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"Water pricing and markets: Principles, practices and proposals"

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Water Pricing and Markets: Principles, Practices and Proposals

Abstract

The allocation of water across space and time is a key challenge of water governance, with demand and supply often not well matched over time and place. Best practice water pricing and markets may promote water conservation, yet their application is limited. We highlight the governance principles needed for best practice water pricing and water markets, describe differences across regions, and provide six key water demand governance recommendations, for both Global North and Global South countries.

Key Words: Global South; Global North; water trade; water markets; water crisis; water security; climate change; sustainable development; taxes; costs; tariffs; subsidies.

1. Introduction

The global water system is in crisis, with growing freshwater withdrawals as a proportion of available freshwater resources (see Figures A1 and A2 in the Appendix). This poses increased risks to sustainable development, ecosystem services, food and energy security, and to human well-being. Population and income growth are important drivers of increased freshwater withdrawals and both are increasing in large parts of the world, especially in the Global South[1] (Bunsen et al., 2021; Dinar et al., 1997; Grafton and Fanaian, 2023; Grafton et al., 2023; Scanlon et al., 2023). The overall level of water withdrawals and consumption can, and have, degraded ecosystem services (Vörösmarty et al., 2010) because of inadequate attention to both measuring and mitigating the negative external costs of how water is used and consumed.

In a world of increasing per capita water scarcity, water must be allocated across many competing purposes. Irrigation water withdrawn by the agricultural sector accounts for about 70% of water withdrawals worldwide (United Nations (UN) World Water Development Report, 2022). The remainder is withdrawn for industry and energy production – primarily the cooling of power plants – as well as households, small

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[1] We use the definition of Global North (namely high-income countries as classified by World Bank) and Global South (upper middle income, lower middle income, and low-income). The Global South is viewed by some as different to low-income countries and is "… more than a metaphor for underdevelopment. It references an entire history of colonialism, neo-imperialism, and differential economic and social change through which large inequalities in living standards, life expectancy, and access to resources are maintained" (Dados and Connell, 2012; 13). Under this definition, parts of the Global North would be in the Global South (e.g. indigenous remote communities in Australia).

businesses, and other establishments (e.g., hospitals, schools, etc.) connected to public water supply systems. However, the global average obscures key differences. In Europe, along with most OECD countries, the proportion of total water withdrawn by agriculture is around 45%, with 40% withdrawn by industry and for energy production, and 15% for household public water supply (Gruère and Shigemitsu, 2021).[2]

Multiple options are available to policymakers to manage water and to prioritize across competing water users and uses (Dinar et al., 1997). Two broad approaches include water supply augmentation, typically through investments in grey (built) infrastructure, and water demand management (Wheeler, 2023). Supply augmentation includes building infrastructure to reallocate existing water sources over time and place (e.g., irrigation infrastructure, dams, weir construction, inter-catchment pipes and channels), reducing water losses in the distribution network, and developing new sources (e.g., desalinated water, reuse of treated urban wastewater). Supply options offer technical and relatively rapid responses to water supply and demand imbalances (Hall et al., 2014) and are especially valuable where there are low marginal costs of additional water supplies (Grafton et al., 2017). Water demand management options include: regulatory and/or planning processes (e.g., legislation and regulation, including temporary quantity rationing); educational measures (e.g., information and campaigns); planning (e.g., multi-stakeholder partnerships and causal risks-processes) and economic incentives (e.g., economic pricing, subsidies, and/or property right changes that enable water markets) (Wheeler, 2023). Ideally, both water supply and demand responses should be integrated to effectively respond to water insecurity, but this is seldom the case in practice (Griffin, 2006; Barbier, 2019).

The 'ladder of water tool interventions' available country by country, or region by region, will differ according to the water resources and timeframes available, and institutional and personnel capability. Given the often-large differences between Global North versus Global South countries, which option(s) is preferred will differ. In a low-income region or country and where there is very limited budget and data, the priority focus would be to develop the 'first rung', namely institutional capacity to further understand water allocations, and sustainable water use, to be able to inform and improve water allocations. In countries with

[2] The situation within Europe is also quite diverse with higher shares of total water withdrawals used for irrigation purposes in Southern Europe. Most of the water withdrawn for irrigation purposes in the European Union is used in five-member states: Spain, Italy, Greece, Portugal and France (European Parliament, 2019).

large institutional capacity and knowledge, more ambitious interventions are possible and could include developing both efficient and equitable water pricing and water markets in both rural and urban areas. A three-step approach should guide the preferred action or intervention that includes consideration of capacities, risks, and decision-making that includes participatory processes (Grafton et al., 2017).

As the available supply augmentation options increase in cost, increasingly water demand management strategies – and in particular water pricing (Grafton et al. 2023b) and water markets – provide possible options to respond to water scarcity (Wheeler, 2023). Deciding on who should receive water, and how much water, is difficult both within (e.g., does a cotton grower or a dairy farmer get priority water access?) and across sectors (should stream flows be maintained or irrigation expanded?). In this decision space, equity and economic principles and the practicalities of implementing water demand options are important when determining how water gets allocated or reallocated. Here, we review the role that pricing and markets play in different countries as a mechanism to reallocate water. Our contribution is to provide a guide to the 'Who, When, What and How' of water reallocation from both a Global North and Global South perspective, as well as providing a set of recommendations for the future use of economic incentives for best practice water management.

2. Water Pricing

2.1 Water Pricing Principles

All types of water use and consumption involve costs, some of which are borne by others (i.e. external or indirect costs). In theory, all water users should pay a price that reflects both the direct and indirect costs of their water use (Dinar et al., 2015). For example, direct costs would be associated with water that is pumped directly from raw water sources (either groundwater or surface water) for irrigation that requires investments in a pumping system and an electricity cost to run the water pump. Delivering water to households and other services/businesses connected to the public water supply system involves: a) *fixed capital costs* (building a network and pumping, treatment, and storage facilities); and b) *variable costs* that depend on the volume of water that is treated and delivered (billing, collection etc.). Variable infrastructure costs are commonly known as operation, management and maintenance costs (i.e. OPEX). For a water service to be self-financing, the price that is charged to water users connected to the public supply system should cover both

OPEX and future capital costs (i.e. CAPEX) which includes the building and maintenance/renewal of new infrastructure (pipes, pumping and treatment plants, storage facilities), as well as covering environmental and resource costs (Leflaive and Hjort, 2020) noting that economists typically recommend pricing water at long-run marginal cost (LRMC) (Chu and Grafton, 2021).

Most types of water use create external costs by exerting pressure on the raw water sources, and second by degrading its quality. The presence of externalities, that is, those (indirect) costs imposed on others and on the environment, justify public intervention and the implementation of policy instruments (taxes, charges, command-and-control etc.). Taxes or charges internalize water costs imposed on others, including the environment. Four challenges faced when pricing water includes: 1) difficulties in the provider knowing the long-run fixed and variable costs when estimating LRMC (Chu and Grafton, 2021); 2) difficulties in valuing indirect other user and environmental costs: 3) political acceptability problems in implementing (or increasing) water pricing; and 4) competing social objectives (e.g., water conservation, equity and affordability) may complicate further price setting and distort price signals (Andrés et al., 2019).

2.2 Implementing Water Pricing Principles through Water Tariffs

These competing social objectives are reflected in the wide variety of water tariffs that exist. Some popular options include: 1) *fixed charge* (or connection charge) for water users that is univariant to the volume of water used; 2) *two-part tariff*: a fixed charge with a single or flat volumetric price; 3) *fixed charge + non-uniform volumetric price*: a common water tariff is the Increasing Block Tariff (IBT) where the volumetric price changes depending on the volume of water used (block rates). An increasing [decreasing] block tariff features volumetric prices that increase [decrease] with the amount of water used or the block of consumption.[3] IBTs are popular, especially in the Global South. Andrés et al., (2021) highlights that about half of all water utilities surveyed in the International Benchmarking Network for Water and Sanitation Utilities (IBNET), use IBTs, and 44% used a single or flat tariff; 4) *volume-differentiated tariffs or jump tariffs:* all water use is charged at the price of the highest block of water used. Dinar et al. (2015) provide additional water pricing experiences from around the world.

[3] IBTs can be characterized by their level of price escalation or progressivity. See Suárez-Varela et al. (2015) for an analysis of the determinants of price escalation across municipalities in Spain.

Complex tariff structures involving several tariff blocks are difficult to design. Inappropriate design can lead to inaccurate targeting and to relatively well-off households benefiting from subsidized water prices while less well-off households receive less or no subsidies. According to the Tinbergen rule (e.g. Tinbergen, 1952), complex water tariffs intended to promote water conservation and to place a greater proportional burden on the wealthier will likely fail to meet all desired goals. Hence, other measures need to be established to assist poorer households and to ensure affordability of water services for all. Such measures could include vouchers or rebates on the water bill for the poorest households where such households can be readily identified (Grafton et al., 2020).

2.3 Water Pricing Efficiency and Cost Recovery

Water prices vary significantly across places and across industries. Some statistics on average water prices (using the IBNET database) across the globe in differing types of countries are shown in Figure One, illustrating wide geographic disparity. The price of water charged to users is, in most cases, below actual marginal cost and rarely includes the external costs imposed on others and on the ecosystem. Thus, in general, the twin goals of water pricing to ensure full cost recovery and allocative efficiency objectives are rarely realized. Figure One highlights that, in general, Global North countries charge higher volumetric consumptive water prices, followed by upper middle-income countries. Lower middle-income and low-income countries seem very similar in terms of water prices charged. Nevertheless, our interpretation is preliminary because the available data is not necessarily representative.[4]

Figure One: Scatter Plot of countries water price by water stress (logged)

The necessity to send accurate signals to water users to conserve water in times of relative scarcity, will become increasingly required with the heightened occurrence of more frequent and severe droughts. Nevertheless, a scarcity component to water price is rarely included in water tariffs and, in general, the underpricing of water relative to the costs of provision and use remains a challenge (Grafton et al., 2020; Andrés et al., 2021; Barbier, 2022), as is failing to adequately value water (Grafton et al. 2023). Andrés et al. (2019) studied in detail the problem of water underpricing and the misallocation of subsidies. They found

[4] Cost comparisons across countries is difficult due to differing service quality, operational and capital costs. In addition, the sample representativeness of utilities in the IBNET database is somewhat questionable, as IBNET has more utilities from the Global South than the Global North, and information is patchy across years.

that only 35% of IBNET utilities (note, Global South utilities were more predominant in the IBNET database) were able to cover their operation and maintenance costs of service provision, and only 14% covered their total economic cost. Global North countries were much more likely to cover their operation, maintenance and total economic costs than Global South countries (ibid).

Achieving full cost recovery is more complicated when utilities suffer from a high level of water losses (e.g. due to poor maintenance of pipes) that translates into high non-revenue water. In some low-income countries, public-owned water utilities are encouraged by the government to employ more workers, increasing the costs for a given level of water supplied. Transmission losses through poorly maintained infrastructure or water theft can also make it difficult to increase revenues to cover costs. Further, if the quality and/or reliability of the water service is poor, households may be reluctant to pay higher water prices, while increasing their incentive to substitute to other sources (e.g. household wells, private vendors). This frequently means the difference between revenues and costs of water utilities is provided through general government revenues. Depending on the size of the subsidy and how it is implemented, this may discourage needed investment in water infrastructure (Grafton et al., 2023b).

For agricultural water users, the challenge of effective monitoring can make pricing and monitoring enforcement even more difficult. In many Global South countries, even where meters have been physically installed, meters may be unreliable or tampered with (e.g. Al-Naber and Molle, 2017; Molle and Closas, 2020). In most Global North countries, the principle of (full) cost recovery guiding water price setting should guarantee the financial viability of the water supply system, while preserving water sources and the environment. This full economic cost pricing requires that the opportunity costs imposed by water abstraction in a water-scarce region, and external environmental costs induced by the pollution of waterbodies, be internalized by water users. Nevertheless, these pricing principles (full cost recovery and allocative efficiency) are difficult to implement in practice because: i) of the challenge of estimating accurately future direct and indirect costs of water abstraction and supply; ii) other objectives (e.g. water conservation, equity, and affordability issues that have already been discussed) that utilities seek with water tariffs that may distort price signals; iii) political pressure to keep prices low; and iv) the lack of control and regulation of informal water markets supplying non-piped households.

The path to full cost recovery will certainly be longer and more arduous for Global South countries, which often face heightened structural problems of underpriced water due to strong opposition to water price increases. Governments and/or water supply providers are unwilling to impose higher water prices that may cause demonstrations and unpaid bills which, in part, is because a much larger proportion of people are in poverty in the Global South than in the Global North. Consequently, if water prices do not cover costs, continuous government subsidies are required to make up the difference. Global South economies should focus first on pricing for capital expenditure and maintenance and management to maintain existing water infrastructure, and wherever possible, greater use of individual water meters. This is because countries often face a structural problem of low prices combined with low quality of service (problems of low pressure, service interruptions, and bad water taste are commonly reported). If the quality of the infrastructure deteriorates, it makes it more difficult for water customers to accept price increases. Thus, our first water pricing recommendation is:

Water Pricing Recommendation One: The true value and opportunity costs of freshwater and groundwater use should be costed wherever possible, to meet the allocative efficiency principle. *Water service providers from Global North and South countries should aim at pricing water to cover operation and maintenance costs, future capital renewal and extension. Andrés et al. (2019) provides examples and guidance for implementation, and Phnom Penh in Cambodia is often put forward as an exemplary water utility recovering costs in Asia (ADB, 2009). Ideally where possible, prices should also reflect scarcity and correct for environmental externalities induced by water withdrawals and water pollution. Since conditions in which utilities operate vary significantly over space, we propose water prices being designed and set at the local level. Centralized authorities can decide on rules and principles of water pricing, but the actual tariff components should be based on local operating conditions.*

2.4 Water Pricing Equity Issues

Equity is concerned with the 'fairness' of the allocation of resources across a given population. Commonly, equity translates into the principle that all water users should have access to safe and reliable water, regardless of the ability to pay. Typically, equity in water pricing is usually paired with the notion of affordability. That is, it is usually accepted that the proportion of income that is devoted to pay for water should not be disproportionately larger for low-income households (or above a specific threshold - percentages from 2-5% of total household expenditure are commonly considered) (Reynaud, 2016). For many OECD countries, the share of water expenditure of income for the average household is below 2% (Grafton et al., 2011; Reynaud, 2016; Leflaive and Hjort, 2020), but this ratio is likely to be above 2% in the Global South (Andrés et al., 2019; Martins et al., 2016).

A more radical proposal is that the poor should receive all their water for free. The problem with this approach is that for the beneficiaries there is no direct economic incentive to conserve water, and that it can be difficult at times to define who is 'poor'. Beyond ensuring a minimum volume of water of adequate quality to meet basic needs for all, providing water at a close to or zero price is not necessarily equitable. This is because it favors those who already have access to existing, and typically centralized, water supply systems (Grafton et al., 2023a; Whittington et al., 2015).

Where it is possible to identify the poor, such as by neighborhood, and when it is a challenge to distribute cash transfers or vouchers, a basic minimum volume of water can be provided free to the poor. South Africa has attempted such a policy since 1997 with its Basin Human Needs Reserve equivalent to 25 litres per person per day for domestic purposes and the Free Basic Water Services Policy from 2001. This Basic Human Needs Reserve (van Koppen et al., 2023) has not been without problems, including chronic underinvestment in water infrastructure, but it has prioritized basic water service delivery and helped to increase the number of South Africans with basic water services by more than 10 million. The Free Basic Water Services Policy has suffered from including people who are not poor within the free water allocation, but it has helped to increase affordable access to potable water to millions of poor South Africans (Muller, 2008).

Residential water users, in general, use a smaller share of aggregate water use than industry or agricultural water, yet frequently face higher water volumetric water prices. These higher volumetric charges are attributable to the higher costs of ensuring more reliable, high-quality water supplies. Water publicly provided to farmers, such as for irrigation, usually does not cover fixed costs or CAPEX and are rarely fully or, at best, partially metered (Gruère et al., 2020), which severely constrains the ability to price water volumetrically (especially the case in the Global South). Contradictory policies such as agricultural subsidies that encourage increased use of water (e.g. power subsidization in India [Sayre and Taraz, 2019] and irrigation infrastructure subsidization in Australia [Wheeler et al., 2020]) further exacerbate water insecurity. OECD (2023) detail the range of input, land, capital and output subsidies to agriculture across both OECD and other Global South and North countries, and highlight that irrigation-related subsidies (through water preferential pricing, lower electricity pumping rates and direct support to infrastructure) make up 6% of total budgetary support. India was listed as one of the largest subsidizing irrigation-related input countries.

A necessary condition for farmers to receive an accurate signal on the value of the water they use, and for sound management of water in places where water is scarce, is the metering and monitoring of irrigation water. When water is not metered, water may be charged and/or allocated on a per hectare basis. If irrigation water is underpriced and water is charged or allocated based on land area, then the wealthiest farmers (who own larger farms) will be the primary beneficiaries of the subsidies. In the Global South, affordability is an additional challenge, where high water prices reduce incomes of poorer farmers (whose water extraction tends to be higher with relatively low value added). Water supply for irrigation – especially in shared irrigation infrastructure districts – can also be classified as a 'club good' (i.e. consumption is rivalrous but only when there is crowding issues or too many members), rather than a private good as in many urban households (i.e. consumption is rivalrous and exclusion is complete) (Grafton et al., 2023a; Wheeler, 2022). Hence, there may need to be more instruments for irrigation districts rather than pricing alone (e.g. membership restrictions). In addition, in many irrigation districts, water is seldom provided on demand, and more likely to be supplied to farmers when available – especially in the Global South – rather than when actually demanded, which can also hinder farmers' willingness to pay (Molle and Closas, 2020).

Our second area of inequity is in areas where some households do not have access to piped water, which occurs mainly in Global South countries, but also occurs in parts of Global North countries. For example, California's San Joaquin Valley is an example of where communities in the Global North are left without access to drinking water because of wells going dry and being disconnected from utilities. In Australia, many remote indigenous communities also suffer from lack of safe water access (Manero et al., 2024). Those households without piped water access usually pay higher water prices. In addition, non-piped households often spend longer time seeking water–which tends to fall upon women and children especially in low-income countries (Grafton et al, 2023a), furthering income and gender inequality.

The third area of inequity is between income groups, with the principle that low-income households should not spend a disproportionately larger share of their income on water. Given that a simple volumetric tariff that applies to all households may not preserve affordability, this has led to the increasing popularity of IBTs. Such tariff schemes are claimed to make high water users (assumed to be wealthier) cross-subsidize water consumption of low users (assumed to be poor). Nevertheless, there is evidence that IBTs almost always fail in targeting subsidized prices to the poor (Whittington et al., 2015; Fuente et al., 2016; Nauges and Whittington, 2017). Andrés et al. (2019) assess the performance of consumption subsidies for piped households for ten countries in the Global South, most of which applied IBTs. They found that on average 56% of subsidies reached the wealthiest quintiles, while only 6% reached the poorest quintile - many of whom may lack access to centralized water systems.

In sum, other instruments should be considered to reduce the burden of water bills for low-income households. Targeted cash transfers or rebates (e.g., covering part of the water bill) for low-income households are one option (Nauges and Whittington, 2017). Cash transfers have the advantage, especially in low-income countries, of being available to all households, not only those that have access to centralized water systems (non-piped versus piped). This leads us to our second water pricing recommendation:

> ***Water Pricing Recommendation Two: Use One Water Policy Instrument to Achieve Each Objective.*** *Water conservation, subsidies and equity objectives can lead to distortion of price signals. Water tariffs cannot achieve simultaneously several objectives (e.g. accurate price signal, recovering all costs, promoting conservation, and equity and affordability). Trying to meet too many objectives has led to the proliferation of complex tariff schemes, such as IBTs, that do not guarantee affordability nor equity. A combination of instruments (e.g. pricing water and targeted transfers for the poor) will usually be required to achieve several objectives. We suggest the use of simpler tariff schemes, featuring a unique volumetric price that reflects marginal costs, combined with cash transfer payments or rebates for households in need. The fixed charge should be set at a level that*

allows recovering fixed costs of the utilities while not penalizing too much small consumers.[5] *Tariffs should vary across seasons to account for scarcity at certain times of the year where water scarcity is seasonal. Global North countries need to particularly focus on avoiding exemptions for certain users (e.g. agriculture). All users should be sent the right signals on the value of the resource, not subsidizing either water use or irrigation infrastructure, and policies should not encourage further irrigation development and/or the use of chemical inputs. Where cash transfers or rebates are not able to be implemented, and the poor can be readily identified, provision of essential water needs to the poor, especially in the Global South, may be justified.*

2.5 Price as an Instrument in Managing Water Demand

Pricing policies are usually considered better tools to manage water demand than quantity restrictions, from a welfare point of view (Grafton and Ward, 2008). Nevertheless, this requires that household demand responds to price changes, and they are correctly informed about water prices. There is evidence that households do not have a good understanding and knowledge of water prices, but improved price information does not always lead to reduced water consumption. Brent and Ward (2019), using a randomized field experiment in Australian, showed that improved price information increased water use. Wichman (2017) found that providing more information through an increase in billing frequency also led to higher consumption.

Estimates of price elasticity of piped water demand in high and low-income countries are similar (Nauges and Whittington, 2010), indicating water demand responds to water prices although the proportional change in water use is less from a proportional change in the water price. That is, water demand is price inelastic and this may, in part, be associated with households' lack of knowledge of their water bill or water use (García-Valiñas et al., 2021). While it is typically true that wealthier households use more water than poorer households, the correlation between household income and their water use is low and income elasticity is often in the range 0.1-0.2 (Nauges and Whittington, 2017). The price elasticity of water demand

[5] A disproportionately high fixed charge would penalize small users since it would increase the average price paid per cubic meter for low levels of consumption.

for households with piped water is usually low, in most cases in the range -0.5 to -0.3 and varies depending on location, season, and household income (García-Valiñas and Suárez-Fernández, 2022).

Policy-makers often favor non-pricing instruments, such as awareness and information campaigns, subsidies for water-saving appliances, and more recently social norms comparisons for water conservation rather than water prices. Campaigns aimed at encouraging voluntary reductions in water consumption usually have limited impacts, and their effects dissipate in the long-run (Fielding et al., 2013; Wang and Chermak, 2021). Rebates or subsidies for the purchase and installation of water-efficient devices can lead to reduced water use (Grafton et al., 2011), but there is a risk of a rebound effect whereby households, in part or in full, increase their water consumption (García-Valiñas and Suárez-Fernández, 2022). Social norm water use comparisons have also been shown to induce short-term reductions in energy and water use of about 1-5%, but are not as effective as water pricing, in both the Global North and South (Nauges and Whittington, 2019; Brick et al., 2023). Our third recommendation for water pricing is:

> ***Water Pricing Recommendation Three: For both Global North and South countries, water pricing is one of the most effective policy tools in regulating household water demand, but other demand management tools (social norms, education, regulation, restrictions, rebates, markets etc), can make pricing more effective if used in conjunction.*** *Some of these other tools may only be applicable or implemented in periods of scarcity (e.g. restrictions on water use per household in a drought). In order for pricing to be effective, the tariff scheme should remain simple and easy to understand to the households.*

The following section discusses another important demand economic incentive - water markets.

3. Water Markets Principles and Practices

3.1 Informal and formal water markets overview

Markets are where buyers and sellers come together to trade goods and services and where payment is accepted by an agreed medium of exchange. The trade location can be physical or virtual. The terms 'water market' and 'water trade', or 'water trading arrangements', are often used interchangeably. Nevertheless, a water trade can exist between just two people, whereas a water market requires several participants. A market is where buyers and sellers trade water. This may exist in an informal setting, or a formal setting where prices and volumes are recorded and are transparently available to other participants (Wheeler, 2022). Water markets allow water to be reallocated, based on the willingness to purchase and the willingness to sell, rather than water allocations being set by a regulator or central authority. Water markets have been proposed as a way to allocate scarce water resources and are growing in both application and academic study (e.g., Easter et al., 2014; Easter and Huang, 1998; Howe et al., 1986; Wheeler, 2021).

Informal water markets exist in many places around the world, in both urban and rural settings. Transactions within such informal water markets are, typically, small, not recorded, temporary, and more likely to occur in times of water scarcity (Bajaj et al., 2022; Garrick et al., 2023; Wheeler, 2021). Other informal markets operate as de facto water markets, such as the example of the Jati Lahur Basin in Indonesia where rice farmers upstream are paid by downstream bottling enterprises to leave part of their water use rights in the river (Keulertz and Riddell, 2022), or in Bangladesh where farmers pay for irrigation water from pump owners by sharing crop returns (Mottaleb et al. 2019).

Lack of access to adequate water services is an issue in both rural areas and urban centres throughout Africa, the Indian subcontinent, and south-east Asia, due to rapid increases in city populations and migration issues. Consequently, many Global South local water utilities face difficulties in meeting local demand, and people must seek water through whatever informal means are available. Within urban cities in developing countries, informal water markets are a common feature of meeting unmet water demands (e.g., Ahlers et al., 2014; Cain, 2018; Garrick et al., 2023; Klassert et al., 2023; Raina et al., 2019; Venkatachalam, 2015, Vij et al., 2019; Zuin et al., 2014). Highly diverse (for profit and philanthropic) informal service providers, using a variety of service models, deliver water services in the Global South (and to some extent, also in the Global North). Water is provided in various quantities, qualities, prices, and forms (e.g., sachets, bottles, barrels, tankers) in regions that do not have established water service providers or where such services are unreliable. Such informal markets are usually competitive and all reflect a variety of differing community characteristics. Klassert et al. (2023) estimated that unregulated water sales in Jordan account for 27% of all the groundwater extracted above sustainable yields. In general, no legislative and regulatory oversight exists for such markets and, in some locations, competition exists between established water service providers and water market vendors (Garrick et al., 2023). For example, private vendors may offer higher quality water not provided by the network service provider (Garrick et al., 2019; 2023; Raina et al., 2019; Venkatachalam, 2015). In other areas, private vendors may offer services that are effectively an extension of the centralized network. Garrick et al. (2019) argue that informal markets have arisen because existing water service providers have failed to fully deliver safe water at an affordable price to all, and they outline numerous case studies that suggest informal water markets can add significant value to water consumers.

Formal water markets are found in both rural and urban settings but where they exist, they are most common in agriculture. Established and extensive formal water markets exist in only a few countries, and the majority of these countries have middle to high incomes. These include Spain, Chile, the U.S., China and Australia (Bjornlund and McKay, 2002; Griffin, 2006; Grafton et al. 2011a; Wheeler, 2021). Markets exist for both groundwater and surface-water, mainly trading volumes of water. Markets also exist for water quality trading (e.g., salinity and nutrient pollution trading), but are less common (Wheeler, 2021). Common challenges of water markets include the incomplete assignment of property rights, pervasive externalities and limited scientific information (Barbier, 2019; Hanemann, 2006). In all formal water markets, trading of physical water volumes involves the exchange of water rights, permanent and/or temporary, in a market framework between willing sellers and buyers, with water traded through brokers/intermediaries or via formal exchanges. Water prices can fluctuate daily, depending on supply and demand, hence it helps to ensure that water's opportunity cost is explicitly accounted for by users (Wheeler, 2022).

There has been extensive study of the possible efficiency gains from water trading (e.g. see reviews by Bajaj et al., 2022 and Wheeler 2022). Water markets have the following advantages over other allocation schemes, namely: flexible water reallocation over time in response to economic, demographic, and social-value changes; involves only willing sellers and buyers; provides security of tenure of property rights; and elucidates the real opportunity cost of water (e.g., Easter et al., 1998; Grafton et al., 2016; Young, 2019; Zekri and Easter, 2005). They allow for risk management (Nauges et al., 2016). The ability to engage in temporary and permanent voluntary trade (in all the differing forms of trading arrangements that exist) leads to three distinct forms of economic efficiency in relation to market uses of water: 1) *allocative efficiency:* where temporary trade allows short-term changes in water decisions in response to changing seasonal conditions (e.g. weather, prices, cropping choices); 2) *dynamic efficiency*: where permanent trade allows changes in long-term farm and resource structural decisions to reflect new investment opportunities, regulation changes or personal strategic choices; and 3) *technical efficiency*: where both temporary and permanent water price changes offer incentives for the efficient use of water resources - as either an investment or input for productive outcomes (Grafton et al., 2017; Wheeler, 2022). Well-designed marketplace rules and infrastructure should also encourage water trade participation, reduce strategic gaming, and improve efficient and equitable allocation. Importantly, water markets allow both buyers and sellers to adapt to changing circumstances. As such, a substantial number of theoretical and empirical models have demonstrated the major economic and financial benefits that are possible from water trading arrangements (e.g., Chong and Sunding, 2006; Howitt, 1994; Schatanawi et al., 1995; Vasquez, 2008; Zekri and Easter, 2005; Zilberman and Schoengold, 2005).

Most formal water markets have evolved from informal water trade arrangements (Wheeler, 2021). When water scarcity is intermittent and the associated costs are relatively low, or where there is a lack of water service providers, two parties may agree on informal water trade arrangements. As water scarcity becomes more prevalent or regular, water trading may become more common, needing more formalized and standardized rules and regulations. The establishment of formal water markets involves official government legislation and sanctioned rules, processes, and catchment areas. As Griffin (2006) commented, the establishment of the conditions that enable efficient trading and the eventual full emergence of water markets may, at times, be more accidental than planned. The pathway for the development of water markets within an area/country reflects the property rights associated with water ownership and the legal, cultural and social history of a region, and any institutional barriers to change (Bjornlund and McKay, 2002; Horne and Grafton, 2019). Whilst the needs of irrigators play a major role in the development and use of water markets in many countries, markets have been used by both urban and environmental users (Wheeler, 2021).

While economists espouse the benefits of water trade, there are many critics of markets (e.g., Bakker, 2007; Dellapenna, 2000), many of whom take a ‘water is too different to sell’ stance (as cited in Griffin et al., 2013; 2). Prime concerns centre around views that water as a basic need is too unique and important to trade (and consequently markets are immoral) (Bakker, 2007). Some governments, especially in Islamic countries, have the belief that water is a gift from God and cannot be bought or sold (Kuelertz and

Riddell (2022). However, often these arguments fail to distinguish between different water uses, and mistakenly equate water markets with water privatisation. Water is not a pure public good, many uses of water are private, and people can be excluded (see Grafton et al., 2015 for further discussion on privatisation, commodification and marketisation issues).

Other commonly cited water market costs include arguments that trade disadvantages rural communities (especially smaller farms), reduces farm profitability, widens inequality, causes environmental externalities and creates an environment for unethical behavior and water barons. Critics, unfortunately, usually fail to distinguish between governance issues and water trade operations. Empirical evidence in Australia consistently finds that water market movements are predominantly driven by seasonal conditions, with little evidence of collusion and cartel behaviour, and that the environment has benefited from water market trade (given water has mainly moved downstream and have facilitated, through reverse tenders to buy water from irrigators, return of water to the environment) (Grafton and Wheeler, 2018). In addition, Wheeler (2022) emphasized that many so-called environmental impacts from water trading in Australia are actually associated with other factors. A review of 26 papers by Bajaj et al. (2022) suggested that there is sometimes a trade-off between equity and efficiency objectives in water markets, but also that a quarter of studies found that both objectives could be achieved simultaneously. In terms of equity issues in water markets, Bajaj et al. (2022) suggested that it was the profile of buyers and sellers that most determined equity issues, while Wheeler (2022) highlights that water trade in Australia increases the probability of water being shared amongst different users – hence increasing participation (a form of equity). This issue regarding profiles of buyers and sellers may be even more applicable in the Global South (Bajaj et al. 2022 highlight issues for India, Pakistan, China and South Africa), and market power issues are more likely to occur where there are: a) a small volume of trades; b) very concentrated or powerful buyers (or sellers); and c) a lack of overall governance in general.

Water markets, like other markets, need to be scrutinized for imperfect competition, externalities, and information asymmetry market failures (Bjornlund and McKay, 2002; Wheeler, 2021) as well as the setting of a Cap that limits the total water use or total water consumption. There may also be serious distributional issues and pecuniary externalities needing consideration. It is important to note that the original property rights allocation in a country can determine distributional consequences (which is not a market outcome, but a political/social one). This leads to our fourth key recommendation:

> ***Water Market Recommendation Four: Initial Property Right Distribution Matters****. Who owns water rights is a critical factor in determining beneficiaries of trade. Many Global North countries are dominated by colonisation, and distributional issues in water rights will need to be addressed for equity reasons. Many Global South countries have the opportunity to carefully craft and distribute water resource ownership, hence addressing equity issues before implementing markets.*

At the International Conference on Water and the Environment in Dublin in 1992, the fourth guiding principle for managing freshwater resources was that water has an economic value in all its competing uses and should be recognized as an economic good (Keulertz and Riddell, 2022). Some proponents have taken this principle to mean that water can be treated (and traded) just like every other commodity. Many others have emphasised that consideration must be given to their significant water meta-governance requirements (e.g., Bell and Quiggin, 2008; Bjornlund and McKay, 2002; Freebairn, 2005; Grafton et al., 2011a; 2016; Wheeler, 2023; Young, 2019). Many Global South countries do not have the regulatory and governance institutions required for markets to deliver efficient outcomes and to respond to market failures. Consequently, we agree with Griffin et al. (2013) that the 'water is no different from other commodities' argument places too much faith in the ability of the market system to create desired societal outcomes. The following section elaborates on the conditions for formal water trading arrangements further.

3.2 Principles for formal water trading arrangements

Water trade arrangements can bring many benefits but it needs to be recognised that they are not a panacea for all water reallocation problems. Indeed, markets are highly complex economic instruments to design, develop, implement, and sustain over time. It is critical to note that water trade only exists within institutions, hydrological rules and structures, which allow and govern the transfer and use of water. Hence, meta-governance frameworks and the sequencing of any water reform is crucial. If the meta-governance needs (e.g., institutions, knowledge, regulations, and structures) that oversee water trade, extraction, and management, are corrupted, or are missing or incomplete, then this can result in negative societal impacts (Wheeler et al., 2017). Even the most developed and adopted water market in the world, in the Murray-

Darling Basin of Australia, has shown a need for governance improvement, such as: monitoring and compliance; water extraction measurement; developing national independent water body institutions; water pricing; and water accounting (Wheeler and Garrick, 2020).

Numerous authors have discussed necessary conditions needed for formal water markets and water reform in general. Some include: Matthews (2004), who highlighted questions relevant for the establishment or reform of a water rights system; Bjornlund and McKay's (2002) nine lessons; OECD's (2015) checklists of key water institutional design principles; Grafton et al.'s (2011a) market comparison across countries; Grafton et al.'s (2019) water reform framework; Perry's (2013) effective water resource management requirements; Endo et al.'s (2018) three legal conditions for markets (e.g. water allocation rules, separation of water rights and land; and relaxed cancellation for non-use); Keulertz and Riddell (2022) various accounting factors for markets; Möller-Gulland and Donoso's (2016) ten criteria influencing the emergence or success of market intermediaries; and Wheeler et al.'s (2017) water market readiness assessment (WMRA) framework. The WMRA framework described three main steps that were needed for both successful water governance in general, and water market establishment in particular: 1) *Enabling Institutions*: this included defining (and capping) the total resource pool available for consumptive use and hydrological factors of use; and evaluating the current institutional, legislative, planning and regulatory capacity to facilitate water trade; assigning supply risk to users; and ensuring enforcement, regulation and monitoring/compliance; 2) *Facilitating Gains from Trade*: developing clear and consistent trading rules; achieving stakeholder acceptance and adoption; assessing benefits and costs of market-based reallocation, ongoing trade transaction costs, legislation reform and assessment of externalities (OECD, 2015); and 3) *Monitoring and Enforcement*: use of water markets and water extractions needs ongoing monitoring and enforcement to ensure compliance, as well as continued development of trade enabling mechanisms.

Wheeler (2021) applied and evaluated the WMRA framework across 20 countries. We update those results here with additional information and cross-comparison, and the Appendix provides two tables: Global South (Table A1) versus Global North (Table A2) countries. Comparing across these tables, only one case study country in the Global South – China – has gone past the basic step of establishing property rights and strong independent water institutions. Although Global North countries have met many more market enabling mechanisms in general, only two countries reached the final step three of the WMRA framework. The key fundamental water governance characteristics missing in many countries include the unbundling of rights; transferable rights; understanding trade impacts; stakeholder acceptance; caps on water use and/or consumption; monitoring and enforcement of water extraction; water registers and trade information. Many of these factors are essential to the successful operation, and further adoption, of water markets.

In terms of the factors that have influenced formal water market adoption across the world, what is clear is that water scarcity/stress is the number one reason for increased adoption. That is, of the three key dimensions of the world water crisis of 'too much, too little and too dirty' (Grafton and Fanaian, 2023), markets respond the most to the 'too little'. Periods of drought and low water allocations increase incentives and requirements to trade water, and greater diversity of crops and agriculture augment incentives to share water across industries, given different seasonal water needs and the ability of some industries (e.g. cotton and rice) to reduce production in a given year (Wheeler and Garrick, 2020). What is also clear from lessons from established markets, is that the initial adoption of formal water trade follows a slow pace, and often evolves from years of informal (or defacto) water trade arrangements (Horne and Grafton, 2019). Farmers are more likely to adopt (or try out) short-term trading arrangements first, and are slower to participate in long-term permanent water trading arrangements (Grafton and Wheeler, 2018). Some countries may never evolve from informal water markets, and indeed, this may be the most socially beneficial scenario.

The evolution of water markets represents a continuous journey of adaptation as circumstances change in relation to water users, institutions, and the environment. While formal water markets may deliver substantial benefits to some water users, they need careful implementation and ongoing improvement (Horne and Grafton, 2019). Developing water markets too quickly, and allowing 'unfettered' water trade prior to the reconfiguration of administrative arrangements may be destructive to, rather than supportive of, water security (Young, 2014). On the other hand, too much regulation and institutional capacity will also stifle the benefits that can be gained from water trade, and hamper key adaptations to climate change such as water reallocation across competing water uses and users. This leads us to:

> ***Water Market Recommendation Five: Facilitating Water Trade is Key****. Water trade leads to three types of efficiency gains for market uses of water: allocative, dynamic, and technical, with much*

empirical evidence suggesting trade provides significant net benefits. Formal water markets, however, are not for place given their meta-governance requirements - facilitating and improving informal water markets (or allowing trade between two stakeholders) may be just as important.

Many Global South countries do not yet have the enabling conditions for fully functioning formal water markets. Hence, focusing on informal or de facto water markets may be most important, and establishing caps on water extractions are critically important. Global North countries need to focus on establishing (and enforcing) caps, enabling legislation, monitoring water use and regulation.

It is essential to recognise that the economic demand management policies of water pricing and water markets only exist within a set of institutions and governance arrangements. Hence, our last water policy recommendation is related to governance issues:

Water Governance Recommendation Six: Regulation, monitoring and enforcement is critical, which will support acceptance and participation in markets.

Government plays a critical role in monitoring and regulating utility behaviour, both in formal and informal water settings. Water bodies need ongoing baseline funding, for both utilities to reinvest and for compliance authorities to utilise income from penalties and convictions to fund further prosecution efforts materially. Water provision and compliance need to be separated, with independent audit and review. Continual investment in water accounting (e.g. hydrological information, water consumption, return flows, etc) is needed.

Global bodies that seek to help the Global South monitor water use could be highly advantageous, and the continual development of satellite and thermal technology in measuring water extraction may provide a cost-effective means of doing so. Further development of FAO's WaPOR satellite and productivity database (FAO & World Bank, 2022) and open source data (e.g. OpenET) and code (e.g. Foster et al., 2017) may provide such an avenue. Global North countries need to focus on best practice lessons such as: simple to understand and enforce water legislation; regular undertaking (and reporting) of compliance activities; enforcement of penalties; enhancing social norms; leveraging remote sensing capabilities (along with drone technology) with traditional 'boots on the ground'; and retrospective prosecution.

4. Concluding Comments

Given the multiple global factors of a growing demand for water and the fact that cost-effective supply augmentation projects are becoming more limited globally; a range of policy options are needed to bridge the gaps between water needs and supplies. Economic incentives, such as water pricing and water markets, offer two valuable options to mitigate water scarcity and to reallocate water at a lower cost than non-economic approaches. Their relative merits for water reallocation depend on the local context, but where they can be established, they work best when complemented by other water management tools (e.g., regulation, education, infrastructure provision, etc.). Our study has provided an overview of the principles, practices and proposals for water pricing and water markets, and in particular focused on differences for Global South versus Global North countries. We provide six best practice recommendations for demand management water governance (fully outlined in Table A3 in the appendix), covering environmental and scarcity costing, policy effectiveness, facilitating water trade (not necessarily markets), focussing on property right distribution, regulation and monitoring issues, and adequate water agency funding.

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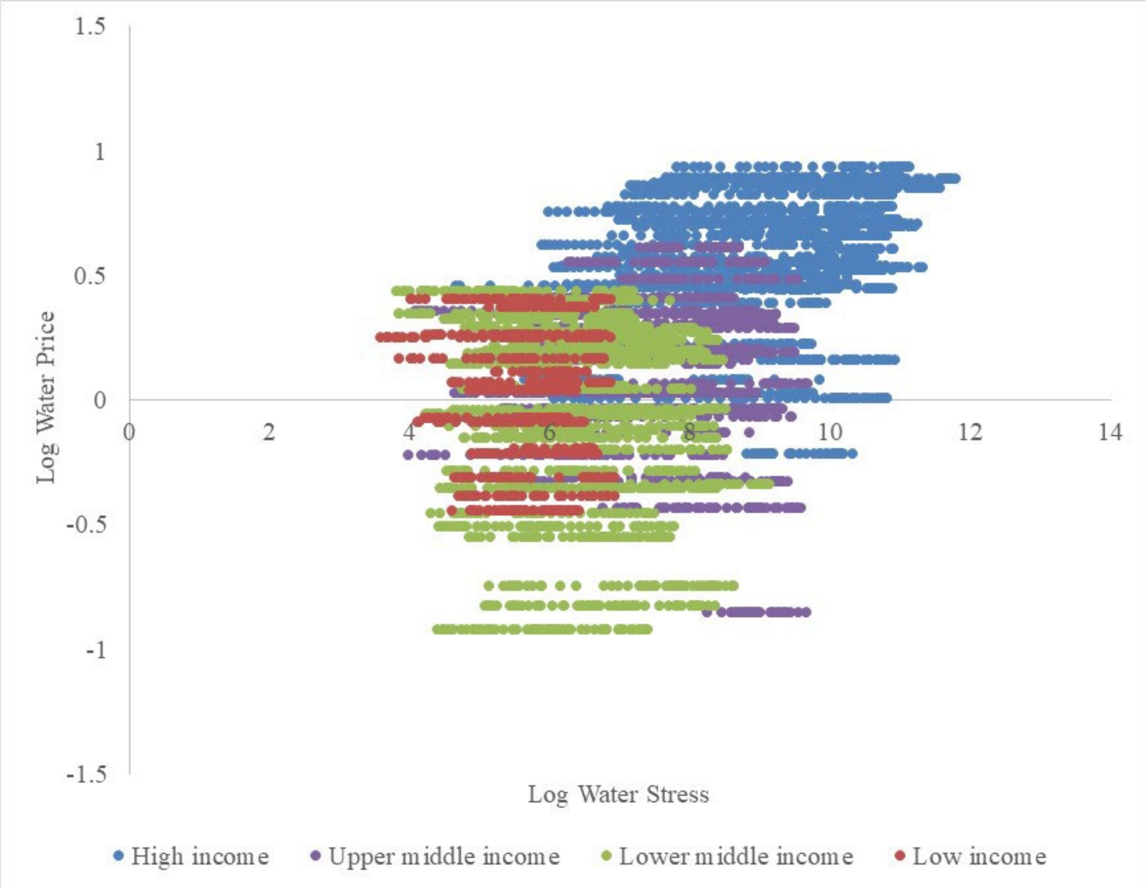
Figure One: Scatter Plot of countries water price by water stress (logged)



Note: We use IBNET average water tariffs by country (in current USD), weighted by population served and based on a consumption of 6m^3 per month (which is based on an average benchmark of 50 litres a day per person (e.g. Gleick, 1996), for a four-person household)

Sources: Created from World Bank Databank (2023) and IBNET database (World Bank, 2023). Water stress (freshwater withdrawal as a proportion of available freshwater resources) values vary across time for countries from 1964 onwards, and are matched with the closest available water tariffs (which it must be noted have far less observations across time, and some observations are repeated)

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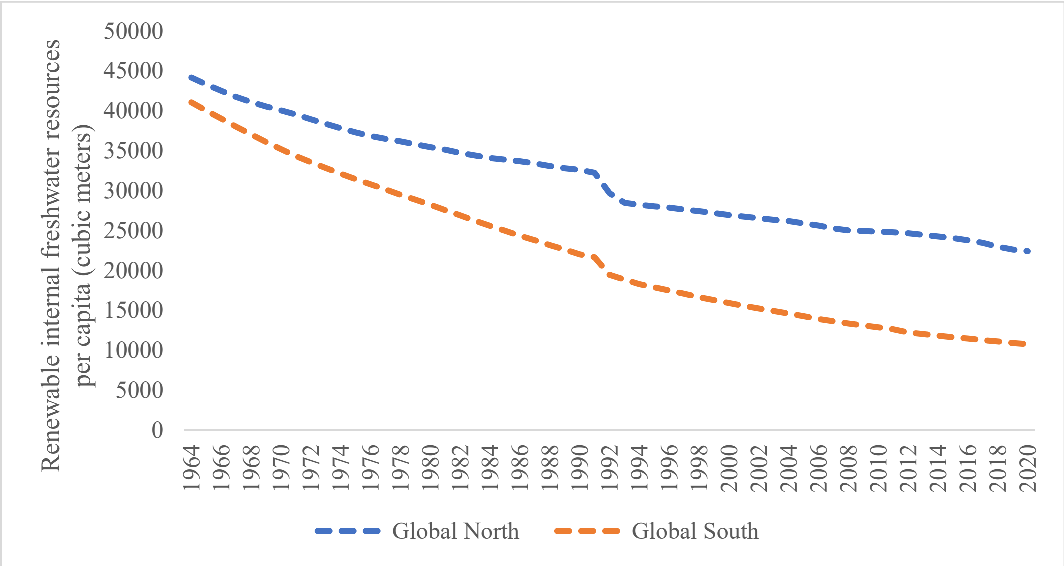
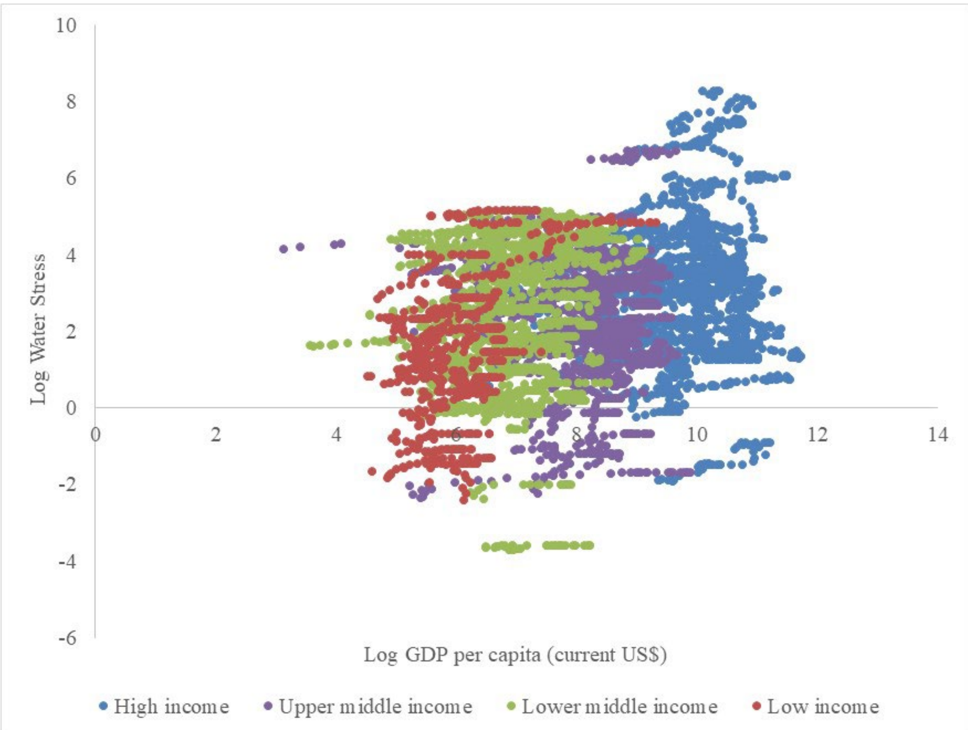
Appendices

Figure A1: Global North versus Global South renewable internal freshwater resources per capita from 1964-2020



Source: Created from World Bank Databank (2023)

Figure A2: Scatter plot of countries GDP per capita by water stress (logged) – pooled data from 1964-2020



Note: Water stress is the level of water stress: freshwater withdrawal as a proportion of available freshwater resources

Source: Created from World Bank Databank (2023)

Table A1 Global South Country Examples of Water Pricing and Market Conditions

Key Fundamental Criteria	*Mozambique*	*Tanzania*	*Zimbabwe*	*Cambodia*	*China*	*India*	*Laos*	*Myanmar*	*Nepal*	*Pakistan*	*Bang-ladesh*	*Thailand*	*Vietnam*
Property Rights/Institutions													
Water Legislation	●	●	●	•	•	●	•	•	●	●	●	•	●
Unbundled rights	●	●	●	⊗	•	⊗	⊗	⊗	●	⊗	⊗	⊗	⊗
Rights transferable	⊗	⊗	⊗	⊗	●	⊗	⊗	⊗	⊗	⊗	⊗	⊗	●
Rights enforceable	⊗	⊗	●	⊗	•	●	⊗	⊗	⊗	●	●	⊗	●
Constraints between connected systems	⊗	⊗	⊗	⊗	●	⊗	⊗	⊗	●	⊗	⊗	⊗	⊗
Water Prices (IBNET index)*	1.29	1.13	2.50	0.35	0.86	0.31	-	-	2.73	0.12	0.44	1.06	0.79
Hydrology													
Documented hydrology system	⊗	⊗	⊗	•	●	⊗	•	•	●	⊗	⊗	•	•
Understanding of connected systems	•	•	●	•	●	⊗	•	•	●	●	⊗	•	•
Future impacts modelled	⊗	⊗	●	•	•	⊗	•	⊗	●	⊗	⊗	•	•
Trade Impacts understood	●	●	●	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Resource constraints understood	⊗	⊗	⊗	⊗	•	⊗	⊗	⊗	●	●	⊗	⊗	⊗
Resource constraints enforced (e.g. caps)	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Externalities/Governance													
Strong governance impartiality	⊗	⊗	⊗	⊗	•	⊗	⊗	⊗	●	⊗	⊗	⊗	⊗
Externalities understood	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Water-use monitored	●	⊗	●	•	⊗	●	⊗	•	⊗	⊗	⊗	●	•
Water-use enforced	●	⊗	⊗	⊗	⊗	●	⊗	⊗	⊗	●	⊗	⊗	⊗
System Type													
Suitability of water sources for trade	⊗	⊗	●	•	●	●	•	•	●	●	●	•	•
Transfer infrastructure availability or suitability	⊗	⊗	●	⊗	•	●	⊗	⊗	●	⊗	●	⊗	⊗
Regulation requirements for trade	⊗	⊗	●	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Adjustment													
Gains from trade (number users/transaction costs/diversity of use)	⊗	⊗	⊗	⊗	•	●	⊗	⊗	⊗	●	●	⊗	⊗
Political acceptability of trade	⊗	⊗	⊗	⊗	•	●	⊗	⊗	⊗	●	●	⊗	⊗
Entitlement registers & accounting													
Trustworthy systems	⊗	⊗	●	⊗	●	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Trade & market information availability	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Water trade step reached – WMRA framework	Step 1	Step 1	Step 1-2	Step 1	Step 1-2	Step 1	Step 1	Step 1	Step 1	Step 1	Step 1	Step 1	Step 1

Notes: * Sourced from IBNET database (World Bank, 2022). '●' for reasonable evidence supporting that criteria; '•' for some evidence of the criteria; '⊗' indicated further reform needed).

Source: Updated and adapted from Wheeler (2021)

Table A2 Global North Country Examples of Water Pricing and Market Conditions

Key Fundamental Criteria	*France*	*Italy*	*Spain*	*UK*	*Chile*	*US (Diamond Valley)*	*US (Idaho)*	*US (Montana)*	*US (Oregon)*	*US (Washington)*	*Australia (Nthn MDB)*	*Australia (Sthn MDB)*	*Australia (Tasmania)*	*NZ (Cantebury)*
Property Rights/Institutions														
Water Legislation	●	●	●	•	●	•	•	•	●	•	•	●	●	●
Unbundled rights	⊗	●	⊗	⊗	⊗	⊗	•	•	●	•	•	●	●	●
Rights transferable	⊗	⊗	•	•	●	⊗	•	•	●	•	⊗	●	●	●
Rights enforceable	•	●	⊗	•	•	●	•	•	●	•	•	●	●	●
Constraints between connected systems	●	⊗	⊗	⊗	⊗	●	•	•	●	•	•	•	●	●
Water Prices (IBNET index)*	5.74	3.77	5.7	5.6	2.8	5.1	5.1	5.1	5.1	5.1	7.34	7.34	7.34	4.58
Hydrology														
Documented hydrology system	●	●	●	●	•	●	•	•	●	•	•	●	●	●
Understanding of connected systems	•	●	●	•	•	●	•	•	●	•	•	●	●	●
Future impacts modelled	•	●	●	●	•	●	•	•	●	•	●	●	●	●
Trade Impacts understood	⊗	⊗	●	●	⊗	●	⊗	⊗	●	⊗	⊗	•	●	⊗
Resource constraints understood	●	●	⊗	●	•	●	•	•	●	•	•	●	●	⊗
Resource constraints enforced (e.g. caps)	⊗	⊗	⊗	•	•	⊗	•	•	●	•	⊗	●	●	●
Externalities/Governance														
Strong governance impartiality	●	●	⊗	•	•	●	•	•	●	•	⊗	●	●	●
Externalities understood	●	•	●	•	⊗	●	⊗	⊗	●	⊗	⊗	•	●	⊗
Water-use monitored	•	⊗	●	⊗	•	⊗	•	•	●	•	⊗	●	●	●
Water-use enforced	•	⊗	•	⊗	•	⊗	•	•	●	•	⊗	●	●	●
System Type														
Suitability of water sources for trade	●	⊗	●	•	●	●	•	•	●	•	⊗	●	●	●
Transfer infrastructure availability or suitability	●	●	●	•	•	●	•	•	●	•	•	●	●	●
Regulation requirements for trade	⊗	⊗	●	•	•	⊗	•	•	●	•	⊗	●	●	⊗
Adjustment														
Gains from trade (number of users/transaction costs/diversity of use)	⊗	⊗	•	•	●	●	•	•	●	•	⊗	●	●	●
Political acceptability of trade	⊗	⊗	⊗	•	•	●	•	•	●	•	⊗	●	●	⊗
Entitlement registers & accounting														
Trustworthy systems	●	⊗	⊗	•	⊗	⊗	•	•	●	•	⊗	●	●	⊗
Trade & market information availability	⊗	⊗	⊗	⊗	⊗	⊗	•	•	●	•	•	●	•	⊗
Water trade step reached – WMRA framework	Step 1	Step 1	Step 2	Step 2	Step 2	Step 1-2	Steps 2-3				Step 2	Step 3	Step 3	Step 2

Notes: * Sourced from IBNET database (World Bank, 2022). '●' for reasonable evidence supporting that criteria; '•' for some evidence of the criteria; '⊗' indicated further reform needed).

Source: Updated and adapted from Wheeler (2021)

Table A3 Six Proposals for Water Pricing and Water Markets

No.	*Recommendation*	*Detail Summarized*
One	The true value and opportunity costs of freshwater and groundwater use should be costed wherever possible, to meet the allocative efficiency principle	Water service providers from Global North and South countries should aim at pricing water to cover operation and maintenance costs, future capital renewal and extension. Ideally where possible, prices should also reflect scarcity and correct for environmental externalities induced by water withdrawals and water pollution. Since conditions in which utilities operate vary significantly over space, we propose water prices being designed and set at the local level. Centralized authorities can decide on rules and principles of water pricing, but the actual tariff components should be based on local operating conditions.
Two	Use one water policy instrument to achieve each objective	Water conservation, subsidies and equity objectives can lead to distortion of price signals. Water tariffs cannot achieve simultaneously several objectives (e.g. accurate price signal, recovering all costs, promoting conservation, and equity and affordability). Trying to meet too many objectives has led to the proliferation of complex tariff schemes, such as IBTs, that do not guarantee affordability nor equity. A combination of instruments (e.g. pricing water and targeted transfers for the poor) will usually be required to achieve several objectives. We suggest the use of simpler tariff schemes, featuring a unique volumetric price that reflects marginal costs, combined with cash transfer payments or rebates for households in need. The fixed charge should be set at a level that allows recovering fixed costs of the utilities while not penalizing too much small consumers. Global North countries need to particularly focus on avoiding exemptions for certain users (e.g. agriculture). All users should be sent the right signals on the value of the resource, not subsidizing either water use or irrigation infrastructure, and policies should not encourage further irrigation development and/or the use of chemical inputs. However, where cash transfers or rebates are not able to be implemented, and the poor can be readily identified, provision of essential water needs to the poor, especially in the Global South, may be justified.
Three	Water pricing is one of the most effective policy tools in regulating household water demand, but other demand management tools can also make pricing more effective	Some of these other tools may only be applicable or implemented in periods of scarcity (e.g. restrictions on water use per household in a drought). In order for pricing to be effective, the tariff scheme should remain simple and easy to understand to the households.
Four	Initial Property Right Distribution Matters	Who owns water rights is a critical factor in determining beneficiaries of trade. Many Global North countries are dominated by colonisation, and distributional issues in water rights will need to be addressed for equity reasons. Many Global South countries have the opportunity to carefully craft and distribute water resource ownership, hence addressing equity issues before implementing markets.
Five	Facilitating water trade is key	Water trade leads to three types of efficiency: allocative, dynamic, and technical, with much empirical evidence suggesting trade provides significant net benefits. But, formal water markets are not for everyone given their meta-governance requirements - facilitating and improving informal water markets (or allowing trade between two stakeholders) may be just as important. Many Global South countries do not have the enabling conditions for fully functioning formal water markets. Hence, focusing on informal or defacto water markets may be most important, and establishing caps on water extractions are key. Global North countries need to focus on establishing (and enforcing) caps, enabling legislation, monitoring water use and regulation.
Six	Regulation, monitoring and enforcement is critical,	Government plays a critical role in monitoring and regulating utility behaviour, both in formal and informal water settings. Water bodies need

	which will support acceptance and participation in markets.	ongoing baseline funding, for both utilities to reinvest and for compliance authorities to utilise income from penalties and convictions to fund further prosecution efforts materially. Water provision and compliance need to be separated, with independent audit and review. Continual investment in water accounting is needed. Global bodies that seek to help the Global South monitor water use could be highly advantageous, and the continual development of satellite and thermal technology in measuring water extraction may provide a cost-effective means of doing so. Global North countries need to focus on best practice lessons such as simple to understand and enforce water legislation; regular undertaking (and reporting) of compliance activities; penalty enforcement; enhancing social norms; leveraging remote sensing capabilities with traditional 'boots on the ground'; and retrospective prosecution.