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The Dialectics of Nature–Human Conflicts for Sustainable Water Security

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Abstract: How humans use and manage water resources under climate change conditions threatens water security, which means risking the availability of enough good-quality water for everybody and for nature's flora and fauna. Integrated Water Resources Management is a state-of-the-art water management model. After 20 years in use, the application of this model failed to achieve its primary goal in many countries, i.e., ensuring the good ecological status of rivers, lakes, and aquifers. This paper shows that because the model is more human-centered than nature-oriented or anthropocentric, it generates severe environmental damages called "externalities." From a historical analysis of the human–nature interplay, three main results were obtained: (1) the nature–human interaction is always in a state of contradictory confrontation, being composed of two opposite human behaviors of conflict and cooperation with nature; (2) this contradiction is assumed as a general ontological principle and epistemic hypothesis, called "dialectical"; and (3) historically, in the balance of power between nature and humans, three clusters are identified: (i) naturalistic, (ii) dualistic, and (iii) anthropocentric. A theory of a novel behaviorist conflict resolution model is suggested to dialectically resolve conflicts between stakeholders and natural laws. This model provides a harmonic symbiosis of humans and nature, removes environmental externalities, and can lead to sustainable water security. Three case studies illustrate the merits of the new dialectical model in real applications.

Keywords: water management; climate change; nature–human relationship; conflict resolution; dialectics

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1. Introduction

Economic growth, human prosperity, and the environmental quality of life in modern societies greatly depend on how water resources are managed for different services and socio-economic activities, such as water supply, energy production, industry, food supply, and agriculture [1]. As a part of nature, humans rely on natural assets, such as water, air, soil, vegetation, and climate. However, humans differ from nature, following an evolutionary timeline. They use their intelligence, brains, and skills to progress through education, culture, science, and technology; in addition, they develop social, spiritual, cultural values and economic goods, such as roads, buildings, and factories. By humans, we mean human societies composed of multiple stakeholders with different conflicting socio-economic interests. In the human endeavor for a better life that has persisted through ups and downs across the successive ages of human evolution, water is not only vital for human and ecosystem subsistence and for maintaining the fauna and flora on our planet [2]; it is also a raw material for all economic activities, mainly those in agriculture, industry, tourism, and energy production. In fact, agriculture uses large quantities of water for irrigation, and water is an essential element for industry, tourism, and energy generation [1].

In contrast to saltwater in seas and oceans, which represents about 97% of the total water on Earth, only 3% is freshwater available in rivers, lakes, aquifers and in a solid state in polar glaciers [3]. Freshwater resources are limited and non-uniformly distributed on the Earth's surface, constantly moving through the global water cycle. Therefore, how countries allocate their natural water resources to various socio-economic sectors, and how these sectors manage water, is crucial to achieving economic growth and the United Nations' Sustainable Development Goals (UN-SDGs) [1]. Climate change has recently induced unprecedented natural disasters, such as heat waves, forest fires, floods, and droughts [4], challenging the way water resources are managed. Since the Second Industrial Revolution in the late 19th century, the atmospheric concentration of greenhouse gases has continuously increased. Greenhouse gases have induced a constant rise in temperature and created atmospheric instabilities, the source of random precipitation patterns. Intense rainfall has been observed in small-scale areas, creating catastrophic floods, although mega-drought conditions have impacted neighboring river catchments. Warmer marine waters in the oceans and the Mediterranean Sea initiate more intense and frequent hurricanes with catastrophic negative impacts on human infrastructure and even the loss of lives [5]. Therefore, developing an effective Water Resources Management (WRM) model in the context of climate change has become a priority for improving water governance and achieving sustainable water security. In this paper, the term model is used in the sense of a paradigm, a framework, or a process that can take different forms, like descriptive, conceptual, numerical, or mathematical.

Although the idea of an Integrated Water Resources Management (IWRM) model [6] goes back centuries, a milestone in WRM's conceptual evolution toward a systems approach was the United Nations Water Conference, Mar del Plata, 14–25 March 1977 [7]. The IWRM model is theoretically very attractive but complicated and very challenging to implement. It served as a general scientific framework for the European Union's (EU) policy on WRM [8]. In 2019, almost 20 years after its implementation in Europe, the EU Commission organized a general evaluation procedure concerning the fitting of the EU Water Framework Directive (EU-WFD) 60/2000, i.e., its relevance, coherence, effectiveness, efficiency, and added European value. The evaluation result was unsatisfactory as more than half of the European water bodies failed to reach good ecological status [9].

The EU Commission argued that the failure to achieve the primary purpose of the Directive was due to insufficient investments for its implementation and lack of integration of water management into other policies, mainly with respect to agriculture, chemical pollution, and administrative issues. However, similar unsatisfactory results obtained by all member states with different socio-economic characteristics, such as gross domestic product (GDP) per capita, administrative structure, and water governance, indicate more radical reasons for the Directive's failure to fulfill its purpose. This is more understandable if we consider the integration of water into agricultural policy. Farmers should manage the Water–Energy–Food Nexus (WEFN), a particular form of the IWRM model for food production. Farmers overuse water and energy because they aim to maximize food, which represents their revenue. Pumping large amounts of groundwater depletes aquifers and consumes excessive energy. The overuse of fertilizers and pesticides also increases food production, creating eutrophication and diffuse chemical pollution.

More generally, when stakeholders in the IWRM framework make human interests the primary target (anthropocentric behavior), they act against nature (with no respect for natural laws). The relationship between humans and nature lies at the center of previous attempts to investigate how the IWRM framework can improve global and urban water security [10–12]. This paper provides theoretical support and methodological guidance for practical WRM applications. It is shown in this paper that historical data indicate that the nature–human interplay has always been a dialectical confrontation. Dialectics means [13] the internal contradiction of exchanging logical arguments using counterarguments. In this paper, nature is represented by natural laws, and the nature–human relationship is represented by the coexistence of two opposite human behaviors against nature, i.e., conflict and cooperation. Depending on the balance of power between human capacity and nature's environmental state in different historical periods, three clusters, *naturalistic*, *dualistic*, and *anthropocentric*, are identified. A breakthrough in the human attitude against nature started after the Second Industrial Revolution, when scientific and technical achievements made humans believe they could dominate and modify nature to maximize socio-economic benefits [14]. This human attitude of feeling superior to nature is reflected in the IWRM model's conceptual structure and is the main reason for producing substantial adverse environmental impacts that economists call "externalities" [15].

The suggested new IWRM behaviorist model aims to reduce and exclude, if possible, environmental externalities. By definition, externalities arise because the natural world is separate from human activities and is considered to evolve as a different entity external to human society. The novelty of the model lies in the dialectical concept of the nature–human relationship, the analytical formulation of water–human interaction, and the description of particular steps in practice for a conflict resolution between human activities and natural laws. In the following chapters, this theory is supported by references to historical data, observations, and analytical interpretations. The scientific approach is reinforced using philosophical arguments explaining that the data are independent from religious or supernatural beliefs.

The theory can be summarized as follows:

I. Nature:

- (I.1) Nature comprises our planet's physical substances and biological organisms, such as soil, air, water, climate, flora, and fauna. Nature is, by definition, everything non-human.
- (I.2) Using scientific data from rock radiometry and fossil observations, the evolutionary timeline of our planet's different physical and biological characteristics since pre-historical times is re-constructed with a certain precision.

II. Humans:

- (II.1) Although connected to nature, humans have developed a human world. Human societies have invented spiritual and cultural values and created additional economic goods using the human brain, intelligence, and skills through education, science, and technology.
- (II.2) Historical data, written documentation, and archeological research can provide information on the time evolution of humans and their cultural and civilization achievements.

III. The doctrine of flux:

- (III.1) Nature and humans on Earth are in constant evolution. In the next chapters, this theoretical principle of eternal flux is supported by philosophical arguments and by scientific observations as well.
- (III.2) Changes in nature and humans are made by strife. Progress is a consequence of repeated contradictions.

IV. Nature–human interaction:

- (IV.1) Nature and humans on Earth constantly evolve, following the doctrine of flux. In the following chapters, philosophical arguments and scientific observations support this theoretical principle of eternal flux.
- (IV.2) The nature–human interplay is characterized by a balance between natural forces and human socio-economic development. Historically, it has evolved into three clusters: naturalistic, dualistic, and anthropocentric.
- (IV.3) The relationship between nature and humans is dialectical, i.e., it is defined by the coexistence of two contraries: conflict and cooperation. The nature–human dialectical interaction is an *ontological principle* and an *epistemic hypothesis*.
- (IV.4) Harmony between nature and humans is obtained by unifying these opposites.

To formulate a dialectical WRM model, stakeholders' behaviors and their activities are analyzed and dialectically harmonized with natural laws through a conflict resolution approach. The various steps of the new model describe how tuning opposite (conflict and cooperation) externalities can be avoided to ensure sustainable human growth and environmental security.

2. Materials and Methods

The Earth has constantly evolved since approximately 4.5 billion years after its formation [16]. The continents are slowly but permanently drifting apart, volcanoes frequently erupt, and the climate has experienced several changes as it constantly evolves. It has moved periodically from warmer to cooler periods, including the formation and melting of glaciers in different long-lasting periods. The history of all these changes describes the timeline of nature's evolution. The chemical and biological characteristics of flora and fauna left their footprint in fossil deposits in rock formations. Geological strata of variable compositions, thicknesses, and depths correspond to different times which, depending on their duration, paleontologists and geologists call ages, epochs, periods, eras, and eons. Around 6 million years ago, the human species first appeared in Africa and continuously left signs of interacting with nature in various geological formations [17]. The timeline of the human footprint provides data showing the interaction between natural conditions and human socio-economic development. In this complicated historical journey, it is of particular interest to analyze the role of water and its use by humans to survive and develop different socio-economic activities.

An analysis of historical data indicates that the coexistence of two opposites, i.e., fighting and friendship, is the basis of the water–human relationship. It is interesting to note here that the coexistence of conflict and cooperation is also the case in the transboundary water resources hydro-hegemony literature. However, no convincing explanation is reported for this apparent contradiction [18]. In the timeline variation of the two opposites, their relationship fails to be harmonious when one prevails, and negative impacts may occur either on the nature or the human side.

The water–human coexistence of contradictory conflict and cooperation is defined in this paper as *dialectical*. This definition implies a relationship between two opposites with the potential to overcome their differences via a logical, synthetic methodology. The dialectical interplay between humans and water is variable over time, and its dialectical nature is described here as an *ontological* principle and also *epistemological* hypothesis. A dialectical conflict resolution model is suggested based on the exchange of contradictory arguments, leading to the union of the opposites, i.e., between human activities and natural laws. From a historical review, valuable lessons are drawn on improving the IWRM model in our times of climate change and reducing significantly negative environmental impacts.

Historical Analysis of Water–Human Interaction

For many reasons, water quantity and quality are very useful environmental indicators for characterizing the relationship between nature and humans. First, enough water of good quality is essential for human survival and all life forms on Earth. Second, as a primary driver of agricultural irrigation, water is essential for food production. Third, water constitutes a raw material for all socio-economic activities, such as energy production and tourism. Fourth, water and sanitation play significant roles in enhancing public health and quality of life. Fifth, as a negative indicator, an excess or lack of water may cause natural disasters such as floods and droughts [19].

Climate variability on Earth generated a time series of atmospheric temperatures in different geological epochs. Data on oxygen isotopes in Greenlandic ice cores [20] indicate the Earth's climate changes. As shown in Figure 1, ~800 kyr ago, over the late Pleistocene, also called the Ice Period, the climate varied in ~100-kyr glacial cycles [21]. In the interglacial Eemian period, humans benefited from relatively warmer temperatures [22]. During that period, migratory movements from Africa to Australia and from South Asia to Europe are reported [23] (Figure 1).

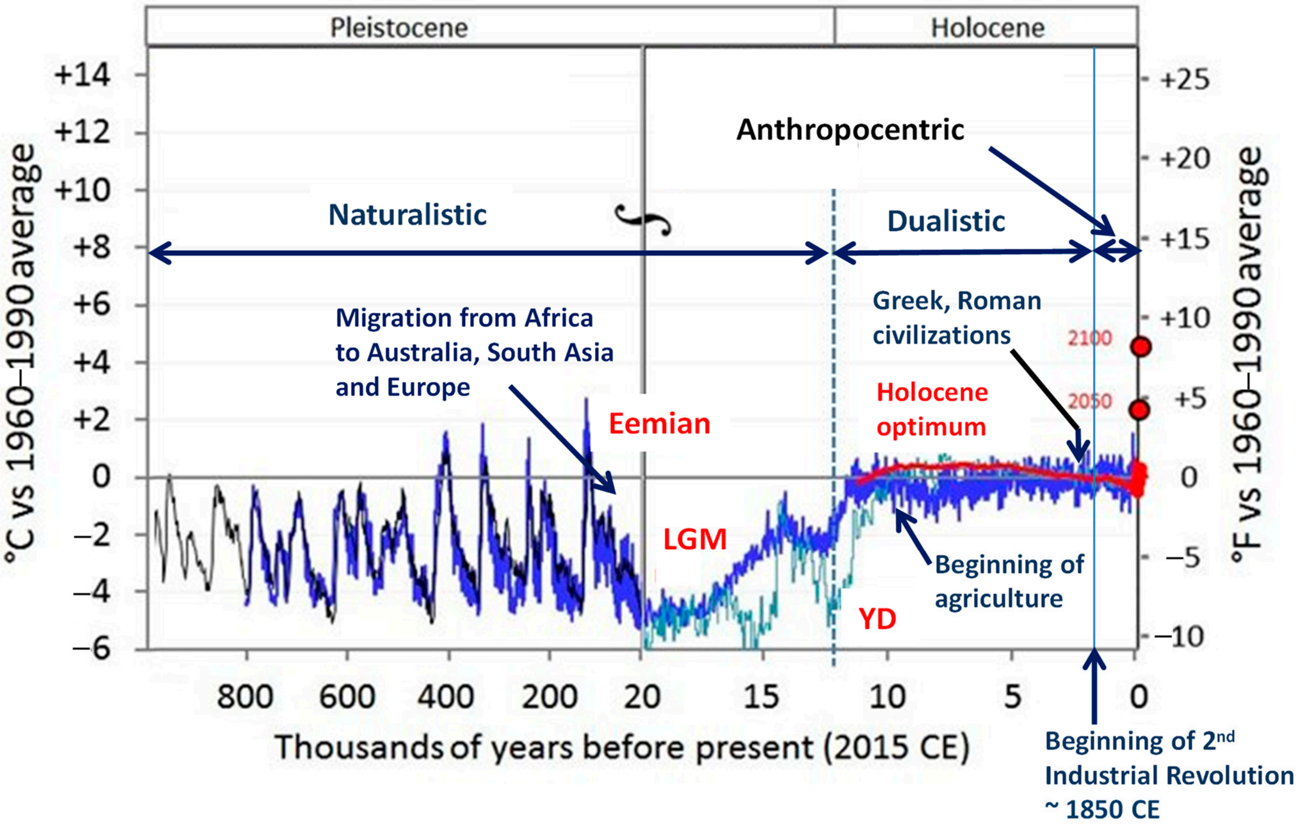

Figure 1. Naturehuman interplay since ~800 kyr ago, modified from [22].

After the Eemian period, we entered the Latest Glacial Maximum (LGM), with almost low temperatures attributed to possible changes in the orbital parameters of our planet. We can observe a significant rise in temperature by the end of the LGM in the so-called Younger Dryas (YD) period. It happened approximately 12 kyr ago, before an almost steady temperature favorable to human activities was reached (Holocene optimum). In the Pleistocene, the fight for survival against wild animals and adverse natural conditions was a priority for humans. While water use was empirical without any technical support, humans, as a part of nature, contemplated the forces of nature in the form of natural disasters, such as floods and volcanic eruptions. Settled in caves and places offering natural protection, humans were dominated by nature.

The Aborigine population in Australia and primitive populations in Africa, Eurasia, and South and North America used to live as nomad hunters, looking for security in caves or precarious homes [24]. Without advanced technical equipment, they used water for survival, fighting against natural forces, hostile animals, and natural disasters. Natural phenomena like the sun's light and the moon's variations were signs of supernatural entities and even gods [25]. Rivers and streams had divine characteristics; the same was true for volcanoes. A volcanic eruption or a catastrophic flood was God's punishment.

About 3000 years ago, the Holocene's optimum temperatures created natural conditions favorable to human socio-economic development. It first happened in regions with abundant water resources, big rivers, and fertile plains. The first human civilizations developed extended agricultural activities in fertile valleys of big rivers, like the Nile in Egypt, the Tigris and Euphrates in Mesopotamia, the Indus River in India, and the Yellow River in China [26].

Humans created the first significant urban centers and human agglomerations around 2000 years ago in the same river catchments. From open irrigation channels archeologists discovered in Mesopotamia to water supply and sanitation networks found in Knossos, Crete Island, we know that ancient civilizations like the Minoan, Egyptian, and Persian civilizations developed essential hydraulic equipment during the late second Millennium. These include norias, hydraulic machinery in ancient Syria used to transport water for irrigation to higher altitudes, and qanats [27], subterranean tunnels used to collect and transport groundwater over long distances for irrigation and water supply.

In the classical era from 600 BCE to 500 CE, the Greeks and Romans further improved different types of hydraulic infrastructure, like the Roman aqueducts for water transportation in cities [28] and the Archimedes screw pump that is used even today for elevating more than water, such as wastewater containing solid material in sewage treatment plants, to higher altitudes. Progress in hydraulics and water management was notable in ancient empires like the Byzantine, Indian, and Chinese empires. Water storage in the form of huge reservoirs of drinking water for big cities, like the Basilica Cistern in Constantinople, the Chant Bahori in India, and the complex scheme of irrigation channels in the Yellow River, China, is well known. However, during that period and in the Middle Ages and the Early Modern Era (500–1750) CE, the WRM paradigm remained primarily empirical. Spiritual and religious concepts dominated water policy at the beginning of Greek and Roman customary law [29].

Signs of change in the human–nature interplay started with the First Industrial Revolution (1750–1870) and have accelerated since 1870, after the Second Industrial Revolution. As shown in Figure 2, since that date, the atmosphere has been exponentially filled with CO_2 emissions from the large-scale industrial use of fossil materials like gas, oil, and coal for energy generation [30]. During the same period, the consumption of water resources impressively increased, especially for food production in agriculture [31] (Figure 3).

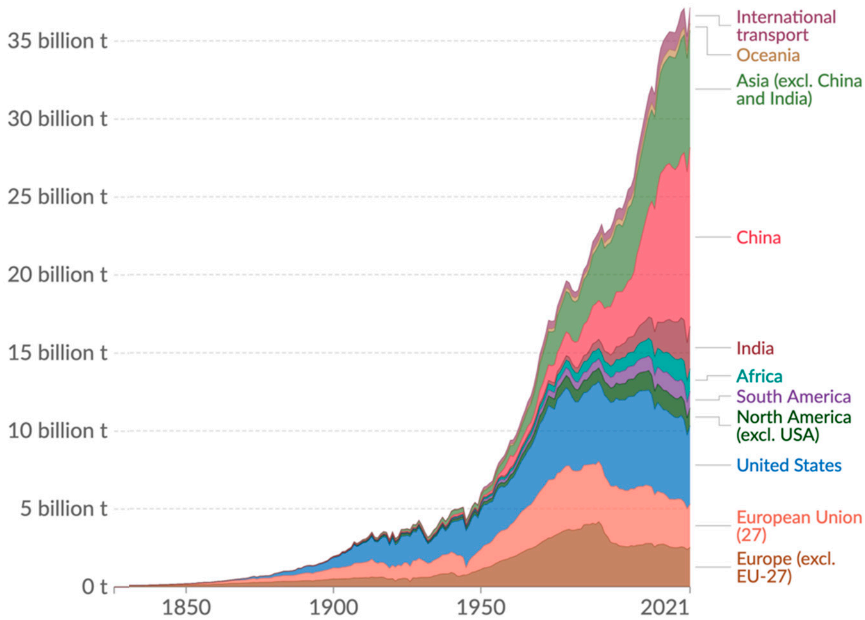

Figure 2. CO_2 emissions by countries, modified from [30].

The Industrial Revolution is also a landmark of the so-called greenhouse effect of climate change on Earth. As shown in Figure 4, this phenomenon causes a continuous rise in global temperature known as global warming (GW) [32]. In terms of the mean temperature variation over a certain period, GW happens at different scales, such as Early, Medium, and Advanced scales (Figure 4). For these time scales, as for the previous Pleistocene and Holocene Epochs, a correlation exists between natural climate conditions and human behavior against nature. We may deduce three main clusters of this interaction and different types of WRM models.

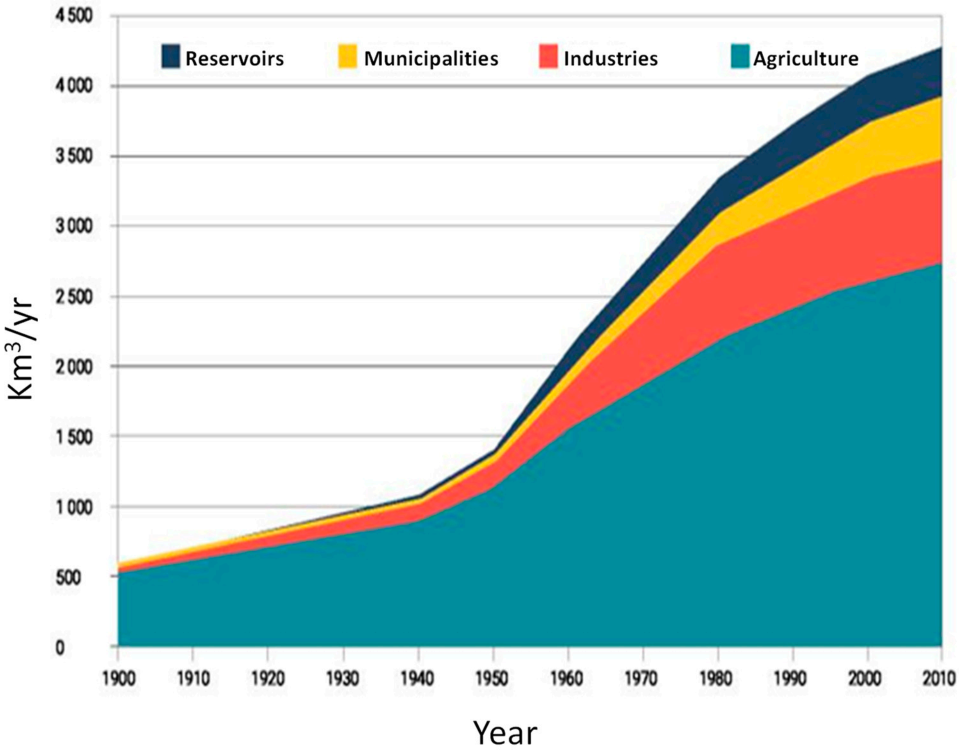

Figure 3. Global freshwater consumption by sectors, modified from [1].

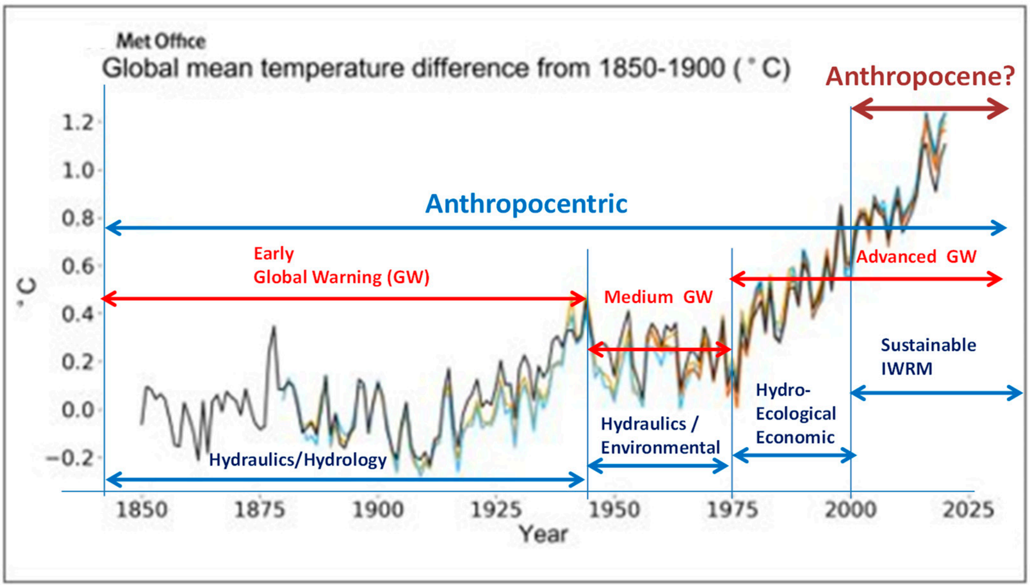

Figure 4. Changes in the WRM model (1850–2025) in relation to climate, modified from [32].

3. Three Clusters of Nature–Human Interaction

The Pleistocene is a period we may call *naturalistic* because nature was the dominant force in the balance of power between nature and humans (Figure 1).

The Holocene Epoch, also called the Human Age, is a preeminent period of stable climate conditions enhancing significant socio-economic and cultural progress. For scientific and geological reasons, the Holocene is still in place. Due to significant technical progress, humans gradually moved their relationship with nature from a naturalistic type to a *dualistic* type until the beginning of the Second Industrial Revolution in 1850 (Figure 1). This means the coexistence of human respect for nature with resistance against natural forces. A typical example of this dualistic behavior from ancient Greece is the perception of the Acheloos River, which was considered to be a demigod and, at the same time, a giant snake defeated by Hercules for producing catastrophic floods [33].

Referring to the rise in global temperature shown in Figure 4, our aim is to analyze the consequences of GW from a scientific point of view in order to understand how humans behaved against nature during that time and the consequences of this behavior for WRM models. Observing how changes in the WRM model correlate with global climate change and specific temperature variations is interesting.

As shown in Figure 4, three types of temperature variation and subsequent models of WRM are distinguished:

(1) *Early GW*, from 1850 to 1945: During this period, an increase of less than 0.5 °C in the global mean temperature was observed (Figure 4). This is the period in which the Second Industrial Revolution started with a massive emission of CO_2 into the atmosphere (Figure 2). During these years, science and technology grew exponentially, especially in the hydraulic/hydrological engineering domain. In 1935, the design and construction of the giant Hoover Dam in the Colorado River, USA, was the period's milestone [34]. Since then, humans have become strong and self-confident and have thought of dominating nature by using big rivers and water resources as human assets. We may call this period *anthropocentric*, i.e., human-dominated [14] (Figure 4).

(2) *Medium GW*, from 1945 to 1975: The global mean temperature during this time seems stable but still exceeds the average 1850–1900 reference temperature. Over these 30 years of the implementation of anthropocentric WRM models, signs of adverse environmental impacts started to be visible. Point and diffuse pollution in rivers, lakes, and groundwater mobilized environmentalists and non-governmental organizations (NGOs). A milestone of this period was the 1972 UN Stockholm Declaration stating that economic development cannot be effective without environmental protection [35] and emphasizing the necessity of an Environmental Impact Assessment (EIA).

(3) *Advanced GW*, from 1975 to 2025: As shown in Figures 2 and 4, the exponential increase in CO_2 continued, with the global mean temperature increasing by more than 1.2 °C. In terms of change in the WRM model, this anthropocentric period is divided into two sub-periods.

    (3.1) *1975–2000*, a period of *ecological* concern: The 1992 UN Rio Summit, in Ch.18 of Agenda 21, reflects the need for environmental protection. This text [36] defines the need to establish the IWRM model, considering the ecological dimension of water and its economic value. Agenda 21 was the base for formulating the Millennium Development Goals (MDGs) in NY during the 2000 UN Summit.

    (3.2) *After 2000*, a period some scientists call the *Anthropocene*: The UN World Summit on Sustainable Development in Johannesburg in 2002 marked political engagement in adopting multilateral partnerships to promote sustainable economic development [37]. Later, the Johannesburg Declaration promoted the 17 UN-SDGs at the 2015 NY World Summit. However, almost 50 years after the 1972 Stockholm Declaration, the integrated management of natural resources produced severe externalities. The IWRM remained anthropocentric, and one-third more CO_2 accumulated in the atmosphere. At the same time, the global temperature exceeded 1.5 °C, causing substantial topsoil degradation and rising seas from glaciers melting. The footprint of recent human activities after 2000 on geological strata is so drastic that many experts suggest the initiation of a new geological epoch called the *Anthropocene* [38].

As shown in Figure 5, the stability of the dialectic relationship between humans and nature depends on the ratio of two opposite forces: (i) A—human pressures on nature (externalities) and (ii) B—natural forces on humans (natural constraints). The power ratio of B/A is a function of the climate and human societies' scientific and technical development. We can distinguish three clusters: (i) B > A—naturalistic, during the Pleistocene epoch; (ii) B≈A—dualistic, during the Holocene; and (iii) B < A—anthropocentric, after the industrial revolutions.

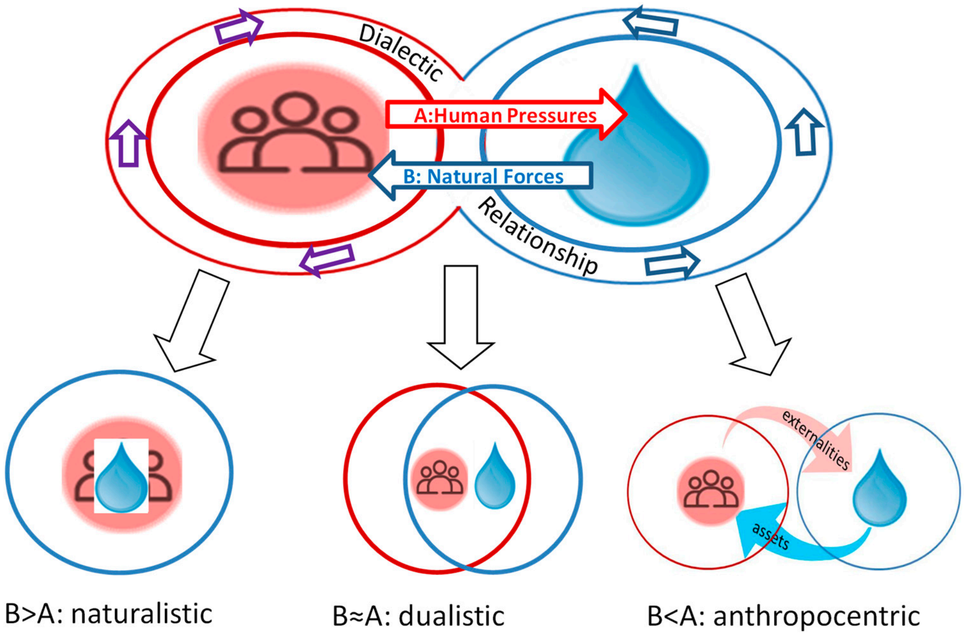

Figure 5. The three clusters of the dialectic human–water relationship.

We should notice here that the dialectical nature–human relationship shown in Figure 5 as the union of two opposite forces differs from the recently promoted nature-based solutions (NBs) [39]. The use of natural materials and the bio-engineering approach of NBs are very useful for small-scale restorations of water infrastructure works and ecosystem preservation. However, NBs do not include the conflictual character of nature–human dialectics, and they do not define how human prosperity is preserved by implementing NBs. The dialectical conflict resolution model we suggest brings a harmonic symbiosis with nature when the opposite dialectical forces come into equilibrium (tuning the two opposite pressures).

4. The WRM Timeline Metabolism

In pre-historic times, humans' water use was elementary, mainly as a necessity for survival. In historical times and more recently, with the exponential growth of science and technology, water management has taken the form of scientific and technical WRM models. The evolution of these models reflects the timeline of water–human interaction following the climate variability of our planet.

Over the last few decades, IWRM models have recorded significant externalities such as diffuse surface, groundwater, and soil pollution, ocean acidification [40], and changes in precipitation patterns producing extreme floods and droughts. The loss of biodiversity has accelerated together with an increase in freshwater consumption. As shown in Figure 3, although after 1950 a slower increase in global freshwater consumption was recorded after 1950, global water consumption has increased by more than eight times since 1900. Water for agricultural activities represents more than 70% of total water consumption. It follows a rapid increase in the global population on Earth. Table 1 summarizes the WRM timeline and changes in water policy since the pre-historic period.

Table 1. Timeline evolution of WRM and water policy models.

Period/ Temperature	Time Interval	Water–Human Interplay	Milestone of a WRM Model	WRM Model	Water Policy Model
Pleistocene +1 to −6 °C	up to 11 kyr	Naturalistic	Homo Sapiens	Empirical	Spiritual
Holocene Optimum	11 kyr–600 BCE	Dualistic	Agriculture	Irrigation	Religious Customary
Holocene Optimum	600 BCE–1700 CE	Dualistic	Roman Aqueducts	Early Hydraulics	Religious Customary
Holocene Optimum	1750–1850	Dualistic	1st Industrial Revolution Watt's Steam Engine	Hydraulic Engineering	Early Hydro-Technical Infrastructure Management
Early Global Warming 0–+0.5 °C	1870–1945	Anthropocentric	2nd Industrial Revolution 1935 Hoover Dam, USA	Scientific/ Engineering Hydraulics Hydrology	Hydro-Industrial Management
Medium Global Warming	1945–1975	Anthropocentric	UN 1972 Stockholm Water Declaration	Hydro-Environmental Protection	EIA Environmental Impact Assessment
Advanced Global Warming 0–+1.5 °C	1975–2000	Anthropocentric	UN 1992 Rio Declaration	Hydro-Ecological Economic	Ecological Water Cost Recovery
Anthopocene Era?	2000–present	Anthropocentric	Johannesburg 2002 World Summit	Sustainable Dev. Goals (SDGs)	Sustainability EU WFD 60/2000/EC

5. Involving Stakeholders and Decision Makers in IWRM

In the use of natural water resources, it is essential to clarify the structural connection between the following three different activities:

(1) Science/management;
(2) Policy/law;
(3) Governance/decision making.

At every administrative level, these activities can be distinguished as follows:

- *Science/management* comprise a set of decisions at the lowest level for planning, controlling, and operating specific projects. Formerly, it should involve science and technology, the use of scientific results, analyses, research, data processing, and the simulation of different scenarios;
- *Policy/law* comprise a set of customary, national, and international laws and regulations aiming to generate decisions for controlling, correcting, and implementing managerial plans and activities;
- *Governance/decision making* is the integration of policy and management into global socio-political decision making.

These three interacting domains form a complex socio-economic environment called the Science–Policy–Governance Nexus (SPGN) (see Figure 3 in [12]). Apart from the usual socio-economic sectors within the SPGN, the main profiles of water stakeholders are classified as follows:

(1) *Knowledge generators*: They actively develop the scientific and technical background of WRM at different scales. They are university professors, researchers, teachers, and other persons involved in private and public research and education activities. They act as advisors to elected politicians, scientifically and technically supporting parliaments, ministries, regional and local administration.
(2) *Law and policy makers*: In democratic countries, the socio-economic and political system of governance relies on the rule of law. Lawyers and experts in public administration

formulate law nationally and globally. Regional and local authorities also issue regulation texts and legal decrees.

(3) *Water professionals*: These are engineers and qualified technicians in the private and public sectors responsible for designing, constructing, and maintaining water-related infrastructure. They play a significant role in developing public and private works and infrastructure for water services, such as water supply, public health, irrigation, and energy production. They should cooperate with scientists to update their technical skills and comply with legal rules and water regulations.

(4) *Public society*: In the advanced democratic world, public associations and all citizens are involved and play significant roles. They participate in public decision-making processes and elect representatives at different levels, such as local, regional, and national. Non-governmental organizations (NGOs), non-profit associations, and professional lobbying groups are important stakeholders in the water sector, primarily through modern social media and the Internet. In more authoritarian societies, the dialectical approach in nature–human relations can be observed in ancient civilizations, such as the Chineese and in the religious Daoist and Buddist dialectics. Some examples are the view of the nature as eternally changing and the aim to attune human activities to natural processes.

The SPGN reflects how different countries behave economically, socially, and culturally in the international arena. Between the three main elements of the SPGN, many feedback items and several issues interact, like socio-economic sectors and international relations, history, the education level of the population, religion, and national economies. For example, science is the principal tool for developing water management models. It also benefits from empirical inputs from stakeholders who may be experts in policy and governance. Lawyers and social scientists make water regulations and laws to translate scientific knowledge into legal forms. To this aim, scientists could translate physical entities, like freshwater, groundwater, streams, and aquifers, into legal terms and develop legislative texts. Also, politicians need scientists and lawyers to exercise policies and support governmental activities [12].

In this complicated SPGN structure, the main issue to formulate is how the scientific paradigm of the new IWRM model could be dialectically redefined to enhance stakeholders' involvement as an essential part of the model.

6. A New Dialectical IWRM Model for Conflict Resolution

Economic and environmental data in support of recent econometric studies [41] indicate that the global financial conditions of humanity in recent decades have improved substantially. According to the World Bank [42], although economic disparities between advanced economies and developing countries are substantial, from 1995 to 2018, i.e., in 23 years, the global economic growth of human wealth on our planet increased by 80%. However, this economic development is non-sustainable as it was developed at the expense of natural assets from which humanity benefited. According to [41], between 1992 and 2021, i.e., for almost ten years, the global domestic product (GDP) per capita doubled. However, the available natural capital per person decreased by 40% during the same period. We count the total monetary value of environmental renewable and non-renewable resources, such as water, soil, forests, food energy, and ecosystem services, as natural capital. In other words, there is a *capital inequality* between human wealth and the availability of natural resources, and this disparity is growing. We may conclude that the adverse environmental situation is due to excessive anthropic pressure on nature, including the anthropocentric character of the IWRM model. This global human–nature conflict is analyzed historically and analytically to find and suggest sustainable WRM solutions.

To reduce negative global environmental impacts due to human activities, two possible alternative solutions that are very difficult to implement are as follows:

(1) Reduce the current level of the global GDP, which means slowing down human activities producing additional economic growth;

(2) Alleviate negative externalities by undertaking global remediation measures, such as planting more trees and restoring the ecological status of water bodies like rivers, lakes, and aquifers.

The first solution is unfair because it could penalize developing countries by delaying access to better quality of life. The second one can produce only limited visible results as it is only operational in the long term. For example, planting the necessary number of trees requires an extensive area, and possible results can be visible after a few decades. Also, the denitrification of soils is likely, but it can take many years and cost an unaffordable amount.

We could develop a nature–human conflict resolution model to avoid environmental externalities by analyzing the dialectic character of the water–human interplay. The terms *dialectic* and *dialectical approach* derive from the Greek "dialogos," a conversation between two persons exchanging contradictory arguments. Instead of two persons, we have humans and nature, as described by nature's laws. By nature, we mean all non-human entities, i.e., the natural environment, the soil, the atmosphere, the hydrosphere and biosphere, the flora and fauna, and all ecosystems on our planet. In our approach, humans are not a homogeneous group of people but human societies consisting of different categories of stakeholders with particular water-related socio-economic interests. These social groups are farmers, industrialists, water professionals, environmentalists, and other social entities developing economic activities that interact with water use. They are also categorized into the four groups of stakeholders that were previously defined in Section 5.

The dialectical conflict resolution model consists of the following main steps:

(1) Defining human–human and nature–human conflicts. We call this step eristic from the Greek "eris," which means strife. Two kinds of conflicts are distinguished:
   (1.a) Conflicts between different social groups (human–human);
   (1.b) Conflicts between social groups and the corresponding natural laws (human–nature).

(2) Dialectical resolution Logical arguments and alternative measures are formulated to attenuate the nature–human conflicts. The best solution is the unification of the opposites, which means respecting the natural laws. The harmonic symbiosis between humans and nature also reduces human-human conflicts.

The main idea of an *Eristic–Dialectical Model* (EDM) was first coined by Heraclitus [43,44], the pre-Socratic Greek philosopher. It was formulated by Socrates, the father of Greek philosophy, and ultimately adopted in the 19th century by the German philosopher Hegel [44]. It served later on as a primary argument in the materialistic dialectical theory developed by Karl Marx and Friedrich Engels [45].

The steps to follow in the EDM-IWRM model are shown in Figure 6, in which a comparison is illustrated using the state-of-the-art IWRM model.

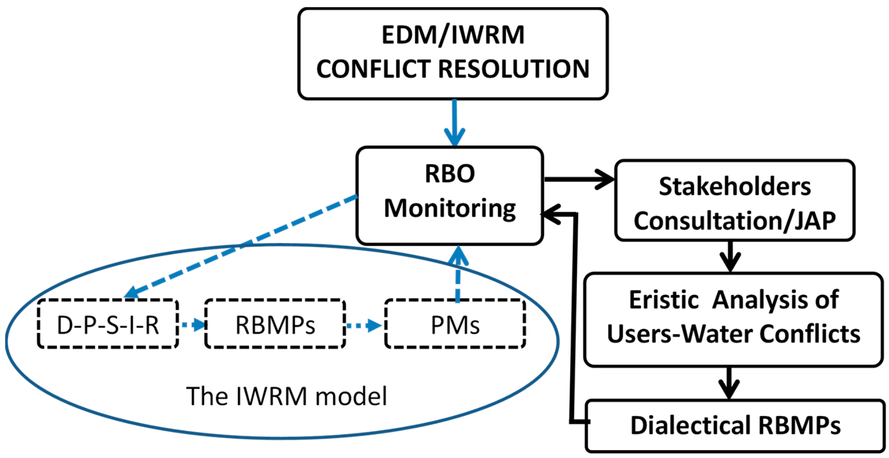

Figure 6. The EDM-IWRM model in comparison with the state-of-the-art IWRM model.

Step 1: Conflict resolution is undertaken by a River Basin Authority (RBO) responsible for monitoring at the river catchment scale.
Step 2: The RBO organizes a consultation with all stakeholders to define a Joint Action Plan (JAP).
Step 3: Different human–human and water–human conflicts are identified that correspond to each socio-economic activity (Eristic Analysis).
Step 4: Dialectical River Basin Management Plans (D-RBMPs) are formulated dialectically by unifying human interests and natural laws.
Step 5: Monitoring D-RBMPs can initiate a new JAP, followed by a revision of steps 3 and 4.

Comparing the EDM model with the anthropocentric IWRM model, we can observe in Figure 6 that step 1 is expected to be shared for the two models, followed in IWRM by the Driving Force–Pressure–State–Impact–Response (DPSIR) step, the establishment of River Basin Management Plans (RBMPs), and the Program of Measures (PMs).

The prerequisites for the use of this model are the following:

(1) A legal definition of the RBO. This agency could have public or private status and is responsible for the WRM at the basin level.
(2) The rules for the economic evaluation of different water and wastewater uses should be defined by law.
(3) Environmental standards and guidelines for water quantity and quality should also be defined by the country's legislation.

The main advantages of the application of the new dialectical model are the stakeholders' involvement in the WRM process and the reduction in externalities by adjusting the stakeholders' activities to natural laws.

Potential drawbacks can result from difficulty in reaching an agreement for establishing the JAP and resolving conflicts between different stakeholder groups, such as farmers and industrialists. However, if all groups adjust their activities to natural laws, it would facilitate potential human–human conflicts.

7. Case Studies

7.1. Dialectical Flood Management in Crete Island, Greece [46,47]

This case study aims to demonstrate the EDM model efficiency for flood mitigation and adaptation in the case of Giofyros River, Iraklion City, Crete Island. In the past, the urban part of the Giofyros River experienced many flood damages of urban infrastructure and losses of private and public property. The severe flood of January 1994 produced significant impacts of many million Euros, including critical damage to the city's wastewater treatment plant.

The general situation of the case study is shown in Figure 7, and the most important steps of the dialectical approach can be summarized as follows:

(a) Stakeholder Involvement:

Public and town authorities decided to establish a coalition of local stakeholders, university professors, researchers, water professionals, and consultants to design and implement an efficient flood risk management framework. Details on the steps followed for developing an Eristic–Dialectical Integrated Flood Management Plan are reported in [47].

(b) Eristic Analysis:

The contradictory behaviors of human–water coexistence were identified: (i) friendly behavior, as humans enjoy the river's water services, such as green areas near the river and the refreshing temperature during the hot summers; and (ii) adversarial behavior toward the river because of the negative consequences of the river's floods, such as the loss of property and even human lives. For many years, humans underestimated the forces of the river and constructed their properties in the river's floodplain (humans against nature). However, river floods inundated part of the city every 20 years (water against humans).

(c) Dialectical RBMPs:

Dialectical RBMPs [47] aim to harmonize human behavior with natural laws, by dialectically unifying the two opposites: conflict and cooperation. Because opening the floodplain by removing the population was very difficult, the inhabited area along the river was protected from flooding. As shown in Figure 7, a system of flood detention reservoirs was provided for retaining the 20-year flood peaks upstream. Also, to attune the RBMPs with natural laws, a jetty was constructed at the river's mouth (Figure 7) to facilitate the evacuation of solid sediments into the sea via a dextral Coriolis forces deviation [47].

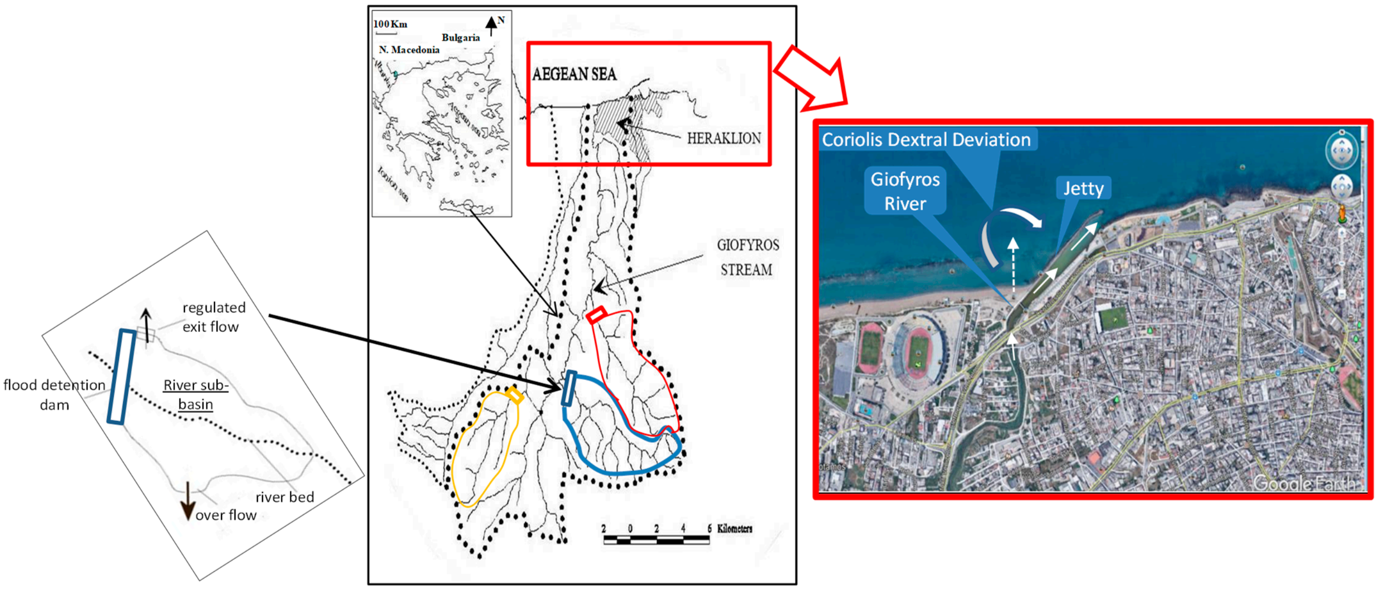

Figure 7. Flood mitigation in the Giofyros Stream Basin, Iraklion City, Crete Island, Greece.

7.2. Sustainable Agricultural Irrigation in the Mediterranean [48]

According to statistical data [48], farmers in Mediterranean countries use more than 86% of water resources for irrigation in summer compared to 59% for Europe and 69% worldwide. The Water–Energy–Food Nexus model (WEFN) was applied in this case study as an integrated system framework for reducing the overuse of irrigation water. The main idea is to use the synergies of the integrated WEFN approach to maximize food production while minimizing water and energy use.

Mathematically and physically, it can be shown that no unique solution exists for maximizing food production and minimizing water and energy consumption. Because farmers, based on economic considerations, tend to increase food production by overusing water and energy, the use of the WEFN model is not sustainable (Figure 8).The case study and the management brief [48] recommend a dialectical solution based on renewable surface and groundwater use (recyclable water) and renewable energy sources, such as solar pumps for groundwater extraction. In this way, by respecting natural laws in agricultural activities, sustainable harmonic nature–human coexistence is ensured.

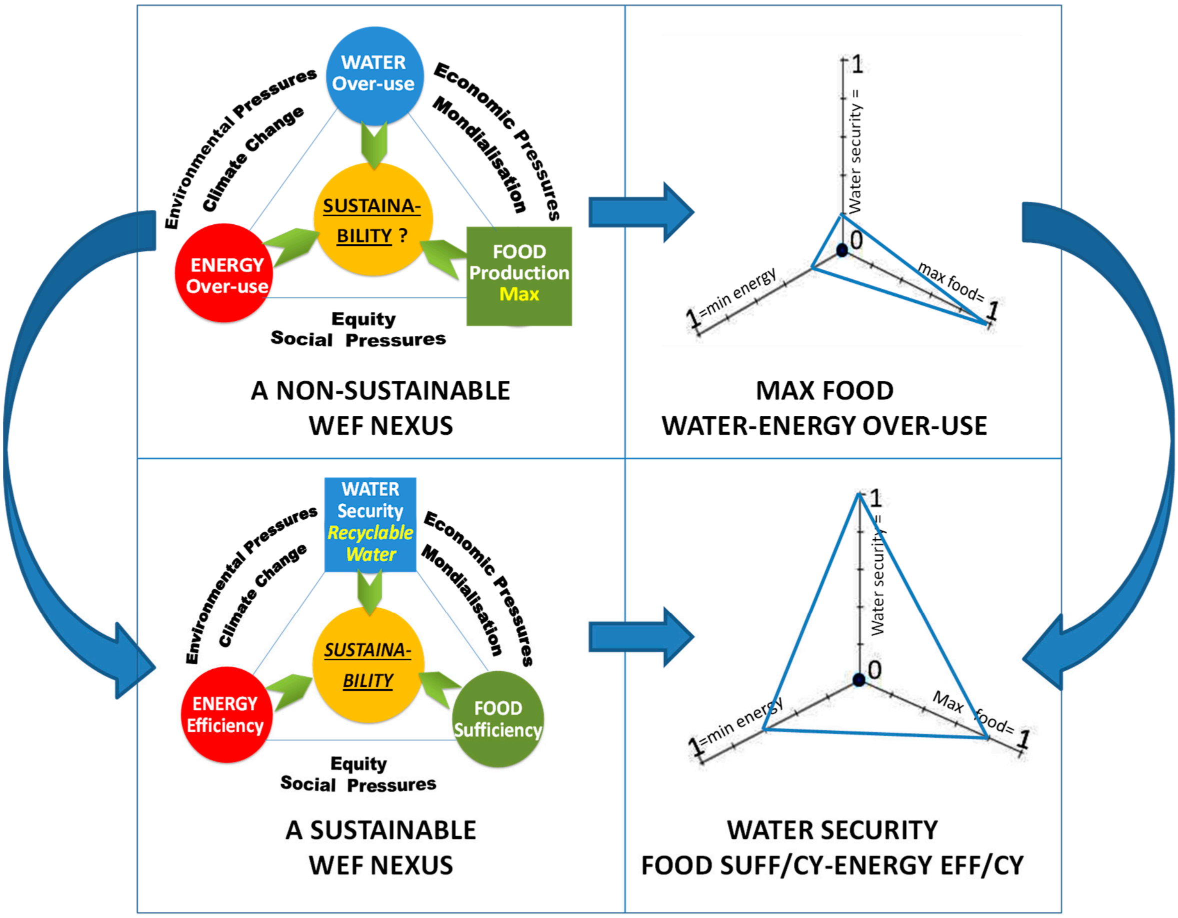

Figure 8. A dialectical WEFN solution for agricultural irrigation by respecting natural laws.

7.3. *Dialectical Urban Water Security: The Case of the Attica Peninsula, Greece [11]*

The urban water metabolism depends on how cities use their water resources, manage wastewater, and protect urban surface and groundwater bodies like rivers, lakes, and aquifers. This case study refers to the Attica Region, where Athens, Greece's capital, is located. Athens has a long-lasting and well-documented history describing the water–city relationship from ancient times to the historic period of classical Greek civilization and, after that, from the Ottoman occupation to modern times after Greek independence in 1830. According to the Greek myth describing the city's creation, Athenians opted for a town with scarce water resources but with the possibility of developing new knowledge and wisdom thanks to the goddess Athena [1]. Athena, one of the 12 main ancient Olympian gods, was chosen by the people of Athens as the city's protector. In a public competition, she offered the olive tree for cultivation and her wisdom for socio-economic development.

Historical data explain the ancient myth as follows: without major rivers in the Attica Peninsula, Athens is protected from significant floods. Two minor rivers in the area, Ilisos and Kiphisos, together with available groundwater resources, offer enough water for drinking and to sustain green areas in the city. Also, the fertile soil of the peninsula provides successful growth conditions for olive trees for oil production and wood for other uses. Following the proclamation of the Greek state, the city authorities decided to cover most of the urban streams, including the rivers Ilisos and Kiphisos.

The unsustainable solution of covering the water courses was proposed in the name of public reclamation works to accommodate many people, create new traffic avenues, and combat surface water contamination from mosquitos. In the case study, a dialectical solution is suggested in the form of uncovering the two major water streams and ensuring their ecological flow in summer using upstream artificial reservoirs. By harmonizing dialectically urban activities with natural hydrological laws, a sustainable solution can be obtained.

8. Conclusions

From the above historical analysis, we may draw some valuable lessons, such as the following:

(1) The nature–human relationship and the WRM models continuously change over time.
(2) Human behavior towards nature is expressed by the coexistence of two contrary attitudes, i.e., conflict and cooperation. This relationship is an ontological principle and can be called dialectical.
(3) The two coexistent opposites are not always in balance. Humans usually perceive their interaction with nature as a competition between their abilities and the strength of natural forces. Depending on the prevailing power, three clusters on different timescales were identified herein: (1) the *naturalistic* cluster, i.e., nature's domination over humans during the Pleistocene; (2) the *dualistic* period during the Holocene, which was characterized by a balance of the two opposites; and (3) the *anthropocentric* period since the second Industrial Revolution, when humans felt they became able to dominate nature.
(4) The IWRM paradigm is currently accepted to be a state-of-the-art WRM model. It is anthropocentric, and since its implementation 20 years ago in Europe and elsewhere, it has generated substantial adverse environmental impacts. Fossil observations and recorded physicochemical data show that humanity has entered a new geological period called the *Anthropocene*.
(5) To reduce anthropogenic externalities, improvements to IWRM are urgently by involving stakeholders and decision makers in the water governance process.
(6) The new dialectical IWRM model suggested here is based on analyzing conflicts between human activities, followed by a dialectical reconciliation of humans and natural water laws. By unifying contradictory water–human behaviors, sustainable water governance can be achieved by avoiding negative environmental externalities.
(7) Three selected case studies illustrate the practical implementation of the EDM-IWRM model.
(8) We may also investigate whether the new EDM-IWRM model could be useful for addressing new WRM challenges, such as the water footprint of new global markets, water overuse in agriculture, new supply chains for batteries and microchips, and possible geopolitical conflicts in transboundary water resources management. For all these issues, if dialectical conflict resolution can mobilize stakeholders and attune human activities and natural laws, it could be a major step toward achieving water security and resolving the human–human adversarial attitude.

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