Ecohumanism Research

A Possible Solution to the Global Water Crisis: The Primary Hydrologic Cycle and Integrated Water Resources Management

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Summary

The global water crisis is avoidable and needless. This paper addresses the relationship between the primary and secondary hydrologic cycles, and demonstrates how they are interconnected. Because of reasons relating to political corruption and scientific dogmatism, there is scant awareness by the scientific community on the primary hydrologic cycle and its significance for ending the global water crisis. Because of how the crisis requires collaboration between scientists and the public, the author analyzes the concepts of ecological integrity and integrated water resources management where he discuss how these concepts can help people to manage their freshwater needs within the context of their geographic regions.

Introduction

The global water crisis refers primarily to the scarcity in the world's freshwater supply and the repercussions this is having on nations that find themselves in a struggle to gain a fair share of the dwindling resource. This issue is characterized by the following: a lack of freshwater to meet human needs, the uneven distribution of supplies, the quality of the freshwater and the impacts on the resource itself stemming from the construction of dams and reservoirs.[1] The above-mentioned issues all stem from the current understanding of the hydrologic cycle where only terrestrial freshwater is considered, in other words, freshwater at or near the surface of Earth. This is proving to be a problem in and of itself because there is another hydrologic cycle that the scientific community appears to be unaware of and is failing to grant it the attention it merits.

In the first segment of this paper I begin by providing some insight into the global water crisis, as it is a concept that is vague, and in lack of a precise definition. In addition, it is a crisis that encompasses more than simply a lack of affordable access to freshwater. The issue affects at least several other components that have long-term, negative consequences for humanity, which is why serious analysis is required. Following this, I describe the nature and the mechanisms of the secondary hydrologic cycle, including those of the primary hydrologic cycle, where I show how the latter is a scientifically valid concept and that its failure to be acknowledged by the scientific community represents a failure to put an end to the global water crisis. I also explain how the mismanagement of water resources contributes toward drought and famine. With that being said, I explain how the crisis is artificially induced, rather than the result of natural developments.

In the second segment of this paper I describe the need for integrated water resources management and how it can be applied for solving other aspects of the crisis, which involves flood management, including the preservation and enhancement of Earth's ecosystems.

Finally, I discuss why there is a lack of awareness of this vital knowledge and how improved education can act as a stepping stone for helping everyone to solve this major problem. This paper thus presents a framework for addressing the global water crisis by combining scientific knowledge of the primary hydrologic cycle and integrated water resources management.

Analysis of Literature

What is the Global Water Crisis?

Although it is unclear what the origin is of the term "global water crisis", it is possible that it was influenced by the first United Nations Water Conference, which was attended by the international community in 1977 to discuss the issues surrounding the world's water resources.[2] Since that time, many researchers have adopted the term to describe how societies around the world would be forced to cope with the decrease in accessible supplies of freshwater.[3] What is important to note is that some of these researchers have explained that the crisis doesn't exist due to freshwater scarcity, but rather, due to how the resource is managed. This perspective is increasingly acknowledged by the scientific community.

A number of researchers have stated that the global water crisis is poorly defined and that the notion of there being such a crisis is ambiguous.[4] One reason for this is that much of the published research relies upon an aggregation of studies, which contain data that is reflective of a certain location, and that the results of those studies are extrapolated to a global level. Because of this, societies have made little progress in solving their problems as they do not have access to research that is contextually appropriate. With that being said, although there is more to discuss on this issue, it is nonetheless clear that there is a crisis, and that it is related to societies that are either currently, or expected in the near future to struggle with freshwater scarcity. The reason I am mentioning this is because I am attempting for the sake of this paper to provide a clearer definition of the term "global water crisis". This will help us to better understand in what ways it is a problem, which by extension will justify the solution, as I have outlined in the introduction to this paper.

As such, I define the global water crisis as "the mismanagement of water resources that is contributing toward a decline in freshwater security, food security, the degradation of ecosystems, and the resultant harm to societies as a result of ecosystem degradation." As we can observe there are three main points in the definition that I have not explained, namely, the terms "freshwater security" and "food security", and the reference to ecosystem degradation. I shall elaborate on this. First, when I state "freshwater security", I am referring to the affordable access to freshwater, which is an issue that is physical due to freshwater scarcity, as well as the improper management of water resources, where these factors are linked and are context-dependent. Second, when I mention "food security", I am referring to the affordable access to food, which is an issue that is directly affected by freshwater security. Third, when I mention ecosystem degradation, I am referring to the improper management of water resources, insofar as the direct and indirect effects of social development are having a negative impact on the natural environment and that this also presents a risk to the long-term survival of the human species.[5] Although the mismanagement of water resources leads to other problems, such as the heightened risk of droughts, flooding and disease, these issues are not quite as serious as the ones outlined thus far, which is why I am not emphasizing them. Another reason for this is because the solution to the global water crisis, as outlined in the introduction, has the potential to address these issues as well.

In terms of the number of people affected, this problem is major. According to some estimates, approximately 4 billion people experience severe water scarcity at least part of the year, and at least 1.8 billion people experience severe water scarcity between 4 to 6 months per year.[6] Thus, the global water crisis does not directly affect everyone, although if left unabated, it will affect more people and will lead to a rise in number of deaths in the long-term future.

The Secondary Hydrologic Cycle: Physical Basis

Water is a necessity for human survival. In spite of its universally acknowledged importance, the United Nations has declared it as a human right only as recently as 2010.[7] One of the principal reasons for this is that the world's freshwater supply has officially been recognized as being under threat due to overexploitation for a variety of reasons that are political, economic and environmental.[8] Such concerns are based on at least three premises, the first of which is due to overconsumption by humans. The second, which is invariably linked to the first, is that there is a lack of integrated water resources management, which involves the intelligent management of terrestrial water in a manner that is ecologically, economically and socially sustainable. The third, is that there are a lack of technologies with the capacity to extract water from the hydrologic cycle and convert it into freshwater in a manner that is economically feasible on a nationwide scale.[9] What is important to note about these issues is that they all stem from secondary hydrologic cycle. How is this so?

The secondary hydrologic cycle is understood as a closed-loop system, where water moves at or near the surface of Earth in a cycle that has no beginning or ending, which is driven mainly by atmospheric processes, which in turn are driven by solar energy (see Figure 1). This concept is maintained by institutions such as NASA[10], NOAA[11] and USGS[12], which is reflective of what the scientific community agrees is accurate.

Although Earth's surface contains an estimated 1.4 billion cubic kilometers of water, only less than 3% of that water is fresh and suitable for human consumption.[13] Despite this, there is enough freshwater available to meet the needs of civilization. According to Peter Gleick, who is considered to be a world-renowned expert on issues related to water, and who is the pioneer of the concept of "peak water", the global water crisis exists not because of freshwater scarcity, but rather, because freshwater stocks are unevenly distributed, where the largest volumes of the resource are found in Antarctica and Greenland in the form of ice.[14] Another reason is that the quality of freshwater supplies is being degraded due to contamination. When these factors are combined, they lead to what Gleick refers to as "peak water", which is comparable to the concept of "peak oil", in that it describes how it is becoming increasingly unfeasible for bottled freshwater to be transported across relatively large distances.[15] For this reason, the concept is useful as it permits us to improve our understanding of why the overall cost of freshwater is rising. To elaborate on this, the concept of peak water is divided into three categories. The first, which is peak renewable water, refers to the limit on the total quantity of water that can extracted from a hydrologic system, which is regulated by renewable flows. However, this does not mean that a water source is unlimited, but rather, that the peak water limit is associated with the total quantity of water available for withdrawal at the source. Examples of such systems include but are not limited to: rivers and streams. In addition, peak non-renewable water is the point at which the rate of freshwater recharge by natural processes is significantly lower than the rate of consumption. This concept is especially apparent in groundwater aquifers where the rate of recharge is so low that for most practical purposes it may be considered as a non-renewable source of freshwater. Finally, peak ecological water describes the point at which the use of water causes serious or irreversible damage to ecosystems, which is important to consider not only due their services that sustain human life, but also due to the services they provide for animals, plants and habitats.

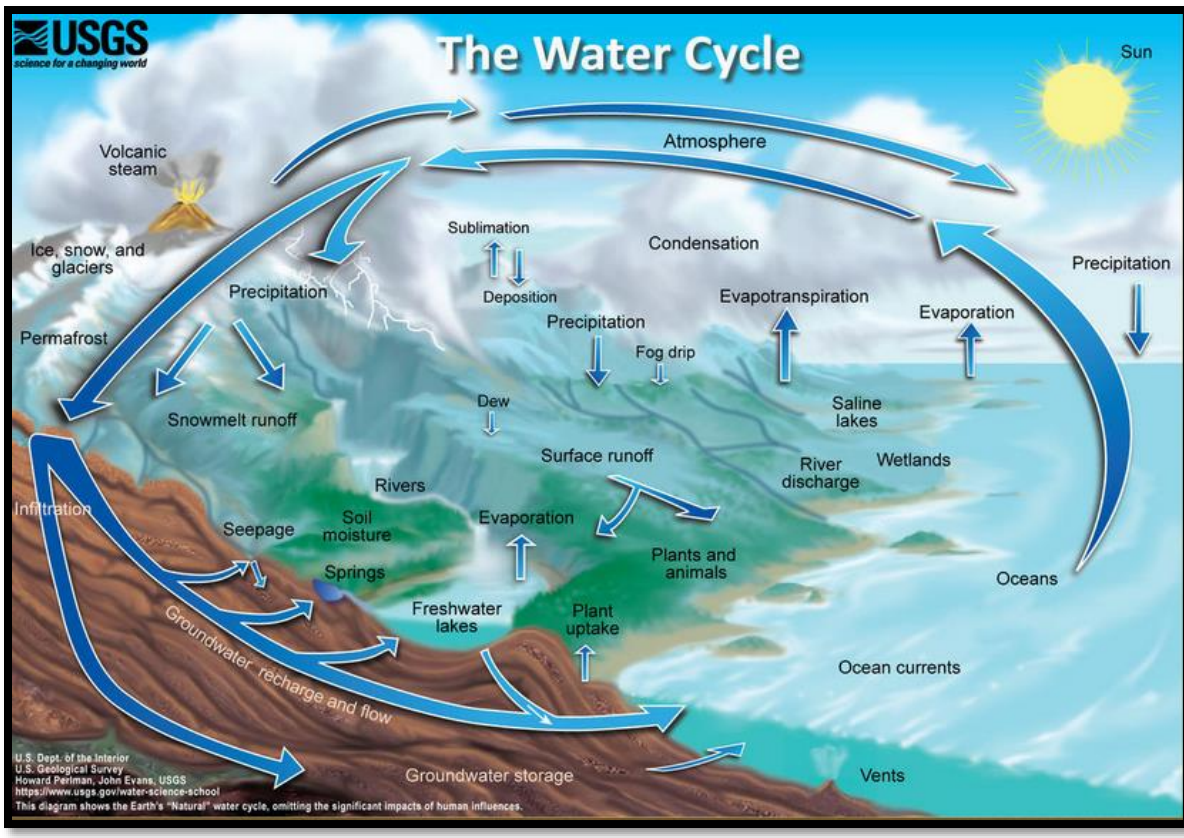

Figure 1. (Credit: USGS)

The Secondary Hydrologic Cycle: Social and Economic Implications

What are the social and economic implications of this cycle? One individual who understands them is Maude Barlow.[16] As with Gleick, Barlow is also a world-renowned expert on issues related to water, although she focuses her time on raising awareness of the socioeconomic and political issues resulting from the commoditization of water.

In a report published in 2017, Maude Barlow describes three ways in which water is being exploited.[17] First, water is treated as a product of industry, whereby trade agreements prevent any restrictions from being imposed on the trade of water. Second, water becomes a service where trade agreements allow for the creation of new markets, where multinational corporations are enabled to purchase water and legally treat it as their own property. Third, water becomes an economic investment, granting corporations the power to challenge government laws and trade disputes. The Investor-State Dispute Settlement (ISDS) is one example of a tool that corporations have access to for essentially bypassing environmental regulations that protect the management of public water services. This is especially problematic when considering that as freshwater becomes increasingly scarce and its demand rises, so does the financial cost.[18] This means that the people lose the right to have secure access to what is supposed to be a public resource. These represent among the greatest contemporary issues affecting societies, and at present the signs indicate they will only become more serious as time progresses. This is even acknowledged in a 2006 report by the United Nations where it states "The availability of water is a concern for some countries. But the scarcity at the heart of the global water crisis is rooted in power, poverty and inequality, not in physical availability."[19]

The issue of corruption becomes increasingly apparent when gathering all of the available evidence. However, we must bear in mind that these issues are all based upon ignorance of the fact that water is generated in abundant quantities within Earth's interior. As I have mentioned previously, the secondary hydrologic cycle only accounts for water that circulates either on Earth's surface or within its proximity. The problem with this perception is that it fails to account for the existence of another water cycle that has the potential to provide freshwater in abundance to all of the world's people, thus putting an end to freshwater insecurity and food insecurity. Yet, this is something that neither Peter Gleick nor Maude Barlow appear to be aware of. The reasons for this shall become increasingly evident in the proceeding sections.

The Primary Hydrologic Cycle: Physical Basis

What is the primary hydrologic cycle? Before answering this question, it is important to note that the concept has been known for at least more than half of a century. In 1960, Michael Salzman published a groundbreaking book (pun intended) entitled *New Water for a Thirsty World*, where he argued that a combination of scientific dogma and political corruption has prevented a number of important scientific breakthroughs from occurring.[20] He explained that this has inevitably led humanity to losing precious time in solving its most significant problems, one of which is freshwater insecurity. As the title of the book suggests, the scientific breakthrough that has yet to be fully acknowledged by the scientific community is that of "primary water", a term that originates from its discoverer, Stephen Reiss.

Knowledge of the scientific validity of this concept, as well as of the primary hydrologic cycle has been made more accessible in due part to research efforts by The Primary Water Institute. The institute's aim is "dedicated to teaching what is known about the volcanic origin of water from deep beneath the crust of our living world."[21] The concept of primary water involves understanding that the primary hydrologic cycle is driven by geologic processes, where one of its defining characteristics is the generation of water deep within Earth's interior and its subsequent movement upward through cracks, fissures and hydrothermal vents. What distinguishes it from the secondary hydrologic cycle is that the movement of water is mainly driven by geologic processes, whereas in the latter, it is driven by atmospheric processes, which are subsequently influenced by solar energy (see Figure 2).

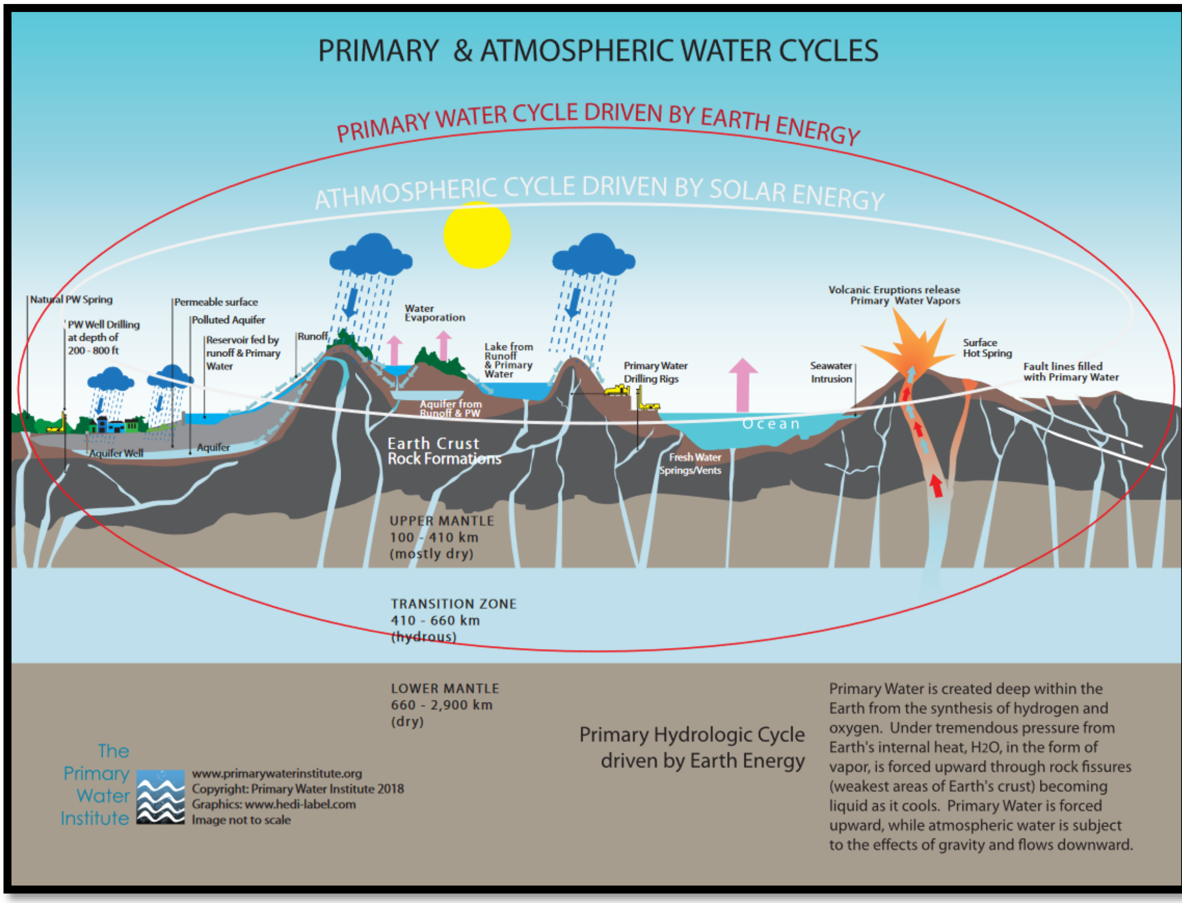

Figure 2. (Credit: The Primary Water Institute)

In 2013, the Geological Society of America had published a special paper, which provides an integral understanding of the planet's hydrologic cycle.[22] What it shows is that the movement of water between the interior and the exterior of Earth is linked by plate tectonic mechanisms. Water is driven out of its interior by volcanism and related aspects.[23] Likewise, water is conveyed toward Earth's core at subduction zones where tectonic plates converge.[24] We learn that the water found on the surface or in its proximity originates from deep within the planet's interior.

A scientific study from 2014 confirms the above-mentioned through spectroscopic analysis. The researchers who conducted the study explain that the formation of ringwoodite and wadsleyite as polymorphs of olivine represent the best available evidence for the origin of the water that exists in the complete hydrologic cycle.[25] It is suggested the above-mentioned minerals may contain up to 2.5% of their weight in water, which was acquired through the bonding of oxygen (O_2) and hydrogen (H) under high-pressure, geophysical circumstances. What this indicates is that the quantity of water varies in accordance to the depth at which it was formed.

The transition zone, which is a distinct layer within Earth's interior is believed to be the region where much of the water is produced. This is something that has recently been confirmed through studies that used a variety of remote sensing techniques.[26-27] It is possible to calculate an estimation of the total quantity of water contained within the transition zone by expressing it in terms of ocean masses. Researchers have estimated the transition zone may contain to the equivalent of 1 to 2 ocean masses or (10.7 * 10^9) cubic kilometers of water.[28] To put this into perspective, the total quantity of freshwater that humanity had withdrawn per annum between the years 2010 and 2015 was approximately 4600 cubic kilometers, according to some estimates.[29] Figure 3 illustrates an equation that permits us to calculate an estimate of primary water stocks based upon the numbers we have retrieved.

A / B = C

Where A = total quantity of water in the transition zone (cubic kilometers)

Where B = annual global freshwater withdrawal (cubic kilometers)

Where C = duration of primary water stocks (years)

(10.7 * 10^9) / 4600 ≈ 2,326,087

Figure 3.

As we can observe, if we were able to exploit the primary water that is made available to us through the primary hydrologic cycle, and if we continue to withdraw water at the rate of 4600 cubic kilometers per year, we would have more than 2.3 million years' worth of freshwater at our disposal. However, this number would change depending on a number of variables. These include but are not limited to: the quantity of freshwater withdrawn per year and the rate of water recharge in the mantle. However, given that water is constantly reproduced in the mantle due to the bonding of O_2 and H, there is no reason as to why this source of water will ever run out, at least for the time being. The purpose of my adding the above calculation is simply to give us an appreciation of the amount of freshwater we have at our disposal.

The Primary Hydrologic Cycle: Addressing the Challenge of Education

Knowledge of the concepts of primary water and the primary hydrologic cycle remains scant. There are a number of reasons for this. These had been first revealed in *New Water for a Thirsty World*, where Michael Salzman identified scientific dogma and political corruption as being the main forces that were preventing humanity from solving its most pressing issues.

When putting this into context, Salzman explained there was a serious gap in knowledge that had been left unattended by hydrologists and geologists, mainly because they were not equipped to think outside the narrow confines of their disciplines of research.[30] The result is that the general public and government officials had been left with the impression that hydrologists were the only water experts. Unfortunately, it appears as though this problem continues today, which is something I have alluded to in previous sections. To expand on this, academic institutions continue to teach and promote the secondary hydrologic cycle, even though it only provides a superficial understanding of the complete hydrologic cycle. The point I am trying to convey is that this cycle is not separate from the primary hydrologic cycle. Not only do they both complement each other, but it is impossible to understand the nature of the water cycle in its entirety unless the two concepts are integrated. One reason why this issue persists is because they are not studied in the same way by specialists. How is this so?

Academic publications presenting the sciences of hydrology and geohydrology demonstrate the plight I am describing here. For example, there is a textbook entitled *Hydrology*, which was published in 2005 and it provides a comprehensive introduction to the subject matter of hydrology.[31] Although it describes the nature of groundwater to some extent, not once does it make reference to the origin of Earth's water, nor does it discuss the generation of water within the mantle. Another example of the plight I am referring to is evidenced in another book entitled *Hydrogeology*, which was published in 2019.[32] This book also provides a comprehensive introduction to the respective subject, which is hydrogeology, which refers to the scientific study of groundwater. What is interesting about this textbook is that the authors explain that hydrogeology has developed over the years into an interdisciplinary science that is more capable of addressing the problem of freshwater insecurity. Apparently, this has occurred out of the recognition that hydrologists have been unable to properly assess the planet's water resources. What is also interesting is that the authors briefly describe the theory of juvenile water, which is analogous to the concept of primary water, although they do not seem to be aware of the existence of the primary hydrologic cycle. The following quote makes it obvious as to why this is so "whether (and to which extent) groundwater recharge is influenced by juvenile water cannot yet be precisely documented, although there have been some isotope hydrological investigations (i.e. $^{4}He/^{3}He$ ratio) on the subject".[33] As we can see, the irony of this statement wouldn't be so regrettable if what the authors were saying was true. It also convincingly reflects the problem that Michael Salzman had described in his book. This is very concerning because it shows that there continues to be a lack of awareness among academics of the evidence for validating the concepts of primary water and the primary hydrologic cycle.

The above-mentioned issues are not isolated cases; the academic peer review system favors disciplinary studies, which means it provides researchers with fewer opportunities to publish cross-disciplinary research in reputable, scientific journals.[34] As a result, governments and funding agencies may have been led to believe that this kind of research is of a lower quality and therefore, should not receive the same amount of funding as disciplinary studies. Similarly, because academics generally do not communicate their discoveries with those that are not working within their discipline, this represents a missed opportunity for publishing scientific research that can contribute toward social evolution. Although it is beyond my scope to discuss all of the possible reasons for the barriers that exist within academia, it is nonetheless important to understand why they exist. This is because they represent an obstacle that is preventing the full potential of scientific research from being realized.

The Primary Hydrologic Cycle: Social and Economic Implications

The implications of the discovery of primary water and the primary hydrologic cycle are significant. As explained previously, we have an immense supply of freshwater beneath us, which means there is no need for concern about freshwater insecurity nor for food insecurity. As societies begin using this water, the price of freshwater will begin to decline until eventually it reaches the point where it can no longer be profitably traded on the market. However, it is possible that such a development will be met with resistance from a variety of vested interests.[35] Although this isn't guaranteed, we must consider that their ability to make a profit and to maintain power is dependent upon people being dependent on their services.

As people learn about the primary hydrologic cycle they will be motivated to learn how they can obtain secure access to primary water. With that being said, extracting primary water involves drilling through hard, impermeable rock. Once a well has been developed, a piping system can be installed so that the people can have access to water that is fresh and mineralized.[36]

Apart from solving the problem of freshwater insecurity, primary water can also solve the problem of food insecurity. Assuming a scenario where societies have begun to drill for it, then this would lead to a major shift in the agriculture industry, as well as for individuals who farm for their own sustenance. People who live in a state of economic poverty and who reside in geographic areas that are arid or prone to drought would experience the greatest change in terms of quality of life. This is because they would no longer have any serious concerns about shortages in water or food.[37] As people become less dependent on water extracted from the secondary hydrologic cycle, its financial and social costs will decrease. The samse in principle applies to the cost of agricultural produce, which in summation means there is no need for the world's population to suffer from freshwater insecurity, nor from food insecurity. This aspect of the global water crisis must be solved by educating the public about the primary hydrologic cycle and the benefits of using primary water. Since relatively few people are aware of these concepts, it is important for those who have knowledge of them to share it. With that being said, one of the objectives of this paper is to accomplish just that; to raise awareness of these concepts and to encourage others to do the same.

Ecological Integrity: What It Is and Why It Is Needed

Ecological integrity refers to the sum of all of our planet's biological elements and processes.[38] The study of ecology involves understanding that ecosystems are comprised of groups of organisms and that they function as dynamic units.

The human mismanagement of Earth's resources is contributing toward a rapid decline in biodiversity and the processes associated with it. More than half of all plant and terrestrial vertebrate species, including other lesser known groups of non-vertebrate species and fungi are found in 36 relatively biodiverse regions on Earth.[39] Of concern, these regions are located in tropical nations that are home to more than a third of all of the world's people. Because these nations are undergoing profound socioeconomic changes, current estimates indicate that less than 10% of ecosystems within those biodiverse regions remain intact. Based upon the quantity of area lost as a result of the negative externalities of industrial development, current projections estimate that all species native to at least 9 of the 36 biodiverse regions are expected to become extinct.[40] In addition, a total of at least 36% of plants native to those biodiverse regions are expected to become extinct. Freshwater organisms are also among the many organisms that are particularly vulnerable to extinction. This is partly because they require specific environmental parameters and because their habitats are confined to small geographic ranges.[41] At present, they are at an even greater risk for extinction because of overexploitation by the fishing industry and due to the introduction of exotic species into fresh waters around the world. According to some estimates, between 1970 and 2012 the populations of freshwater vertebrates, which includes fish, amphibians, reptiles, and mammals has declined by over 80% in certain regions of the planet.[42] Thus, what the evidence suggests is that ecological integrity for these regions is declining, which will have a number of direct and indirect impacts on humanity. How is this a problem?

Ecosystems are vital for humans because they serve a multitude of functions.[43] First, they act as systems for regulating essential ecological processes by providing organisms with resources they need for survival. Second, they provide organisms with refuges, which are vital for maintaining biodiversity. Without this element there would be fewer species of organisms, and thus, fewer sources of food for humans to consume, given that organisms have an intricate relationship with vegetation. Third, ecosystems are beneficial to humans due to their aesthetic appeal.

The above-mentioned functions are all dependent upon the presence of water. Because of this, we must acknowledge the importance of integrated water resources management for maintaining these functions. In this context, it requires us to consider the needs of the environment for sustaining itself. If we fail to do this, then there is a greater likelihood that we make a decision that causes significant, irreversible damage to the environment, while also contributing toward the extinction of ecosystems. It is for this reason we must strive to either restore or maintain ecological integrity because without it, we imperil our existence in the long-term.

Solving the Global Water Crisis

Governments around the world are struggling to solve the problems affecting their societies. The technocratic model of governance is losing its influence as people become more aware of the need for a different way of governing human affairs.[44] What we are observing today is how a form of hybrid governance is emerging in response to the prevailing model of governance.

Technocratic governance is characterized by a top-down approach, where the governing authorities are primarily responsible for managing human affairs, whereas a hybrid approach encourages cooperation between the citizens and the governing authorities. As such, the inclusion of a democratic approach allows the governing authorities to act as enablers for promoting public involvement in the management of natural resources. In essence, the hybrid approach forms the basis for integrated water resources management, which involves coordinating activities among various stakeholders with the objective of maintaining or improving economic and social welfare and equity, as well as protecting ecosystems. Thus, it encourages a more appropriate form of governance, and one that is based upon scientific data and tools.[45] In this context, the emphasis is on mobilizing action and resources from the bottom-up where local, regional, and national stakeholders are accounted for in the decision-making process. More significantly, these stakeholders must be granted the legal right to take responsibility for managing their own water resources by using science that is specific to their location. Because such a process is inherently context-dependent, the methods and techniques used will not be the same across the various administrative divisions within a nation. Having said that, how do we transition toward a hybrid model of governance?

The challenge with implementing the necessary changes is that they will require a shift in the way science is practiced. Researchers find that there has been a tendency for hydrologists to be dominant in the discourse of the management of water resources.[46] Subsequently, there is a lack of research incorporating perspectives from the social sciences, which would permit for a more integrated understanding of how societies are affecting and are affected by water-related issues. Likewise, these perspectives would enable the transfer of scientific knowledge into the public sphere of influence where it could be used for implementing a more integrated approach to the management of water resources. To reiterate, in order for us to transition successfully toward a hybrid model of governance, this will require greater democratic deliberation, which is something that has been historically lacking when it comes to the management of human affairs. Citizens will need to take greater responsibility for coordinating research activities with engineers, scientists and technicians in order to manage their water resources effectively and efficiently. This also applies to flood risk management, where plans can be developed for mitigating the risks associated with floods and flash floods, where the watershed plan will differ in accordance to the administrative division and the geography of the respective location.[47] With regards to primary water, those who have knowledge of the primary hydrologic cycle will need to take responsibility for sharing it so that a collaborative plan can be formed to help everyone locate and drill for primary water wells.

With the United Nations having declared the period from 2018 to 2028 as a Water Action Decade, this represents a great opportunity for us to address the issues analyzed in this paper.[48] Nevertheless, this will only signify the beginning of the end of the crisis because it will still take a number of decades before public awareness grows enough so that the appropriate action can take place.

Conclusion

The global water crisis is a serious problem that affects most of the world's people and it is defined by political corruption and scientific dogmatism. As I have indicated in the title to this paper, the solution to the global water crisis involves combining knowledge of the primary hydrologic cycle and integrated water resources management.

What most aren't aware of is that they have the capacity to contribute toward ecological integrity by changing the way in which they govern human affairs. By applying integrated water resources management, it becomes possible to restore and maintain the integrity of ecosystems that humans are dependent upon, while also reducing the risk of flooding.

All of the above-mentioned will require a dramatic shift in the way governance is approached. Subsequently, people who are appropriately informed will need to take responsibility for helping others to educate themselves about the issues discussed in this paper. The solution to the global water crisis is possible in the sense that it is not the only existing solution, although given the evidence, it may be among the best available solutions. It is also possible because the science and the technology required for ending this crisis exists. It is my hope that this analytical paper will serve as a reference for accelerating the end of the global water crisis as it provides a framework for implementing a solution that is both comprehensive and feasible.

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[16] According to her biography as presented by the Council of Canadians, she is the honorary chairperson of the same organization. She served as Senior Advisor on Water to the 63rd President of the United Nations General Assembly and played a major role in having water recognized as a human right by the UN. The following link provides some details of her background: https://canadians.org/maude.

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[19] This is in accordance to price elasticity of demand. Please refer to the following link for a definition and description of this economic concept: https://www.investopedia.com/terms/d/demand-elasticity.asp.

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[35] The following video demonstrates what happens when someone attempts to educate others about primary water during a public meeting: https://www.youtube.com/watch?v=ojWXxF-IqCQ.

[36] In the following video Paul Pauer, the founder of the Primary Water Institute, explains what it is like to drill for a primary water well: https://www.youtube.com/watch?v=nOE7cJVwwhc&feature=youtu.be.

[37] Maji Mengi is one example of a project that has helped to provide secure access to primary water for people living in rural East Africa. The following video documents this: https://www.youtube.com/watch?v=prhK7zUWXTE&feature=youtu.be.

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