

Opinion

On Seven Principles of Water Governance

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Abstract: Water problems extend beyond the watershed of local communities and single countries. A novel governance approach must comprise coordination and institutional arrangements at the global scale, and rely on a set of axioms that guide the decision-making and actions of various stakeholders involved in water-related issues. These principles must reflect the awareness of water paradigms across history and geography, as well as the economic, social, environmental, and ethical dimensions of water, aiming at ensuring its sustainable and equitable use, driving governance towards recognizing the value of water for public health and social cohesion, the link of landscape and identity values to water bodies, the social, aesthetic-recreational, and symbolic values of water across the world, and the functions of water in nature. The principles presented here include the human right to water, ecosystem centrality, the principles of shared integration, precautionary, responsibility, and subsidiarity, along with the concept of the common good. The assessment of principles of water governance is essential for implementing any guideline of water management aimed not only at efficiency and security, but at equity and sustainability of water supply and flood mitigation in a globalized and conflict-ridden world.

Keywords: water governance; human right to water; ecosystem centrality; shared integration; precautionary; responsibility; subsidiarity; common good

1. Introduction

Since “the crucial role of water requires managing aquatic ecosystems, the water cycle and water itself in a fair and sustainable way, involving local, regional and global populations in a nested governance structure” [1], improvements to water governance are a key factor to approach the manifold challenges that fall within the complex nexus of water scarcity and supply, flood risk mitigation water ecosystem management, and poverty reduction [2]. Water governance is defined as the range of political, social, economic, and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society [3]. According with Paul et al. [4], the study of water governance is concerned with the interactions that determine how rules and structures are created, how power is shared and exercised, how learning informs decision making, and how transparency and accountability in decision making can be ensured.

Governance and management are often associated with water randomly. Water management and water governance, while closely related, have distinct meanings [5]. The first refers to the activities involved in the handling, supervision, and control of water resources. This includes the planning, distribution, and optimization of water resources. Water governance, on the other hand, relates to the enabling environment in which water management actions take place. It includes the overarching policies, strategies, plans, finances, and incentive structures that concern or influence water resources. It also involves legal and regulatory frameworks and institutions, as well as planning, decision-making,



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and monitoring. In other words, it refers to who gets what water, when and how, and who has the right to water and related services, and their benefits.

Water must be viewed in multiple dimensions. It encompasses not just engineering and economy, but also geographical, ethic, religious, and other aspects. Water governance basically involves ensuring that the distribution of water resources is both economically and ecologically viable, and equally distributed across different segments of society, regardless of gender, caste, and financial capability. Therefore, we can define water governance as the practice of coordinating and making decisions among various actors in the context of contested water distributors.

Accordingly, water governance encompasses multiple planning and policy measures, the equitable distribution of water resources, the empowerment of local water users, and the regulation of large and well-financed water companies. The current water governance literature is primarily about how it connects to the development dialogue, but the analysis should be more specific about how collective actions occur at different scales. The philosophy of knowledge has been the driver of the scientific approach. Moving from water management to water governance involves a progression from action to policy setting, organizational capacity enhancement, and improved regulatory controls. The methodological framework can be expanded by a philosophy of wisdom approach, which not only clarifies the roles of governance and management but also defines overarching principles (see second paragraph).

Water governance requires the proper distribution of water, voice authority, and expertise. It relies on and is crucially dependent upon insights from various academic domains, such as public administration, anthropology, geohydrology, civil engineering, law, human geography, ecology, political science, and economy. The study of human–water relationships in the context of water governance has gained significant attention in recent years, reflecting a growing recognition of the complex and interdependent nature of social, cultural, and ecological systems. Savenije et al. [6] asserted ten years ago that “we have reached a stage at which a more systemic understanding of scale interdependencies can inform the sustainable governance of water systems, using new concepts like precipitation sheds, virtual water transfers, water footprints, and water value flow”. The absence of principles shared by humanity, which have mainly focused on formulating managerial criteria, has contributed to the incomplete overcoming of this concern.

In the midst of challenges like complexity and diversity, as well as the growing understanding of network governance, practitioner-oriented guidance is emphasizing general principles and specifically avoiding normative approaches. In this paper, some principles are presented based on this multifaced relationship as a fundamental step to develop management guidelines capable to account for different attitudes of humankind towards “water, very useful and humble and precious and chaste”, echoing St. Francis of Assisi’s teachings. To address the “four major issues to be addressed at global scale: efficiency, equity, sustainability and security of water supply in a globalized world” [7], the principles of water governance must be driven by the different, neverending paradigms of water governance, as introduced in the fourth paragraph. The descending principles are detailed and discussed in the fifth paragraph.

2. The Approach

The methodological approach moves from “the need to develop a new relationship between the social sciences and humanities on the one hand, and the natural sciences on the other hand” [8]. The rational inquiry of water governance can be chased by moving from an approach based on the philosophy of knowledge to one based on the philosophy of wisdom. The goal is to fulfill the fundamental purpose of academic inquiry, which

is to assist humanity in resolving its conflicts and problems of living in more just and cooperatively rational ways than in the present.

The unavoidable capacity of social action to have all kinds of unforeseen consequences should be considered when taking into account the immense complexity of problems related to water governance. Moreover, the immense diversity of character, circumstances, capacities, aspirations, desires, and fears of people in society plays a major role. Any adequate solution to a social problem that involves multiple people acting cooperatively must almost always be so complex and diverse that no one can have a complete understanding of what the “solution” or “action” means. The approach based on the philosophy of wisdom pioneered by Nicholas Maxwell can help establish the shared root for humankind to explore some basic standing points to build equitable water policies, with “wisdom being the capacity to realize, that is, apprehend and create, what is of value in life, for oneself and for others. Wisdom thus includes knowledge and technological know-how, but much else besides” [9].

The approach is “just to render commonplace the Socratic idea that we are all more or less ignorant of what is of most value in life and of how it is to be realized, learning in this domain being both possible and supremely desirable” [10]. Accordingly, the search of principles of water governance is the search for a shared set of axioms descending from what is of value, namely that our feelings and desires would have a vital rational role to play within the intellectual domain of inquiry. A conceptual flow chart is reported in Figure 1, and it is based on the hierarchy introduced by Russel F. Ackoff in 1988, as follows: “descending from wisdom there are understanding, knowledge, information, and, at the bottom, data” [11].

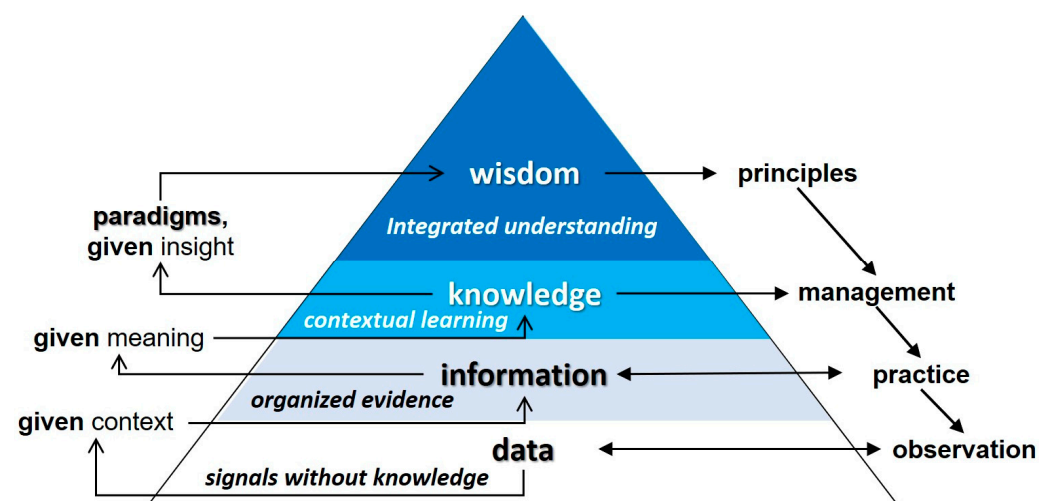


Figure 1. The approach.

3. From Management to Governance

Although the definitions of water governance and water management are somewhat similar, the control function is what makes water governance different from water management. There needs to be an authority to ensure that all policies and plans are properly coordinated and controlled. The increasing levels of conflicts triggered by water scarcity and pollution as well as the water–food–energy nexus indicate that top-down command and control solutions are not capable of resolving the complex issues that arise. Effective water governance requires collective action, particularly to address its connector attribute, which is often used to describe complex water management challenges [12].

International discussions have been taking place since the UN water conference at Mar del Plata in 1977 about how water governance can and should respond to the challenges of

sustainable development. New global institutions were established to promote universal norms of governance based on the 1992 “Dublin Statement” uttering that water is an economic good. The OECD released its “Principles on Water Governance” in 2015, many years after the Mar de la Plata and the Rio de Janeiro Earth Summit, and the 1992 United Nations Dublin Conference. More than 170 governments and stakeholder groups, including 7 non-OECD members, 140 stakeholder groups, and OECD’s members, supported these statements. Since water is an economic good, one adopts the economy vocabulary when discussing water. These principles cover areas such as clear roles and responsibilities, policy coherence, appropriate scales of governance, capacity building, data and information sharing, financing, regulatory frameworks, innovative practices, integrity and transparency, stakeholder engagement, managing trade-offs, and monitoring and evaluation. However, these could be viewed as guidelines or, according to the OECD’s statement, twelve must-do, i.e., requirements that governments should meet to design and implement effective, efficient, and inclusive water policies.

The OECD Principles represent a significant effort to improve water governance globally. However, they face several criticisms related to inclusivity [13], adaptability [14], complexity [14,15], equity [16], power dynamics [17], and integration with other frameworks. The principles have been critiqued for their Western-centric approach [18], challenges in practical implementation [19], and inadequate addressing of equity and justice issues, particularly in relation to Indigenous communities and marginalized groups [20] and transitional countries [21].

Accordingly, the implementation of market-based approaches to water management is controversial. This approach can hardly cope with equity and access concerns, particularly for marginalized communities, the risk associated with the overexploitation of water resources, and challenges in accounting for the full ecological and social values of water. Moreover, there is a growing focus on the role of trust and social dynamics in water governance, recognizing that effective governance requires more than just technical solutions [22].

Addressing these criticisms through ongoing dialogue and refinement of the principles is crucial for enhancing their effectiveness and ensuring sustainable water governance. Future revisions of the management guidelines should focus on improving inclusivity and stakeholder engagement, especially for marginalized communities, enhancing adaptability to diverse local contexts; simplifying implementation while maintaining comprehensiveness; strengthening the focus on equity and justice in water governance; integrating non-Western and Indigenous knowledge systems and governance practices; and addressing region-specific challenges in implementation.

As indicated by Taylor et al. [16], the OECD’s 12 principles on water governance [23] are based around three dimensions: effectiveness, efficiency, and trust and engagement. Principles 1 to 4 (clear roles and responsibilities, appropriate scales within basin systems, policy coherence, and capacity) deal with effectiveness. Efficiency is addressed by the core principles 5 to 8 (data and information, financing, regulatory frameworks, and innovative governance). Trust and engagement are the focus of the final four principles (integrity and transparency; stakeholder engagement; trade-offs across users, rural and urban areas, and generations; monitoring and evaluation). However, the dimension of human development is not solely dependent on individual productivity, which is the ability for individuals to improve their productivity and participate in income generation, but also on equity, sustainability, and empowerment [24].

The assessment and the integration of equity, sustainability, and empowerment in water governance must transcend the “consumerist vision of human beings, encouraged by the mechanisms of today’s globalized economy, has a levelling effect on cultures, dimin-

ishing the immense variety which is the heritage of all humanity” (Pope Francis [25]). It requires going upstream and seeking general and shared principles that reflect the set of water paradigms that humanity has developed throughout history and that still govern the attitude of mankind towards water.

4. Paradigms of Water Governance

The importance of water in life, development, and ecosystems has made it necessary for humanity to establish regulations for its distribution and use, especially since it is a scarce and vulnerable resource. Trends that reflect dominant attitudes and practices have consistently shaped the governance of water. As specified by Hassan [26], these paradigms encompass deeply rooted perceptions of water’s spiritual and religious essence, as well as assessments of its economic cost and value, both of which have shaped a contemporary historical framework. Existing psychological frameworks have been institutionalized and codified by these paradigms through the process of social communication, behavior, and interpretation.

The oldest paradigm is that driven by spiritual-religious issues. It is deeply embedded in mythology, tales, and religious doctrines worldwide. It was the major driver in man’s history and it also continues to emerge in various contexts of water management, particularly in addressing water conflicts and coping with extreme events. The Bible depicts water as a source of life, beginning with the creation narrative where the Spirit of God hovers over the waters (Genesis 1:2). In Christian theology, water is often used as a metaphor for the Holy Spirit. Sacred springs, such as Lourdes in France, are managed as both spiritual and environmental resources, requiring governance that balances religious practices with conservation. Islam holds water in high regard as a symbol of Allah’s paradise. In this context, water symbolizes righteousness and closeness to Allah. The Qur’an acknowledges rain and rivers as sources of safe drinking water from the Paradise gardens.

While Islam and Christianity explicitly treat water as sacred and integral to religious rituals, Confucianism emphasizes harmony with nature, which extends to water management practices. The symbolic significance of water in Confucianism is more philosophical than overtly religious. In Hinduism, water is seen as a divine entity and a purifier, similar to Islam’s view of water as a symbol of purity and a divine gift. The spiritual significance of rivers like the Ganges in India has been central to water governance and conflict resolution, particularly in efforts to clean and protect these sacred water bodies. Let alone, the neverending idea of divine punishment is associated with floods, as it that emerges in various cultural and religious interpretations of natural disasters [27–29].

Another ancient paradigm is the aesthetic-recreational one. It was established by monarchs, state leaders, and the nobility through the construction of gardens, water fountains, baths, and spas, serving both as spaces for leisure and as symbols of status and authority. It has influenced royal practices from the Roman Emperors to the Ottoman Sultans and continued to shape the behaviors of royal families during the Renaissance and Modern Eras. Current efforts to reduce the effects of industry and pollution on aquatic landscapes are once again highlighting the recreational and aesthetic aspects of water [30].

The paradigm of hydraulic engineering dates back to four millennia ago with the development of complex water works like qanats, aqueducts, and mechanical water-lifting devices. Water mills in the Roman empire [31] and the development of Islamic water technology significantly reinforced it much later [32,33]. In the Far East, the Chinese water heritage was at the heart of Chinese technological civilization, since the story of the hydraulic works of China is nothing short of an epic [34]. It would take too long to list all the hydraulic technological interventions and their successful transformation of Europe and Asia since the medieval period.

As the industrial period began, this worldview was joined by the scientific paradigm that sees water as primarily a chemical and physical material whose properties are studied by science. Water quality issues and the association between water pollution and disease was a factor that bolstered this paradigm. The rise in the industrial and hydraulic engineering paradigm is mainly associated with energy production, when water became the *houille blanche*: “white coal is the energy of running water transformed by electricity and carrying out various works that fuels burned in machines until now” [35]. In the Roman age, however, the water-mill provided a source of energy (the water-mill) and irrigation to support the development of the Mediterranean economy.

The rise in the industrial and hydraulic engineering paradigm led to the economic-financial paradigm becoming the prevailing archetype by the end of the 20th century. A central theme in the current paradigm is the economic valuation of water resources. This involves assigning monetary values to water-related goods and services, many of which are not traditionally traded in markets. The valuation process aims to capture the full economic cost of water, often adopting shadow pricing to estimate these values, particularly in sectors like agriculture where water charges may not reflect the true economic value of water.

The ecological paradigm [36] is sometimes in opposition to the latter paradigm because it places emphasis on sustainability in ecology, environmental ethics, health, and spirituality. This aligns with the spiritual-religious paradigm in this way. From the Islam world to the Hindu society, from Native American’s heritage to that of indigenous Polynesian people, the spiritually and religiously driven water paradigms in the world demonstrate a profound and enduring influence on how water is perceived, valued, and managed in connection with nature. From ancient irrigation systems to modern sustainable development policies, principles of harmony, balance, and reverence for nature continue to shape approaches to water management.

The aesthetic-recreational paradigm was established by royals, state rulers, and nobility, who used gardens, water fountains, baths, and spas to enjoy and show off their rank. The paradigm has been a guide for royal families throughout the Renaissance and Modern Eras, with the start of Roman Emperors and Ottoman Sultans. At present, the aesthetic-recreational paradigm in water governance emphasizes the importance of water bodies not only as resources for practical use but also as spaces for recreation, beauty, and cultural value. Water is valued for life-sustaining and practical aspects, but also for its aesthetic and recreational qualities, which contribute to human well-being and cultural identity. The cultural and social fabric of cities is enhanced by urban water bodies, which are not only functional but also provide spaces for recreation and aesthetic enjoyment. Water quality, not only quantity and temporal distribution, play an essential role in integrating aesthetic and recreational values into water policies, because water bodies must be preserved not only for their ecological and practical functions but also for their cultural, emotional, and recreational significance.

Water quality issues open an additional perspective, the scientific-health paradigm. For instance, water was perceived as having negative qualities in the late Middle Ages because of its role as a source of infection during the 14th century epidemic known as the plague or the black death. Accordingly, water is treated as a chemical in the scientific-health paradigm because it can harbor pathogens. Its origins date back to the seventeenth century, and it is derived from the sanitary paradigm established by Vitruvius in his masterpiece, *De Architectura*, twenty centuries earlier, and even the Paracelsus tradition of early 16th century alchemy. The scientific-health paradigm in water governance focuses on ensuring water quality and availability to protect public health by integrating scientific research, public health priorities, and governance frameworks to address water-related challenges. These include contamination, waterborne diseases, and equitable access to safe drinking

water, since “drinking water quality is paramount for public health. Ensuring access to safe drinking water is a fundamental responsibility of water governance frameworks” [36]. More recently, monitoring wastewater from urban areas has been proven an efficient method to detect the arrival and subsequent decline of pathogens, such as SARS-CoV-2. Also, to guarantee fresh water and protect the health of the seas, pollution control is crucial, with plastic waste causing up to eighty percent of total marine pollution.

The legal and ethical paradigm has existed since ancient times. At the end of the first century AD, in Ancient Rome, “any private connections to Rome’s aqueduct network were only sanctioned by the imperial government”, as Frontinus [37] reported in his two-book masterpiece, *De Aquaeductu*. Appointed censor in 184 BC, Cato the Elder reportedly cut off aqueduct water “running or carried into any private building” (Livius, as reported in [38]), and presumably this action was only taken in the cases of people who were stealing water from the aqueducts [38]. The intergenerational regulation of water was also a concern for the ancient Romans, since “the right to granted water does not pass either to the heirs, or to the buyer, or to any new occupant of the land” [37]. As a result, the grant holder’s death resulted in the right to draw water from the public supply expiring.

In the modern age, the establishment of national states enforced legal and ethical issues in water governance. As disputes between users inside and between countries have begun to intensify, it has mostly taken over in the last several decades. The legal-ethic paradigm is part of a broader shift in water governance, moving towards more inclusive and justice-oriented approaches. Paradigms and theories in water governance are evolving to address the complex interplay between legal frameworks, ethical principles, and practical challenges in resource management [39]. This reflects the growing recognition of the need for integrated approaches that balance legal and ethical considerations, as well as the other paradigms across a comprehensive approach to water governance that includes the feedback between data availability and information building, acquisition of knowledge, and wisdom assessment [40], as sketched in Figure 1.

5. Seven Principles of Water Governance

The growing number of water conflicts [41] claims for a deeper understanding of water governance principles, a set of axioms that guide the decision-making and actions of various stakeholders involved in water-related issues. The aim of these principles is to ensure water’s sustainable and equitable use by reflecting its economic, social, environmental, and ethical dimensions. By bringing together the diverse water paradigms, it becomes apparent that water governance should be founded on the human right to water, the ecosystem approach, and the principles of shared integration, precautionary, responsibility, and subsidiarity, as well as the common good concept. These principles play a crucial role in implementing any effective and equitable guidelines on water management.

5.1. The Human Right to Water

The concept of the human right to water is built around the belief that water is vital in achieving other human rights, like the right to life, health, food, education, and dignity. “Recognition of the human right to water could make a huge contribution in the settlement of international disputes and proper water management worldwide. Instead of fighting over water, the law should be developed to contribute to the proper distribution of water and help reduce the mismanagement of water and its pollution and contamination” [42]. Under the single lens of the economic-financial paradigm, the human right to water is sometimes criticized because it lacks enforcement mechanisms and arrangements concerning water use [43], and the implementation of water rights is not trivial and does not automatically lead to an improved situation for the people who are deprived of water [44].

The human right to water implies that everyone should have access to sufficient, safe, acceptable, physically accessible, and affordable water for personal and domestic use, without discrimination or interference. Access to an adequate, safe, sufficient, and reasonably priced water supply for residential and personal use is a fundamental right of all individuals. In this context, national states and their institutions are the key players.

The human right to water requires states to uphold, defend, and grant it to their citizens. States are not allowed to hinder or limit people's access to water. Preventing and resolving any harm caused by third parties or natural factors that affect the amount or quality of water is their responsibility. Proactive steps must be taken to create institutional, governmental, and legal frameworks to prevent and monitor the exercise of this right to guarantee that everyone can actually enjoy this right. Although wastewater is an actual source of water supply, minor efforts towards practicing are so far deployed in both rich and poor countries. Water scarcity can be alleviated by reusing water from urban waste water treatment plants, as droughts are becoming more frequent in several regions. Reuse plays a fundamental role in the preservation of water resources by ensuring a safe and predictable source of water, reducing pressure on water bodies, extending the life cycle of fresh water, and enhancing adaptation to climate change.

The human right to water encompasses the empowerment and participation of individuals and groups in making water-related decisions. Access to information and education related to water-related topics is necessary for individuals to express their views on water policies and services. Accountability must be held for anyone responsible for supplying or controlling water. In the case of water violations or disputes, people should be able to obtain effective remedies and justice.

States are accountable for respecting, protecting, and fulfilling this right for their citizens, as recognized by the United Nations General Assembly in 2010 [45]. About 40 states, including South Africa, Kenya, Uganda, and Zambia in Africa and Brazil, Uruguay, Mexico, Colombia, and Peru in South America, have a constitution that guarantees the right to water. The constitution of almost all OECD nations does not mention clearly the right to water. As an illustration, the United States Constitution only ambiguously acknowledges the right to water as a part of the right to a healthy environment.

5.2. *Ecosystems Centrality*

A number of ecosystems that provide essential services for human survival and well-being are sustained by water, which is a fundamental component of the natural world. Social and natural sciences have traditionally been separated, neglecting the overlap of both fields of knowledge, resulting in limited theoretic and methodological development for joint analysis, and a shortage of available data for management. Linking biophysical and socioeconomic variables is a significant challenge when considering water as a socioeconomic heritage, given the current knowledge and modeling capabilities. An ecosystem-based strategy considers how water interacts with other elements of the environment, such as air, land, biodiversity, and climate.

The ecosystem centrality principle states that water governance must maintain or restore the ecological integrity and resilience of water resources and ecosystems. This approach has the potential to boost agricultural system productivity and sustainability by supporting the natural mechanisms that foster crop growth, such as soil fertility, water retention, pollination, pest management, and nutrient cycling. Integrating ecosystems, water resources, and energy production can lead to improved trade-offs and synergies.

Both benefits and trade-offs can be realized in maintaining or restoring the ecological integrity of water resources and ecosystems. The advantages include improving the provision of ecosystem services, commonly defined as the benefits humans obtain from

ecosystems [46]. The benefits also include lowering the vulnerability and risk of disasters, and supporting the conservation of biodiversity. The trade-offs comprise economic and social costs, clashes between different objectives, and the challenge of facing uncertainties and limitations.

The ecosystem approach to water governance, focusing on integrating ecological principles and balancing societal and environmental needs, provides an essential paradigm for water governance at different scales. “It also seeks an attitude founded upon the sharing of habitat with other ecosystem components and the minimization of human impact. Moreover, there is no final condition: rather, there is an ethos always to improve performance” [47]. However, major economic investments may be necessary under uncertainty associated with the complexity of natural systems, and the lack of adequate data, knowledge, or capacity.

5.3. Shared Integration

The concept of sharing encompasses that of Integrated Water Resources Management or IWRM [48]. This method encourages the coordinated development and management of water, land, and related resources to maximize economic and social welfare without jeopardizing the sustainability of vital ecosystems. IWRM demands a comprehensive and integrated perspective that considers the connections between water and other environmental elements. To plan, implement, and evaluate water policies and actions, all relevant stakeholders must be involved in a participatory and adaptive process taking into account the social, economic, environmental, and ethical dimensions of water use. The implementation of IWRM can lead to sustainable development by balancing the economic, social, and environmental aspects of water use.

Integrating should be guided by the ecosystem principle. Nature-based solutions (NBSs) are another pillar that IWRM includes [49]. By employing or mimicking natural processes, these activities address a variety of environmental, social, and economic issues in urban environments.

Different contexts and situations can utilize the IWRM approach. Cooperation and coordination among countries sharing water resources across political boundaries can be facilitated by IWRM within the transboundary area. The Nile River is an example of a typical large-scale context where IWRM could serve as the roadmap to resolve conflicting issues caused by large-scale projects like the Grand Ethiopian Renaissance Dam or the Jonglei Canal. This is not a utopia. IWRM has been implemented by 14 Pacific Island countries at the national and regional levels to deal with water governance, water quality, water supply, sanitation, and climate change adaptation.

Improving preparedness to cope with droughts and floods can be achieved by managers and citizens through IWRM. Integrating structural and non-structural measures is a way to address flood vulnerability. The approach is applicable not just in developed countries, but also and especially in poor countries, as suggested in Sudan to mitigate flood risk in Kassala, where structural measures like sediment control in riverbeds are paired with non-structural strategies such as early warning systems and community engagement to reduce flood risks in arid regions [50]. Integrating various sources can lead to enhanced municipal water security, as demonstrated by the Four National Taps of Singapore, a comprehensive strategy for water management. Bringing together local catchment water, imported water, high-grade reclaimed water, and desalinated water has resulted in an improvement in the livability and resilience of the city through water diversification and optimization [51].

5.4. Precautionarity

The precautionary principle is widely discussed in environmental science as a guideline for policy-making. The precautionary principle encourages policies that protect human health and the environment in the face of uncertain risks [52]. This approach is particularly relevant in cases where scientific uncertainty exists, such as predicting the impacts of climate change on water availability and flood risk. Water resources and ecosystems can be threatened and at risk due to natural or human-induced factors, such as pollution, over-exploitation, or climate change. The result is an increase in uncertainty and vulnerability. Water governance must take proactive measures to anticipate, prevent, or mitigate any potential harm to ecosystems and water resources before it occurs.

Developing precautionary water strategies must consider the scientific uncertainty and the lack of conclusive evidence about the impact of substances or special activities on the environment and human health. This need can be fulfilled by taking proactive and preventive measures to safeguard ecosystems and water resources from potential harm, instead of relying on a reactive and corrective approach that waits for damage to occur before taking action. This includes the role of wastewater-based epidemiology in developing control strategies and effective surveillance systems to cope with infections and pandemic events.

Flood control, municipal water supply, and the water, food, and energy are just a few examples of water-related issues and risks that the precautionary principle can be applied to. To ensure the availability and quality of water supply, a precautionary approach involves controlling pollution and managing demand, while also fostering the diversification and integration of water supply options [53]. Water supply systems can be made more resilient and reliable through rainwater harvesting, groundwater recharge, or wastewater reuse. The precautionary principle can also encourage the adoption of low-carbon and low-water technologies and practices in order to cope with the water, food, and energy nexus.

The decision-making process faces significant challenges in terms of the legitimacy and accountability of the precautionary principle. Complex and controversial issues that require scientific, ethical, and political judgments may arise as a result of the precautionary principle. Ensuring that the decision-making process is transparent, inclusive, participatory, and evidence-based is crucial. It is vital to make sure that decision-makers are held accountable for their actions and subject to review and revision.

5.5. Responsibility

Since water is a precious and scarce resource that can be damaged or depleted due to pollution or overuse, responsibility must be carefully considered. The ‘polluter pays’ principle has its roots in the history of humanity, since Plato wrote 24 centuries ago that “if anyone intentionally spoils the water of another. . .let him not only pay for damages, but purify the stream or cistern which contains the water” [54]. In modern times, this principle was recognized in 1972 by OECD, where the polluter was kept responsible for the pollution. Under the ‘polluter pays’ principle, the polluter is obliged to pay for preventing or repairing damage caused by pollution or the overuse of water resources. This principle states that water management should incorporate the environmental costs and benefits of water use into economic instruments like taxes, charges, subsidies, or markets.

The application of this principle embodies the ethical and legal notion of responsibility and accountability for the consequences of one’s actions on water resources and ecosystems. It also provides a source of income for the public authorities to fund water protection and restoration measures and other programs aimed at preserving and replenishing water resources. On the other hand, it includes an economic incentive for polluters to reduce or avoid environmental harm.

The polluter pays principle can be applied to a variety of water-related activities and impacts, such as irrigation, industry, or sanitation. Imposing charges or fees on the use of water or fertilizers can be used to apply it to irrigation activities that could cause water pollution or overuse. The water agencies in France charge farmers for using nitrogen fertilizers, which is then used to fund water protection and restoration measures [55]. A more efficient approach involves making farmers adopt best management practices or technologies that reduce water losses, runoff, or leaching, such as precision farming and buffer zones. Imposing taxes or fines on pollutant discharge or water abstraction is coherent with the polluter pays principle as well. But a more advanced strategy involves enforcing the installation of treatment facilities or monitoring systems to ensure that water quality or quantity standards are met.

5.6. Subsidiarity

Because of the nature of water, a diverse and complex resource that varies according to local contexts and needs, the responsibility and authority for water-related issues should be assigned to the lowest appropriate level of governance. The aim of this principle, known as the principle of subsidiarity, is “to promote efficiency and local ownership over policies and regulation, while placing a check on centralized governance and consolidation of authority at the highest levels of government, while placing a check on centralized governance and consolidation of authority at the highest levels of government” [56].

This principle respects the autonomy and capacity of local communities and institutions to manage their water resources according to national and international laws and standards. The participation and empowerment of local stakeholders in water-related decision-making and management are enhanced. Sustainable development is made possible through the subsidiarity approach by balancing the economic, social, and environmental aspects of water use.

Subsidiarity at the global level involves acknowledging the sovereignty and autonomy of states in managing their water resources under international laws and standards, as introduced in the Dublin Statement. Subsidiarity is achieved at the national level by decentralizing the authority and responsibility for water management to lower levels, like states, provinces, or municipalities. At the local level, subsidiarity deals with empowering local communities and institutions to manage their own water resources in accordance with their needs, preferences, and capacities. An effective recognition of subsidiarity should involve reconciling international water frameworks with the human rights’ standards of the United Nations Declaration on the Rights of Indigenous Peoples [16].

5.7. The Common Good

In the third millennium, water governance is becoming increasingly important and urgent. Water governance is rooted in the concept of the common good, which is a fundamental and unifying principle of social ethics. As stated by Pope Francis in his Encyclical letter *Laudato Si’* [25], “the common good is the sum of those conditions of social life which allow social groups and their individual members relatively thorough and ready access to their own fulfilment”. The common good is founded upon respecting the fundamental and inalienable rights of the human person, and by considering water to be a human right, it must be managed accordingly.

Since water is a human right, it needs to be managed as a common good. Those who cannot afford or access market prices will be left behind if water is considered a commodity or a business opportunity. The commodification of water will delay the attainment of sustainable development objectives and hamper efforts to resolve the global water crisis,

which is further aggravated by the triple planetary crisis. Climate change, nature and biodiversity loss, and toxic pollution affect the lives and health of billions around the world.

Recognizing water as a human right requires its management as a shared resource. Considering water as a commodity or a business opportunity will leave behind those who cannot access or afford the market prices. The commodification of water will derail the achievement of sustainable development goals, as well as hamper efforts to solve the global water crisis, further exacerbated by the triple planetary crisis. Climate change, nature and biodiversity loss, and toxic pollution affect the lives and health of billions around the world, since the lives and health of billions worldwide are impacted by climate change, natural disasters, and toxic pollution.

Because of its stabilizing function in the Earth's system, freshwater serves as a global common. Treating water as a shared resource demands a rethinking of its economics. The management and regulation of blue water is largely focused on making it a public good for drinking and sanitation. Yet, public ownership undervalues water, as one person's access does not limit another's access, even though water is a finite resource. As specified by Pope Francis, "when we speak of the need to care for our common home, our planet, we appeal to that spark of universal consciousness and mutual concern that may still be present in people's hearts. Those who enjoy a surplus of water yet choose to conserve it for the sake of the greater human family have attained a moral stature that allows them to look beyond themselves and the group to which they belong" [57].

The human rights to water and sanitation are clear illustrations of the indivisibility, interrelatedness, and interdependency of human rights and are vital for achieving an adequate standard of living. The physical security of women and girls, the discrimination against Indigenous Peoples, peasants, minorities, the human rights to health, adequate housing, a clean, healthy and sustainable environment, education, and many others, all are intimately linked to water and sanitation.

Sharing general principles, such as those introduced above, can help overcome the conflict between local and global criteria, as well as between developmental and environmental goals [58]. "Achieving water security requires addressing two fundamental challenges at all scales: enhancing water's productive contributions to human and ecosystems' well-being, livelihoods and development, and minimizing water's destructive impacts on societies, economies, and ecosystems resulting, for example, from too much (flood), too little (drought) or poor quality (polluted) water" [59]. This goal cannot not be achieved without shared principles. The seven principles are not all-inclusive or exhaustive, but rather complement each other and are interconnected. They provide a link between the different paradigms of human attitude toward water and the management guidelines that are needed for coping with water problems arising all around the planet. The principles provide a normative framework to guide the formulation and implementation of water policies and actions at different levels of governance. The shared vision and goals of sustainable development are balanced by balancing the economic, social, environmental, and ethical aspects of water use. Through the implementation of these principles in practice, water management can enhance human dignity, well-being, security, justice, peace, and prosperity for both present and future generations. It has the potential to fill the gaps inherent in the dimensions considered in current management must-do, as shown in the flowchart of Figure 2.

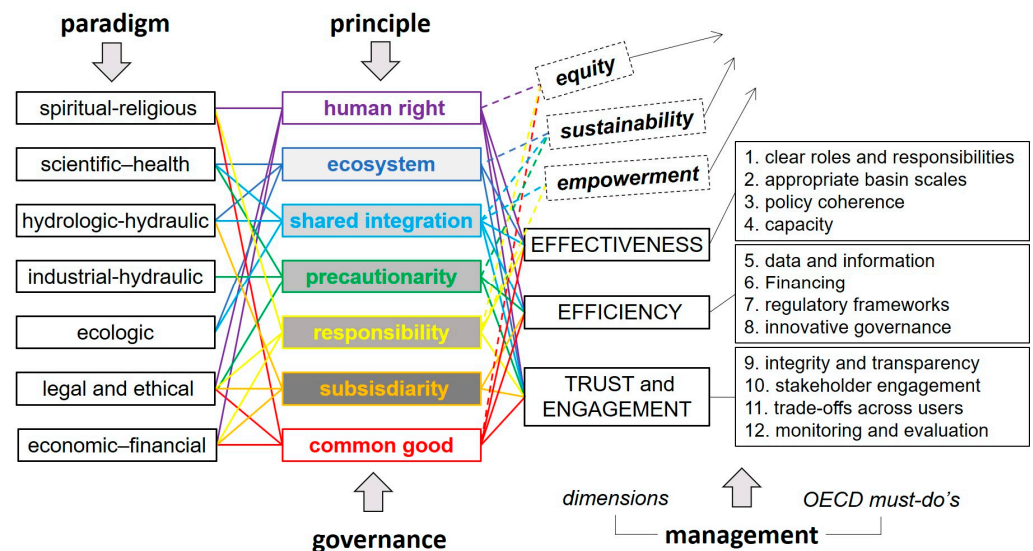


Figure 2. How water paradigms and principles drive governance and management under a complex network of interactions. Solid lines are associated with current dimensions, while dashed lines refer to lacking dimensions. Each color refers to a specific principle of governance.

At the beginning of the millennium, Petrella [60] proposed a World Water Contract based on the assumption that “eight billion people who will live on Earth twenty years from now, including more than three billion who will not have access to safe drinking water and five billion who will face major problems of scarcity and quality”. His prediction of population growth was quite accurate, but something has been conducted in the meanwhile to approach water availability, since globally only two billion people, not three, do not have access to safe drinking water, according to multiple reports from the United Nations and the World Health Organization. However, additionally 2.2 billion people lack access to “safely managed” drinking water services, which include water that is free from contamination and available on premises when needed [60–63]. Sharing some basic principles is the fundamental step for the Water Contract to become a real thing, because any guidelines for water management descending from a top-down approach are not enough for countries that have poor access to water and lack economic, cultural, and social resources to cope with extreme events.

6. Conclusions

This paper offers a novel approach to identify basic principles of water governance. Shared principles are needed to implement effective and equitable water management rules as well as approaching water conflicts that are dramatically increasing worldwide. Further research is needed to verify the capability of these principles to assist humanity in resolving its conflicts and problems of living with water in more just and cooperatively rational ways than in the present. It is also important to evaluate whether the proposed principles are redundant or need to be modified or integrated after testing them against historical and current practices.

One major challenge in the implementation of the principles is information. The traditional separation of social and natural sciences has been characterized by disregarding the overlap of both fields of knowledge, which has resulted in limited theoretical and methodological development for their joint analysis, as well as a paucity of available data for management. Considering water as a socio-ecological patrimony necessitates linking biophysical and socioeconomic variables, which is a significant challenge due to the current knowledge and modeling capabilities. Information on the complexity of socio-hydrological systems is vital, as they are reflexive, adaptive, non-linear, and complex, with feedback

loops, emerging properties, and non-predictable responses to management interventions. The recognition of these knowledge limitations is of vital importance in light of the evolving paradigm for water governance.

Another challenge is transferring these principles into a management approach that combines integrated water resources management, ecosystem-based approaches, and adaptive management. The combined strengths of each approach address different moral and ecological challenges, while minimizing tensions may contribute to more effective water management in the Anthropocene. This involves increasing stakeholder involvement in the processes of water management planning, which is a crucial platform for society to negotiate resource use in the Anthropocene.

Further research in governance history should investigate where the above principles were applied at different spatial and institutional scales with positive outcomes, and where their failure triggered supply scarcity, water conflicts, and significant flood vulnerability. Also, completeness must be further assessed. These principles must be assessed in light of examples and counterexamples based on a different cultural heritage. One must be aware that the confutation of these principles is a challenge. To fully understand the thoroughness of these principles, it is necessary to examine them at different scales, from large rivers, like the Nile, to small irrigation systems in the high mountains of the Himalayas and European Alps.

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