orientation of policy maker might be able to further explain the presence of water markets. Qualitative research instead of the extensive quantitative research available in the field might be able to give insightful information on the reasons why water markets countries have chosen this form of governance instead of others. Furthermore, we made the decision in this research to focus on macro-economic indicators (at the country scale) but a more local approach might give an additional perspective on issues that are spread and complex. This research has also only focused on formal water markets, but it might be interesting to compare formal and informal water markets with several indicators to see if the only difference in their

implementation is due to weak institutions and legal instruments. Sometimes, countries witness the cohabitation of two water markets: a formal one and a parallel illegal one; research on the topic remains limited and could be beneficial. Many distinctions can also be made within water markets: formal/informal, centralized/decentralized but also distinctions based on the water rights allocation system, on the tools used around markets (ex: water futures). The implications of those distinctions within the model could be studied further.

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Datasets

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