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Water Security in the Anthropocene: A Dialectical Water–Man Interaction Model

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Abstract: The impacts of human activities have been detected in geological strata by rock radiometry and fossil recognition. They represent the timeline of Man–Nature interaction in different periods of climate change over a long duration. A notable exception is the human footprint during the industrial period, starting in the 18th century. Due to the severity of human impact during the last few decades, some scientists have suggested calling this era the "Anthropocene". One of the main challenges in the Anthropocene is to achieve water security with innovative approaches aiming to improve natural water resources management, policy, and governance. In this paper, it is suggested to reformulate the Water–Man interaction as the union of two opposites: conflict and cooperation. Their dialectical unification by conflict resolution leads to a new model of water resources management and policy that can initiate a harmonious symbiosis between Man and nature, minimize externalities, and increase water resilience.

Keywords: water resources management; social issues; dialectics; conflict resolution

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1. Introduction

Since the origin of human life on our planet, Man has been an integral part of nature. His survival is dependent on flora and fauna, especially on natural water resources [1]. Throughout human evolution, Man has acknowledged a strong interaction between his way of living and the surrounding environmental and ecological conditions. This is particularly true for the use of water resources, the source of life on our planet, with no other substitute.

The way humans use and manage natural water resources is the necessary precondition for ensuring water security. Water security can be defined as the preservation of sufficient quantity and quality of water for human needs and ecosystem services at "all times", including climate change, floods, and droughts. Water is the sine qua non element, necessary not only for drinking and the survival of ecosystems but also for enhancing human socio-economic activities [2]. It is the common denominator and the principal indicator for maintaining life on our planet, achieving socio-economic growth, and ensuring a good environmental and ecological status on Earth. Sufficient water of good quality means a healthy Man, a green environment, and adequate ecosystem biodiversity. On the contrary, polluted surface and groundwater may induce deterioration of human health and environmental and ecosystem degradation.

The conceptual framework of water resources management by human societies [3] is continuously evolving. It depends on the economic and cultural progress of humanity as well as the temporal changes in natural environmental conditions. On the one hand, humans use natural assets, such as water, plants, fossil resources, and minerals to produce food, energy, and manufactured products. On the other hand, nature is vulnerable to climate variability, which induces temperature variations, droughts, and floods, and more recently, to climate change due to the greenhouse effect and excessive human activities.

In the history of mankind, the appropriation of natural water resources by Man has oscillated between friendly and antagonistic. During Man's nomadic, pre-historic period, natural phenomena were interpreted as the wish of the Gods and signs of either a friendly or adversarial attitude of nature, either recompensing or punishing human attitudes. For example, the role of the sun, giving everyday humans the necessary light and energy to survive, and the water cycle, producing water and food throughout the seasons, were considered gifts of nature [4]. On the opposite side, floods, volcano eruptions, and other natural disasters were signs of nature's hostile feelings toward humans. During that pre-historic period of 100,000 years, Man experienced climatic hazards of high and low temperatures. He moved from Africa to Asia, colonized Australia and Europe, and found refuge in caves to resist the forces of nature, such as low temperatures, thunderstorms, floods, and even glaciers that covered many parts of the Northern Hemisphere. Humans in those times were dominated by Mother Nature and were obliged to follow her divine properties.

About 10,000 years ago, Man entered an era of relatively stable environmental conditions. Scientists have named that period from the Greek "όλος": whole and "καινός": new, the Holocene, i.e., the "wholly new" period. During the Holocene, Man developed the first agricultural revolution, domesticated animals, and promoted the trade of manufactured goods and exchange of agricultural products. His relationship with nature varied between conflict and cooperation. Greeks and Romans placed human activities related to natural phenomena and natural hazards under the protection of the Gods. To interact with nature and deal with natural disasters, they asked for help from Gods [5], such as Poseidon/Neptune for sea navigation, Artemis/Diana for hunting, and Demeter/Ceres for agricultural production.

In the Man–Nature interaction, an exception has been noted during the period that started about two centuries ago. In this period since the industrial revolution, which continues today with its 4th stage developments in informatics and robotics, Man has felt able to dominate nature. Due to strong scientific and technological progress, hydraulic engineers have demonstrated their capability to dam big rivers, change their beds, reclaim wetlands, and pump groundwater from thousands of meters deep. These activities have produced such important negative impacts on nature that many experts agree that they mark a new era called the Anthropocene [6].

To deal with externalities in the Anthropocene, it is necessary to reverse the conceptual framework of Man prevailing over nature by reconsidering the Water Resources Management (WRM) and policy model. Instead of aiming to control the natural water environment completely, Man and nature should be integrated into a common interactive system, unifying them harmoniously to achieve sustainable hydro-governance.

The main objective of the new model is to add a social component to the existing state-of-the-art Integrated WRM approach. Social activities related to water are assessed, analyzed, and compared to hydrological/hydraulic/natural laws. Most of the time, these socio-economic activities tend to overuse surface and groundwater resources, generate and diffuse pollution, and contribute to soil degradation and erosion in conflict with natural laws (the *Eristic* component of the new model). To achieve their resolution dialectically, unification between the opposites is suggested by making them compatible with natural laws (*Dialectical* component).

2. Historic Timeline of Water–Man Interaction

Historically, Man has perceived his relationship with nature as a balance of power between his physical and technical capabilities and the forces of nature. In tribal societies around the world, Man survived in a hostile natural environment by hunting and cutting trees to build precarious houses. During that period, which lasted for many millions of years, nature prevailed over Man. Natural entities, such as high mountains, volcanoes, and rivers, were considered divine by humans. We may call this type of Man–Nature interaction *Naturalistic*, i.e., nature, including natural water resources, dominating humans (Figure 1a).

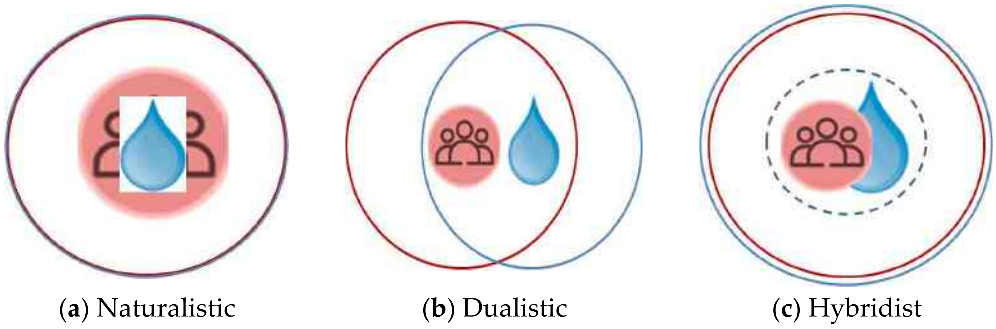


Figure 1. Different types of Water–Man interaction.

The collective agricultural development in Egypt and Mesopotamia and the domestication of animals that started a few thousand years before intensified during the historical times of the Greeks and Romans. Similar developments occurred in China, India, and South America. During that time, human civilization made substantial progress with new, big cities flourishing around the Mediterranean and in China and South America. The development of arts and sciences initiated a new relationship between humans and nature, oscillating at the same time between friendly and adversarial. Friendly, as natural water resources and river streams were able to purify humans, offering them clean water for drinking and sanitation. For example, the Hindu religion in ancient India and China consider rivers and water streams to be gifts from the Gods. In ancient Athens, the river Ilissos was considered a Man-God and was depicted as such in a one-piece marble statue made by Phidias, a well-known sculptor at that time, on the western pavement of the Parthenon [7]. River-Gods became angry with humans from time to time, coming out of their riverbed and producing catastrophic floods. This was the case with the Achelous River in Greece, which is depicted in ancient potteries as a serpent with the head of an angry bull. The myth of Hercules, a legendary ancient hero who challenged the Achelous in a fight and defeated him, is well-known [8]. His victory against the river was a symbol of the human capacity to control the natural forces of a river and reduce flood damages. This model of the Water–Man contradictory relationship, both friendly and antagonistic, can be named *Dualistic* (Figure 1b).

The statesman and enlightenment philosopher Jean Jacques Rousseau, born in Geneva, Switzerland, pled for a social movement on social equity and its relationship to nature [9]. Inspired by the French Revolution, he claimed that although Man is part of nature, his ability to choose and his tendency for perfectibility differentiate him from nature (Figure 1b). In a frame of a dualistic relationship with nature, he advocated that Man should preserve his life, liberty, and property by giving up his rights to the community in a frame of a "social contract".

As Perreault [10] (p. 234) explains in his review article, a group of scientists aiming to conciliate Man and nature has suggested a unified model between hydrological and social issues. As a result, the main hydrological law, the water cycle, could be combined with social activities to become a hydro–social cycle [11,12]. Territories could also be identified as hydro–social and classified into similar groups, taking into account not only their hydrological characteristics but also their socio-economic structure. They have called this model of the Water–Man relationship *Hybridist*.

In a succession of numerous industrial revolutions that started in the early 18th century and continue with the fourth one until today, important technological advances have influenced the way humans use natural water resources and interact with nature. The dualistic relationship between Water–Man in the classic and post-classic eras, became a Man-dominated, anthropocentric interaction (Figure 2).

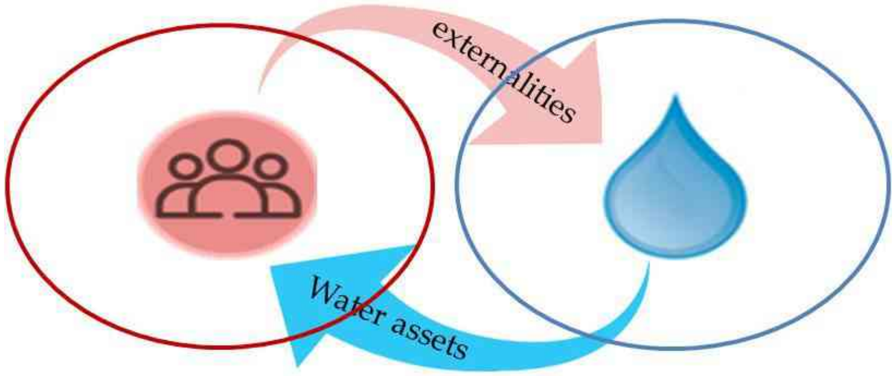


Figure 2. Anthropocentric Water–Man interaction (industrial revolutions–today).

The construction in 1935 of the Pharaonic Hoover Dam on the Colorado River in the USA is probably the main milestone of Man separated from nature as a dominator [13]. It was the highest dam in the world at that time, and it was considered a proud achievement of the engineering profession to be able to dam a big river and create, in the middle of a desert, a huge water reservoir, Lake Mead. Although the human benefits from electricity production and other water uses are important, almost a century after its construction, a lot of negative consequences have surfaced, such as erosion in the river's delta, a decline in fisheries, biodiversity loss, and negative socio-economic impacts on coastal communities [14]. These negative impacts, which economists used to call *externalities*, have been exacerbated recently by the climate crisis. A long-lasting drought has provoked huge evaporation and decreased precipitation and snowfall. At the same time, the construction of many big reservoirs has produced a feeling of water abundance and an over-allocation of the water that the river can provide. The Hoover Dam and related infrastructure of multiple reservoirs illustrate the negative environmental impacts humans can produce by exercising huge technological pressures on nature. This Anthropocentric Water–Man interaction, as shown in Figure 2, tends to maximize human benefits at the expense of nature. It is not sustainable and could become, in the longer-term, detrimental to humans.

3. The Water–Man Interaction: A Key to Improving WRM and Water Governance

The way humans interact with nature is directly connected to how they use natural water resources to fulfill their needs. In the very old times of nomadic life, when Man was dominated by nature, his main preoccupation was to survive. He lived in places near springs, lakes, and rivers. The abundance of the surrounding water prevented him from any thought about rational water use; water was available in quantity and good quality to satisfy all his needs.

In historical times, extensive agricultural activities in many parts of the world started to enhance the need for large quantities of irrigation water. The domestication of animals and the increase in population in new cities also contributed to the additional need for water supplies and marked the beginning of rational management of water resources. At that time, the first dams were constructed in the Middle East and ancient Greece, and subterranean tunnels were constructed to transport drinking water over long distances [15]. The Roman and, later on, the Byzantine aqueducts are very famous robust constructions made from a series of rounded stone arches many meters high, able to channel water using gravity over several miles. Many of these aqueducts still work today in parts of Europe, bringing water to cities. They are exceptional engineering structures that require very precise planning, especially for fixing the small inclination of the water channel on top of the edifice while traversing valleys and overcoming hills and other obstacles to convey water from its sources to the city using gravity [16]. This structural infrastructure was part of a more general planning process of WRM.

The main objective of a WRM plan is to satisfy human needs for water by providing sufficient quantities of good quality water. The planning process is then translated into a series of laws aiming to organize and regulate the use of water without producing harm to neighbors and the community. Some of the first laws regulating water are known from references to ancient Athens in Greece [17]. Around the 5th century BC, Solon, the well-known Athenian statesman and legislator, introduced specific laws aiming to guide Athenian citizens and regulate how to drill individual wells for groundwater use.

As shown in Figure 3, to preserve the rational use of water for the community, there is a continuous interaction between the way humans interact with nature for establishing WRM plans and producing, through a series of laws, a policy regulation framework. WRM and water policy regulation are two processes that belong to an overarching framework integrating them into the Socio-Political and Socio-Economic domains. The integration process can take the form that we call *Water Governance* or *Hydro-Governance* (Figure 3). Different definitions of Hydro-Governance are available in the literature, such as the one given in [18] (. . . "as a 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").

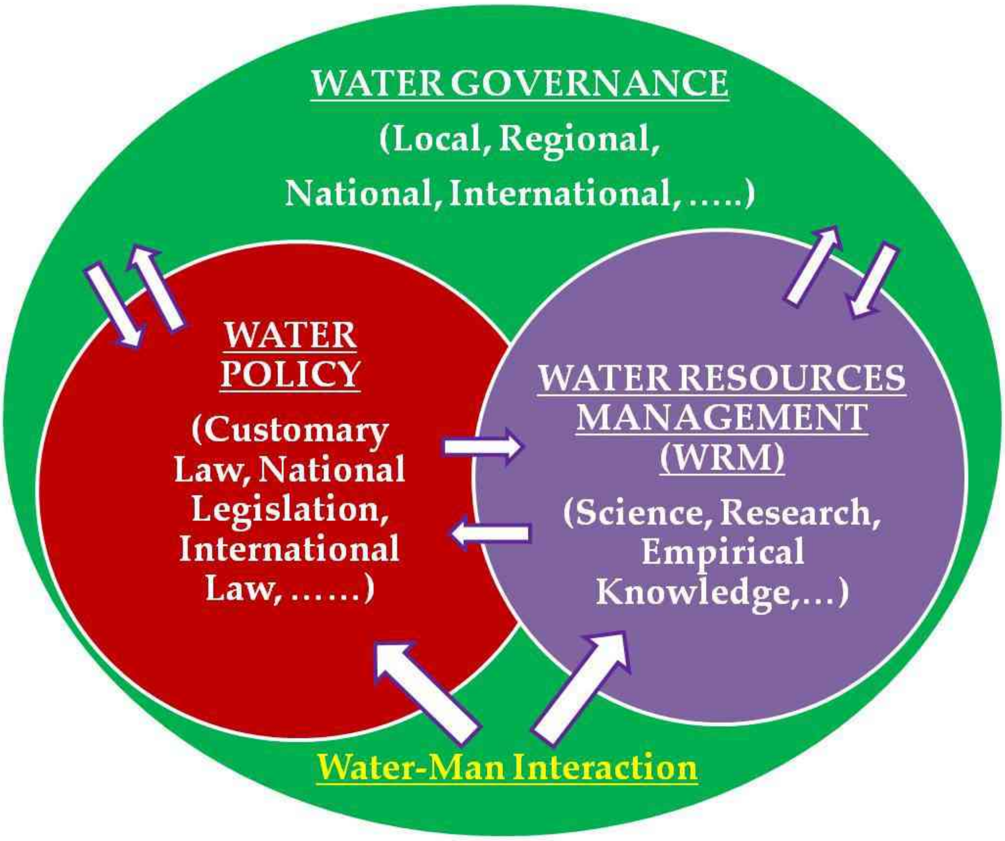


Figure 3. Impact of Water–Man interaction to WRM, Water Policy, and Water Governance.

Political decisions taken by elected officials are in strong interaction with existing WRM and Policy frameworks. That means that because of interconnections, changes in WRM and Policy models can positively or negatively affect the decision-making process and, ultimately, the Water Governance. The opposite is also true: ineffective Water Governance can deteriorate water policy and negatively impact the WRM process, with negative impacts on water use and the well-being of the society.

4. The Rise of an Integrated WRM Model (IWRM)

During the pre-historic period (up to 600 BCE), there was no need for a plan for managing various water uses. At that time, humans were nomads or living in small communities with limited organizational and technological tools. Local farming was the main socio-economic driver, and managing water was empirical, following local customs and traditions. Some exceptions, however, can be noticed about 3000 years BCE in the Mediterranean, Persian Empire, Ancient Egypt, India, and China. A type of WRM evolved during the Minoan civilization, which flourished on the island of Crete in the Aegean Sea and extended to the Peloponnese, Greek, and small Mediterranean islands close to Crete. A milestone in WRM was the conception of *pipe and open channel networks for water supply and sanitation*, as was found in the King Palaces of Knossos, Phaestos, Pylos, and Mycenae [19]. In those pre-historic times, a milestone example of WRM was the concept of *Canats*, a subterranean system of tunnels transporting water using gravity over several miles. It was developed in the ancient civilizations of Persia, Egypt, India, and China

During the classical period (600 BCE–600 CE) and the post-classical or pre-modern era, including the dark years of the middle ages (600–1750), Greeks and Romans and later on, the Byzantines and the Islamic world accomplished new advances in WRM. In ancient Egypt, Mesopotamia, and China, the invention of the Archimedean screw and the Noria Wheel boosted the extension of irrigated fields for food production. The first water regulation laws were also developed, such as in ancient Athens for drilling wells in an urban environment and Roman and Byzantine regulations on water rights. The WRM model at these times was based on limited technical infrastructure, the main preoccupation being technical safety.

During the era of the first and second industrial revolutions (1750–1950), the exponential growth of science and technology had a strong impact on the WRM model. This period was marked by huge progress in the engineering profession, both in industrial and environmental activities. Due to the abundance of natural resources and cheap labor, together with the use of new sources of energy (petroleum, electricity), and many industrial inventions, new technological achievements were realized during that period.

During that period, the WRM process was considered mainly a technical activity, aiming to maximize economic efficiency. For planning, it was guided by scientific disciplines, such as hydraulics, hydrogeology, and water engineering. In developed countries, the need for large amounts of energy and water resulted in extensive technical water infrastructure. Engineers demonstrated their ability to dam big rivers with massive concrete structures, modify patterns of river beds for navigation, reclaim swamps for agriculture, and cover water streams in cities to facilitate urban circulation. Big dams were erected for multiple purposes, such as hydropower generation, water supply to newly populated cities, and flood protection of downstream plain-land. New agricultural activities consumed huge quantities of irrigation water, and water was necessary for the massive production of new industrial products.

By the end of the second industrial revolution, the WRM model became technocratic and anthropocentric, following the Water–Man interaction shown in Figure 2. It was water supply-oriented to satisfy growing water demand and state-centered to provide services at low cost. The main objectives of technical safety and economic efficiency were guaranteed by centralized technical services supervised by the state administration. A few decades after its implementation, the data showed that this technocratic WRM model had created severe environmental impacts, usually reported as externalities.

Two decades after the Second World War, amid a substantive improvement in the quality of life in Europe and North America, mainly due to technological progress, multiple concerns about the negative impacts of industrial and agricultural activities on the public health, air, and water pollution and the state of our planet, such as depletion of the ozone layer began to be raised. UN-related institutions, NGOs, scientists, researchers, and environmentalists pled for the inclusion of environmental and ecological issues in the WRM model. A milestone event focusing on environmental issues in WRM activities is the UN Stockholm declaration, stating that preserving a healthy environment for all is a public obligation.

A further step to reduce externalities from WRM practices was the introduction of the notion of sustainability in humanity's socio-economic development. In the year 2000, the

UN Rio summit and the World Water Forum held in The Hague agreed to issue declarations that underline the necessity to introduce the notion of sustainability into the socio-economic development of our human societies.

Although the definition of sustainability is not precise, in simple words, our society should provide good economic, environmental, and social services to all citizens, not only for the current generation but also for future generations to come. For the structure of the WRM model, this can be translated as the need to ensure water security by taking into account not only technical, economic, and ecological considerations but also by adding issues of social equity.

The sustainable WRM model became the Integrated WRM (IWRM) paradigm, shown in Figure 4. IWRM follows a systemic approach by taking into account not only surface water but also groundwater, soil properties, vegetation, and land use. Various activities that use water, the most important socio-economic sectors that could be included in the model, such as energy, tourism, industry, and transportation, are not enumerated expressibly.

The model's description has been presented in a series of technical papers by the Global Water Partnership (GWP) [20,21], an NGO located in Stockholm and connected to the UN and the World Bank. The IWRM is considered the state-of-the-art WRM model and is promoted by several UN-affiliated organizations, such as UNESCO, GEF, UNEP, UNDP, and the UN-ECE.

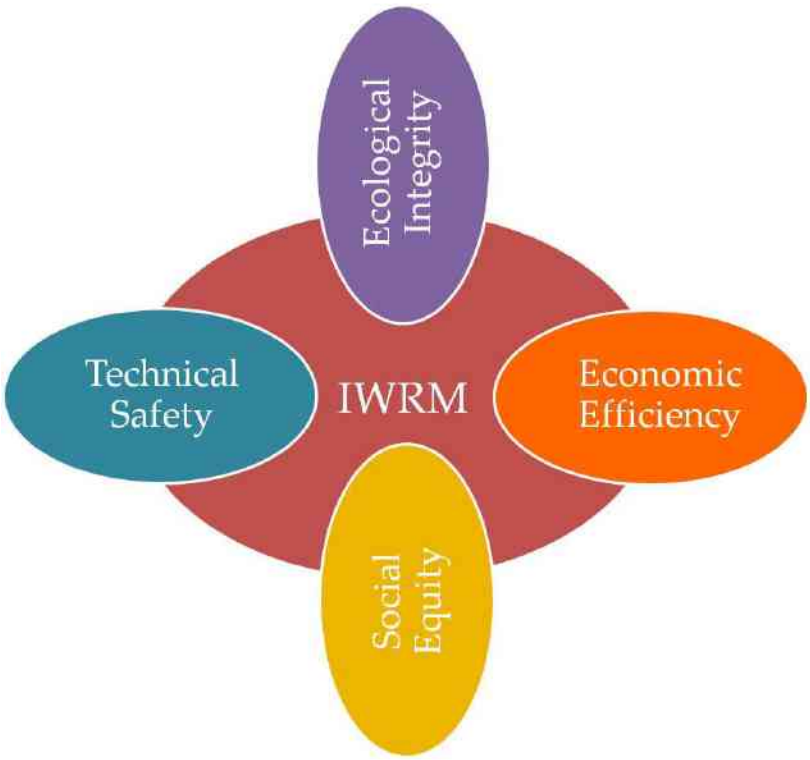


Figure 4. Main components and objectives of the IWRM model (2000–present).

5. Policy Limitations of the IWRM Model

The IWRM is a water-centered model of WRM that aims to take advantage of potential synergies by assembling under one water management system other natural resources and socio-economic sectors in close interaction with water. The main idea is to overcome problems of bad services and unsustainable use of natural resources due to traditional sectoral approaches. More precisely, IWRM targets all kinds of water, such as surface, groundwater, and transitional waters, water quantity and quality issues, other natural resources in close connection to water, such as soil and vegetation, and multiple water-related socio-economic sectors, such as agriculture and energy. Considering the multi-disciplinary expertise necessary to deal with an integrated approach, IWRM also calls for the contribution of different disciplines, such as engineering, economics, social sciences, research institutions, and various stakeholders. Ultimately, the IWRM model aims to take into account various water-related environmental impacts, such as chemical, biological, and ecological [20,21].

This theoretically very attractive holistic approach of WRM has been revealed in practice to be complicated and difficult to implement for different reasons. First, the term "integration" in the model remains vague, without guidance on the main issues to integrate and how water-related economic sectors are taken into account in the integration process. Secondly, there is no available theory linking different socio-economic sectors and how to allocate the necessary water resources to them. Finally, the institutional support for implementing the IWRM model in policy and governance is lacking, not only in developing countries but also in the Western world. Governments operate by distributing responsibilities to specific ministries that correspond to traditional economic sectors, such as the Ministry of Agriculture, Environment, and Energy. Institutional coordination of different sectors has proven to be very difficult in practice and attempts to create super-ministries, integrating different sectors, have proven to be a management disaster in practice.

The basic idea and various components of the IWRM model were outlined in Europe in a policy document called the 2000/60 Water Framework Directive (WFD) [22]. The application of this directive is compulsory for all Member States with the main aim of preserving a "good" environmental state of all European waters. After many years of negotiations and consultations between the European Commission, the European Parliament, different professional lobbies in Brussels, environmentalists, NGOs, universities, and research institutions, the WFD was adopted by the European Parliament and the European Council on 23 October 2020. Its main components are the following:

1. Water management planning should take place in River Basin Districts by specific River Basin District Authorities (RBDAs);
2. National monitoring systems and databases of water bodies should be developed to collect the time-variable characteristics of water quantity, quality, and ecological status;
3. The RBDAs should establish River Basin Management Plans (RBMPs) to be revised every 6 years and implement Programs of Measures (PoMs) in case of environmental degradation;
4. Economic considerations on water pricing and water services should be based on the cost-recovery and the polluter-pay principles;
5. RBMPs and PoMs should be extensively discussed and revised in multiple Public Consultations.

In the year 2019, the EU Commission organized a Fitness for Purpose Assessment of the EU/WFD. The main goal was to evaluate the degree of achievement of different criteria such as effectiveness, efficiency, coherence, relevance, and the EU added value of the WFD. Almost 20 years after its implementation, this assessment has given mixed results that vary in the EU from country to country [23].

According to the directive, the objective of achieving a "good" state of all European waters had to be reached by 2015, with the possibility of relying on exemptions. The Commission's assessment report in 2019 showed that no substantial improvement of water bodies in terms of their overall status could be demonstrated. A significant portion of Europe's water bodies has not yet met the good status objectives laid down in the WFD. For surface water bodies, the WFD's objectives have only been achieved for 40% for ecological status and 38% for chemical status. The situation is better for groundwater; about 84% of groundwater bodies (representing 74% of the total groundwater body area) have good groundwater chemical status, while 92% of groundwater bodies (representing 89% of the total groundwater body area) have a good status. In Greece, where agricultural activities are dominant, 80% of the lakes and 30% of the rivers fail to obtain a "good" ecological status.

Many different reasons are cited in the assessment report to explain why the EU/WFD 60/2000 has only partially achieved its goals. The main reason was the failure to incorporate into the directive the environmental objectives of other socio-economic sectors, mainly those of agricultural activities. In Europe, and especially in the Mediterranean, agriculture not only overuses water but also creates intensive diffuse pollution from pesticides and fertilizers. Other reported issues that explain that unfortunate situation are water governance, the lack of adequate funding, the delay caused by intensive external consultation, and the lack of efficient sectoral coordination.

In our opinion, the reasons for not obtaining the directive's targets completely during its implementation are more radical and connected to the conceptual structure of the IWRM model. A detailed list of different explanations and drawbacks of the directive is given in [13] (pp. 11–12). These can be summarized as follows:

(1) The Water–Man relationship

For developing the RBMPs, the main activity prescribed in the directive is *technical*. It is based on the DPSIR (Driving Forces-Pressures-State-Impact-Responses) process as a tool to evaluate:

(a) environmental Pressures on water bodies derived from specific Driving forces (socio-economic activities);

(b) from different Pressures, the State of the water-related environment is obtained by use of specific indicators;

(c) negative environmental Impacts are analyzed, and water bodies are classified accordingly;

(d) as a Response to previous threats, a Program of Measures (PoMs) is applied to remediate negative environmental consequences.

This process is *anthropocentric*, because Man, as shown in Figure 2, is supposedly capable of regulating nature by taking up *natural and ecological assets* and rejecting *externalities* to nature. In the Anthropocene period we experience, data has shown that human demand for environmental assets exceeds the available environmental supply (impact inequality) [24].

(2) The assumption of reversibility in the PoMs

In the directive, it is expected that the PoMs can face human interventions by increasing the water resilience up to the point that we can recover the environmental state before the application of different human-related pressures. This implies that we assume a linear and reversible cause–effect relationship. However, in the Anthropocene, the negative global impacts from human activities (externalities) are so large that, in many cases, we are reaching our planetary limits, where reversibility is not valid anymore [25].

(3) Conflicts between social actors and natural laws are neglected

The technocratic character of the DPSIR process restrains social activities only marginally, as a reference to socio-economic drivers and as a possible part of the PoMs (social measures). The main goal of the IWRM policy is to resolve the conflicts between the social actors and nature.

(4) Stakeholders' participation is procedural

Although information and stakeholder participation is extensive, it is more procedural than substantial because social partners are involved in the decision-making process only a posteriori.

For these reasons, we may conclude that to improve the IWRM conceptual model in policy, we should reinforce the role of social partners and consider how to remediate conflicts between their social activities and the natural laws. We may call this new approach Eristico-dialectical because it combines the eristic character of conflicts (*eristic* meaning *conflictual*) with its dialectical resolution (*dialectical* meaning *reaching the truth by exchanging arguments*).

6. Resolving Conflicts between Humans and Nature: The Eristic-Dialectical Model

From the previous historical versions of the WRM throughout different eras of various socio-economic conditions, we can learn that the relationship between Water and Man is in constant evolution. It depends on the power balance between humans and nature and is also crucial for impacting not only the structure of the WRM model but also Water Policy and Governance (Figure 3).

The Water–Man relationship started by being nature-dominating (Naturalistic) during the pre-historic era of humanity (Figure 1a). It became Dualistic, i.e., partially connecting Man to Nature during historical and pre-modern times (Figure 1b). This interaction started to become Man-dominating during the successive ages of industrial revolutions (Figure 3) and remains anthropocentric and technocratic in the state-of-the-art IWRM model. The main drawback of the anthropocentric relationship is that it generates negative environmental impacts or externalities that, in the Anthropocene period, have become excessive.

To reduce environmental pressures and limit externalities to acceptable levels, we should think about how to redefine the Nature–Man relationship. The solution is not to go back to older models of dualistic or naturalistic relationships but to articulate a conceptual relationship based on the following criteria:

(a) Preserve the individual characteristics and future aspirations of Man and nature;
(b) Provide a fair distribution of power between Man and nature;
(c) Consider conflicts and cooperation between Man and nature in a unifying framework of mutual respect and understanding.

Concerning the first and the second criteria, it is clear that we should exclude naturalistic and anthropocentric relationships because both try to dominate the other party by exercising adversarial pressures. To satisfy the third criterion, we may observe that during all periods in the past and independently from the balance of power between the two parties, two opposite attitudes between Man and nature coexist: fighting and cooperating, being friendly and adversarial, identical and different. We may call this relationship *Eristic-Dialectical* by explaining the following:

Eristic is a derivative of the Greek word "eris", which means "discord", "strife," or "fight". In ancient Greece, "*Eris*" was the Goddess of discord, whom the Romans have called "*Discordia*". In our proposal, eristic is defined as a methodology for analyzing contradictory arguments based on conflicting interests. The eristic method was used in the past by "sophists" to create logical "puzzles without reaching a conclusion or solving a particular issue" [26].

Dialectic is rooted in the idea first coined by Socrates, the father of Greek philosophy, who showed in the famous Plato dialogues that contradiction can be resolved by exchanging arguments between opposing ends [27]. The idea that a new entity is made up of opposites is attributed to Heraclitus, an ancient Greek Ionian philosopher of the 5th century BCE. The unity of the opposites is exactly his *dialectical model of nature*, claiming that new entities are generated by contrary properties. *Heraclitean dialectics* as a contradiction between ideas were adopted in the 19th century by the German philosopher Hegel [28] and served to produce the theory of the *dialectical materialism* by Karl Marx and Friedrich Engels [28]

The Eristic-Dialectical process makes three assumptions:

- Change in nature and humans is constant and inevitable;
- Water and Man are distinctive and interconnected;
- Opposites can be unified to get a harmonic symbiosis closer to the truth.

This kind of Water–Man relationship is shown in Figure 5:

- The *Eristic component* at the center originated from conflicts between the socio-economic interests of humans and the natural/hydrological laws that control the environmental processes on our planet;
- The *Dialectical unification* of the two parties can be achieved by resolving the conflicts through the unification of the opposites (human interests against natural laws). This is not a compromise between adverse interests but the union of opposite issues that can generate sustainability and the best harmony between the two.

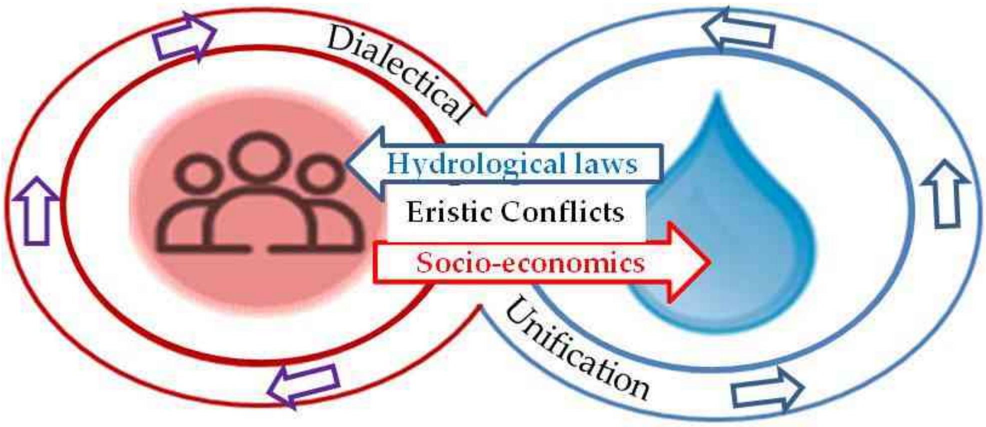


Figure 5. The Eristic-Dialectical interaction of Water and Man: separated and united.

The Eristic-Dialectical relationship between Water and Man can be implemented in practice as a complement to the existing IWRM model. As it is indicated in [13], after:

- *setting the scene* by detecting all surface and groundwater bodies at the watershed scale;
- *performing the DPSIR* process for determining the physical, chemical, and ecological state of the water bodies;
- The development of RBMPs and PoMs should involve a social component for resolving conflicts between stakeholders and natural laws.

The conflict resolution process, as shown in Figure 6, could add environmental equity as a necessary condition to obtain integrated sustainability. In the paper [13] (pp. 18–20), two case studies, one on flood protection and another on agricultural irrigation, illustrate the new process.

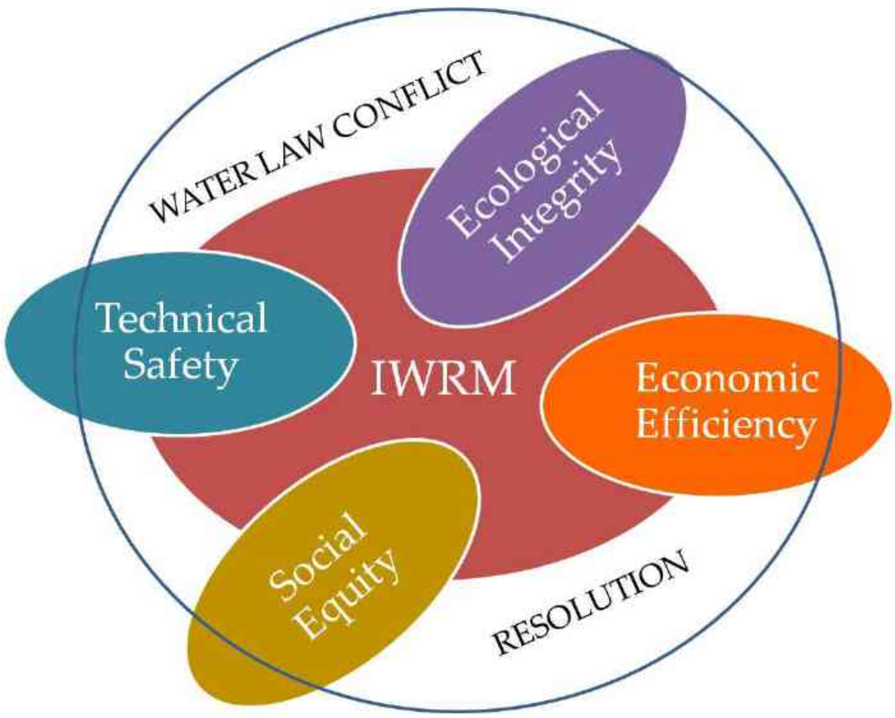
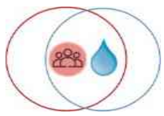
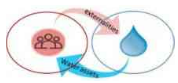
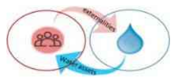
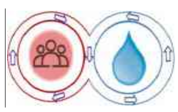


Figure 6. The Eristic-Dialectical model: adding conflict resolution to IWRM.

7. Discussion

Table 1 resumes the timeline of the Water–Man relationship from ancient times until the present. It also indicates the evolution of social and economic characteristics, the water-related milestones, and the Water–Man relationship changes. We can also observe that the WRM scientific paradigm and the Water Policy models are under constant evolution.

Table 1. Timeline of Water–Man interaction, and IWRM, and Water Policy models.

Period	Social Characteristics	Global Development	Milestones	Water–Man Interaction	WRM Scientific Paradigm	WRM Policy Model
to 600 BCE Pre-historical	Nomadic Life Small Human Communities	Farming	3000 BCE -Qanats in Persia -Minoan Hydraulic Structures	 Naturalistic	Traditional Empirical	Customary Local Domestic Law
600 BCE–600 CE Classical-Historical period	Empires: Persia Greek World Roman India, China	-Agriculture -Sciences -Laws -Policy	-Archimedean Screw Pump -Noria Wheel	 Dualistic		Laws for Drilling Wells. Water Supply in Ancient Athens
600 CE–1750 CE Post-Classical and Pre-Modern	Empires: China Byzantine Ottoman Islamic	First Hydraulic Works	Roman and Byzantine Aqueducts			Policy for Urban Water Supply
1750–1950 Modern Times	First and Second Industrial Revolution	Technico-Economical Technological	1935 Hoover Dam USA	 Anthropo-Centric		Hydraulic Engineering Technical, Water Infrastructure Rules
1950–2000 Pre-Contemporary	Global Economy	Ecological Environmental Externalities	1972 UN Stockholm Declaration			Technico-Economic Cost Recovery Enviro-Impact Assessment
2000–today Contemporary	Post Global Economy	Sustainable Social Equity	2000 -Rio Summit -World Water Forum The Hague	 Anthropo-Centric		Holistic-Integrated IWRM EU/WFD WEF Nexus
>2022 Suggested	Post Global Economy	Sustainable Environmental Equity	Climate Change Huge Externalities	 Dialectical		Conflict Resolution Eristic-Dialectical Model

Our first conclusion is that nature and Man are in constant change, which is in line with the Heraclitean dialectics. We can also observe that the relationship between Water and Man is the catalyst for formulating adequate WRM and Water Policy models. Ultimately, as shown in Figure 3, this can influence Water Management and the Decision-Making Process.

In Table 1, we can also notice that after a strong socio-economic development as a result of the first and second industrial revolutions, the change in the Water–Man interaction from dualistic to anthropocentric produced huge negative environmental impacts, known as externalities. These include climate change, groundwater nitrification, ocean acidification, ozone depletion, land degradation, and loss of biodiversity. In some of these issues, we have already reached or are heading to the planetary limits, which are the boundaries within which humans can continue to develop.

The anthropocentric and technological-dominated Water–Man relationship is still included in the state-of-the-art WRM and Water Policy models that follow the IWRM process. Therefore, to reduce externalities and obtain sustainability, a radical intervention is needed. In this paper, we propose to adopt the Eristic-Dialectical model as complementary to the IWRM model. The new model is based on a social component of the water management process by analyzing conflicts between stakeholders and natural/hydrological laws (eristic analysis), followed by a conflict resolution (dialectical exchange of arguments).

The suggested Eristic-Dialectical model enhances new activities of social character at the community level and may achieve collectively complementary results reinforcing water resilience, water security, and environmental sustainability. By analyzing conflicts between water users and natural laws, stakeholders are intensely involved in the decision-making of the water management process. For example, in the traditional IWRM approach, the development of RBMPs and the PoMs are the responsibility of water managers and technical experts, with limited and only a posteriori interaction with local elected authorities and water stakeholders.

In the new model, stakeholders are involved in the management process from the beginning. They participate in establishing a *Joint Action Plan* (JAP) and can influence the development and implementation of the RBMPs. Furthermore, by agreeing to resolve potential conflicts between their water practices and the natural laws, sustainable nature-based solutions can be achieved.

8. Conclusions

Recent advances in the field of WRM and Water Policy recommend the state-of-the-art IWRM as a tool for "good" Water Governance. A critical review of the model and a historical investigation of its timeline evolution have indicated that IWRM is the continuation of a Man-dominated behavior against nature. This technocratic model has created huge externalities, which can only be reduced by involving the water stakeholders in the WRM process. We suggest increasing the role of the social component by adopting an Eristic-Dialectical model of conflict resolution between stakeholders' conflicting interests and the natural laws.

The main advantages of the new model can be summarized as follows:

- Active involvement of water users in the planning of RBMPs and the implementation of PoMs;
- Change of human water-related behavior to comply with natural laws;
- The Nature–Human relationship changes from Anthropocentric (Figure 2) to Eristic-Dialectical (Figure 5);
- Water–Human interactions are now in both directions (Figure 2) rather than as "externalities" (Figure 5);
- The new Human–Water relationship is now, at the same time, separating and unifying, antagonistic and cooperative (Figure 5);
- Dialectical Conflict Resolution is not a compromise between socio-economic activities and the natural laws; it is based on the unification of two opposites, human adversarial behavior and natural/hydrological/hydraulic laws;
- The final solutions for resilient water resources management do not privilege nature (nature-based solutions) but are concerned with human water-related needs as far as they are not in conflict with natural laws.

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