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Editorial

Water Supply and Water Scarcity

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Abstract: This paper provides an overview of the Special Issue on water supply and water scarcity. The papers selected for publication include review papers on water history, on water management issues under water scarcity regimes, on rainwater harvesting, on water quality and degradation, and on climatic variability impacts on water resources. Overall, the issue underscores the need for a revised water management, especially in areas with demographic change and climate vulnerability towards sustainable and secure water supply. Moreover, general guidelines and possible solutions, such as the adoption of advanced technological solutions and practices that improve water use efficiency and the use of alternative (non-conventional) water resources are highlighted and discussed to address growing environmental and health issues and to reduce the emerging conflicts among water users.

Keywords: water management; water scarcity regime; water reuse; water use efficiency; rain harvesting; desalination

1. Prolegomena

Water scarcity refers to the lack of fresh water resources to meet water demand. Thomas S. Eliot (1888–1965) reported that "Drought is the death of the earth". The disruption of agriculture and social order by intense and prolonged droughts, called megadroughts, appears to have dictated the cultural time horizons of several civilizations [1]. In prehistoric times, for example the Hittite Empire, the Egyptians of the Pharaohs, and other civilizations collapsed due to the prevalence of intense and prolonged droughts that occurred in their lowlands [2]. Later, the Mayas; Salinas Puebloans; and the Khmer Empire, also known as the Angkor civilization, collapsed from the impacts of megadroughts [1,3–5]. In more recent history, the Dust Bowl (1930–1936) was the driest and hottest drought that hit the USA with significant and long-lasting effects in land productivity and society [6]. In line, intense droughts have hit Europe, the USA, and Australia in recent years, with significant socio-economic, environmental, and ecological impacts [7–9]. Despite the significant improvements in relevant infrastructure, updated water management plans and technological solutions improving water use efficiency (WUE), water scarcity remains a major concern in several parts of the world, listed as one of the largest global risks over the next decade [10]. Millions of families around the world remain vulnerable to water scarcity or do not yet have access to clean and adequate drinking water. More specifically:

(a) Over 2 billion people are living in regions experiencing high water stress and this number is expected to increase.

(b) Over 1 billion people do not have access to clean and safe drinking water.
(c) About 3.4 million people die each year due to the use of contaminated water.
(d) Millions of women and children spend several hours each day collecting water from an average distance of 6 km.
(e) At any given time, half of the world's hospital beds are occupied by patients suffering from diseases associated with lack of access to clean water.

Water scarcity imposes strong constraints in terms of social integrity and economic development. The primary sector that is affected is agriculture, accounting for more than 80% of the total water use [11]. Domestic use also follows an increasing trend over the years due to population growth, living standards requirements, and increasing temperature. These human alterations in the natural hydrologic cycle in conjunction with global warning will cause strong shifts in water availability and demands, and will intensify conflicts between users, outlining the need for updating the existing water governance plans to meet future demands and to ensure sustainable use of water. The improvements will require water resource planning at a finer spatial scale than the basic hydrologic unit (watershed) and give greater emphasis on water recycling, improved WUE by users, and real-time monitoring of water reserves and demands.

Considering the uneven spatial and temporal distribution of water resources and increased water demand, it is necessary to investigate the exploitation of alternative water sources, e.g., recycled water, brackish water, and rainwater [12,13], in order to close the gap between offer and demand [14]. Water recycling, particularly in agriculture, provides comparative advantages since it increases water availability for other activities (domestic and industrial use), reducing the competition between users and preventing overexploitation and degradation of natural water bodies. This perspective seems to be developing in many countries around the world [13,15–17].

The above-mentioned challenges of the water sector in a changing world underline the need for updating the existing water governance frameworks, policies, and applied management strategies to provide incentives and generate opportunities for sustainable use of water resources. Such measures are (a) the need to re-examine all potential sources including non-conventional sources, (b) development of region-wide water resource management programs, and (c) implementation of voluntary and mandatory water conservation measures.

This Special Issue on water supply and water scarcity addresses some of the above aspects, emphasizing on the current knowledge, future trends, and challenges in the water sector under water scarcity. More specifically, this special issue advances our existing knowledge on water resource management on five disciplines, focusing on (a) evolution of hydro-technologies through the centuries, (b) water management issues under water scarcity regimes, (c) rainwater harvesting (RWH), (d) quality of water resources, and on (e) climatic changes and/or variability impacts on water resources.

2. The Main Contribution of This Special Issue

The articles included in this issue cover a wide spectrum of thematology. The 12 papers published are grouped into 5 categories: (a) one paper deals with the evolution of irrigation technologies, (b) six studies focus on water management issues under water scarcity, (c) two papers investigate rainwater harvesting (RWH), (d) two papers deal with water quality and degradation of water resources, and (e) one paper addresses the chimeric changes impacts on water resources.

Angelakis et al. [18] review the evolution of irrigation practices through the millennia, considering archeological evidence from remnants and the relevant literature. Compiled knowledge indicates the development of sophisticated irrigation and water storage systems since the prehistoric times to adapt to water scarcity. Examples are provided from the Bronze Age civilizations (Minoans, Egyptians, and Indus valley), pre-Columbian societies, those grown in historic times (Chinese, Hellenic, and Roman), late-Columbian societies (Aztecs and Incas), Byzantines, Ottomans, and Arabs [19]. In ancient Egypt, for example, farmers took advantage of the periodic flooding of the Nile River to increase crop yields by putting out seeds in soils that had been recently covered and fertilized with floodwater and silt deposits. In arid and semi-arid regions, farmers used perennial springs and seasonal runoff under conditions completely different from the rivers of Mesopotamia, Egypt, India, and the first dynasties in China. The implications and impacts of irrigation on modern management of water resources, as well as on irrigated agriculture, are also discussed and the major challenges are outlined. An important finding from the study is that ancient practices could be adapted to cope with the present challenges in agricultural production and environmental protection.

2.1. Water Management under Water Scarcity Regimes

Preservation of ecological flow and natural water bodies remains a high priority under water scarcity conditions. Effective restoration and management plans for water can lead to significant benefits to the economy, society, and environment. Such a case is the historical Aculeo Lagoon, which is one of the largest natural bodies of water in central Chile [20]. The lake, from 2012 to 2018, was progressively dried as consequence of intense droughts in the surrounding area, causing imbalances between water reserves and withdraws. In the study, the modelling (MODFLOW) simulations confirmed the water imbalances between lake inflows and outflows, attributable to (i) high groundwater demands; (ii) drying of the lagoon's natural and/or man-made stream tributaries; and (iii) decreases in precipitation that affected water capture, storage, and natural drainage, resulting in the lake drying up. To address the problem, the study proposed the implementation of a monitoring and recovery plan (MRP) based on the simulation, considering the combination of three feasible options: (i) the recovery of natural tributaries, (ii) reductions of groundwater pumping, and (iii) feasibility analysis of water importation alternatives either from groundwater or nearby basins. Moreover, the authors argued that the restoration of the Aculeo Lagoon will require supporting actions, such as investments (USD 10 million) in infrastructure for water transfer into the lagoon and training of the involved stakeholders.

Acute and chronic water scarcity affects 4 billion people worldwide, a number that is likely to climb in the upcoming years due to population growth [21]. McNally et al. [22] investigated the development and implementation of a monthly acute water scarcity monitoring system on the basis of hydrologic data gathered from the Famine Early Warning System Network (FEWS NET) and the Land Data Assimilation System (FLDAS), as well as population data from WorldPop. The system computes the annual water availability per capita and yields updated maps of acute water scarcity at monthly intervals by using the Falkenmark classifications and departures from the long-term mean classification. The maps, designed to serve FEWS NET objectives, highlight the acute water scarcity events and provide up-to-date and interpretable information to decision-makers. Further improvements could include the applicability of the approach to lower spatial scales, improved coverage of the populations living in marginal areas (the Sahara Desert, Eastern Kenya, the Kalahari Desert), and addressing the uncertainties stemming from hydrologic or land surface modeling.

The study of van de Griend et al. [23] deals with the indoor use of water, examining the bathing technology. More specifically, the study showed that the inclusion of a hyperbolic vortex in a showerhead can increase the flow rate compared to a showerhead without a vortex for a given discharge without reducing the nozzle diameter. This was achieved by air bubbles introduced from the central part of the nozzle matrix in the sprayed liquid, causing higher liquid velocities and break-up length in the peripheral nozzles. The study argues that a vortex showerhead could save up to 14% of the water compared to conventional showerheads. Additionally, they detected an increase in pH and a reduction of the redox potential compared to conventional technology, indicating an increased degassing of CO_2 and an increased intake of O_2.

The Mediterranean region is among the regions that will be affected by climate fluctuations. Tzanakakis et al. [17] reviewed the availability of water resources and water uses in the island of Crete, highlighting the current and future challenges and opportunities for water management. In the island, despite the high theoretical water potential, there are areas under water scarcity, particularly in the southeastern part of the island, related to local soil-climatic conditions and the imbalances between water availability and demand. Important challenges highlighted by the study are the over-exploitation of groundwater, over-consumption mainly in the agricultural sector, mismanagement at the local level, low overall water use efficiencies, limited use of non-conventional water sources, lack of modern mechanisms of control and monitoring, and inadequate cooperation among stakeholders. The study proposes the improvement of the current water governance framework encouraging the implementation of an integrated and flexible water management plan, accounting for local social and economic specificities to allow for the successful adaptation to changing climatic conditions and to increasing water needs [17]. Moreover, it proposes the exploitation of alternative water sources (recycled water and brackish water); however, further work should be done on legislative framework to promote water reuse, particularly in agriculture, while ensuring the product safety and marketability. Finally, to alleviate the pressure on groundwater resources, the authors propose the adoption of cost-effective technological advances that improve water use efficiency in fields (efficient irrigation methods, crop adaptations, reduced soil tillage, and improvement of soil health).

Expenditure forecasting should be an integral part of long-term water resource management [24,25]. Borisova et al. (2020) estimated the expenditures required to develop alternative water supplies (e.g., reclaimed water, brackish groundwater, surface water storage, and stormwater) in the state of Florida, USA, to cope with the increasing needs for water, mostly driven by the constantly growing population, as well as to protect water resources from over-exploitation. The projections were based on estimations of previous projects using scenarios relying on such commonly used water sources. It was estimated that the state total investments needed to meet future water demands could reach USD 2 billion in the next 20 years, with the project implementation cost being dependent on project capacity, type, implementation status, and implementation region. The authors propose the expansion of stormwater use and the adoption of water conservation practices (defined as practices reducing wasteful and inefficient water uses) as more cost-effective options.

Urban water supply requires improved administration and operation of the domestic water distribution networks. Decision making processes should rely on reliable data that describe system operation, such as flows, potential failures, losses, and/or other problems, in order to addresses all issues properly and in a timely manner. Erickson et al. (2020) provided a detailed and long-term description of the water supply patterns in four areas in Arraiján, Panama, characterized by an intermittent water distribution network, identifying concurrently the challenges and opportunities for the current and future network management. The authors proposed an improved monitoring scheme for the water network that is based on the pressure and flow accounts, which could be helpful for longer-term planning and for the prioritization of system improvements. On a larger scale, they proposed reduction of water losses along with the increase in distribution storage capacity as a proper means to mitigate the adverse effects of the potential operational failures. Finally, the authors highlighted the need for investments in monitoring and data analysis to improve the potential and reliability of the intermittent water supply.

2.2. Rainwater Harvesting (RWH)

Rainwater harvesting (RWH) is a sustainable water management practice that has been adopted since the ancient times to augment water-potable and non-potable supplies in water-limited areas. Following a decline in the development of RWH systems in the last century, a renewed interest has emerged since the second half of the 20th century, driven mainly by rising water demands due to growing population, urbanization, climate variability, and by food security [26].

Yannopoulos et al. [27] provide a concise overview of the historical evolution of RWH systems, their current status, and the need for incentives for spreading RWH practice worldwide, particularly in water-limited countries. The compiled information indicates a renewed concern for RWH systems on a global basis, either as a standalone or combined with conventional technologies to confront water scarcity. They successfully state, "*Worldwide, rainwater harvesting has retrieved its importance as a valuable water resource, alternative or supplementary, in conjunction with more conventional water supply technologies. If rainwater harvesting is practiced more widely, many water shortages, actual or potential, can be alleviated*".

They also underline the need for more research, investments, and public awareness on the importance of RWH; economic incentives (subsidies and tax exemptions); and the development and enactment of pertinent regulations to meet the full potential of RWH systems as a complementary water supply technology, not only in rural areas but in urbanized areas as well.

Kuntz and Chisi [28] investigated the economic feasibility and user satisfaction in RWH systems in a residential building in Florianópolis (Brazil) by using a questionnaire survey. The economic feasibility analysis considered different rainwater demands, residents' habits, user satisfaction, and the importance of potable water savings. The findings of the study documented the economic feasibility of RWH systems in residential buildings for the middle and upper socioeconomic class. Showers had the greatest share (54.2%) of water consumption, followed by washing machines (21.3%), kitchen tap (9.3%), toilet flushing (9.2%) (the most economically feasible), and washbasins (2.6%). Overall, residents were satisfied with the perspective of a RWH system, indicating its high potential not only in reduction of the potable water consumption but also as a new marketing strategy for the private sector.

2.3. *Quality of Water Resources*

Water pollution is a critical issue in intensively managed agricultural areas derived from over-application of nutrients and pesticides and the adoption of non-sustainable field management practices [29]. Diffusing pollution from agricultural watersheds may cause severe problems in ecosystem functioning, quality of water resources, biodiversity, and human health [30].

Sihi et al. (2020) investigated the impacts of different farming systems (organic vs. conventional) of basmati rice on water quality during the rainy season at the Kaithal area, India. Drinking water quality and additional parameters were monitored and evaluated, including nitrates, total dissolved solids (TDS), soil salinity (as electrical conductivity EC), sodium adsorption ratio (SAR), and pH. Most parameters were kept below the regulated thresholds, except nitrates, for which an almost twofold increase was found in conventional fields compared to the organic fields, indicating potential risks for the drinking water supplies. This finding has profound implications for decision-makers in terms of managing nutrients and protecting water quality in agricultural areas more effectively.

The rapid rates of urbanization and industrialization have resulted in increased risks for the ecological degradation of rivers and, thereby, of the derived services [31]. This problem is widespread in China, particularly in the water-limited regions of the northern of part of the country [32]. Thus far, a key role to address the problem is the proper reservoir operation, which can restore the damaged river environment. Deng et al. [33] investigated the urban section of the Yitong River in Changchun, northern China, providing estimations of the ecological water demands and the reservoir operation. A reservoir operation scheme was proposed to restore the ecological quality of the river in its urban section, considering the existing limitations in the process of such operation schemes, including clarification of department responsibilities, updated regulations, strengthening service management, and encouraging public participation. The effect of proposed scheme on water quality and natural habitat of the river was evaluated by simulations with MIKE 11 a one-dimensional hydraulics-water quality model and the Physical Habitat Simulation Model (PHABSIM), indicating improvements in the ecological quality of the urban section of Yitong River.

2.4. *Climate Change Impacts on Water Resources*

There is a growing body of literature investigating the impacts of climate change on the availability of water resources at either the global and continental or country level. However, the pertinent simulations at local scales are still subjected to additional challenges arising from the downscaling procedure and from uncertainties [34,35]. Molina et al. [36] investigated the effect of climate change on the water budget in eastern Colombia, which currently experiences water scarcity due to increasing water demands for food production, industry, and domestic use. Using the model BROOK90 and historical and projected meteorological data, the authors provide information for potential changes in the water balance in four different regions characterized by distinct climatic conditions.

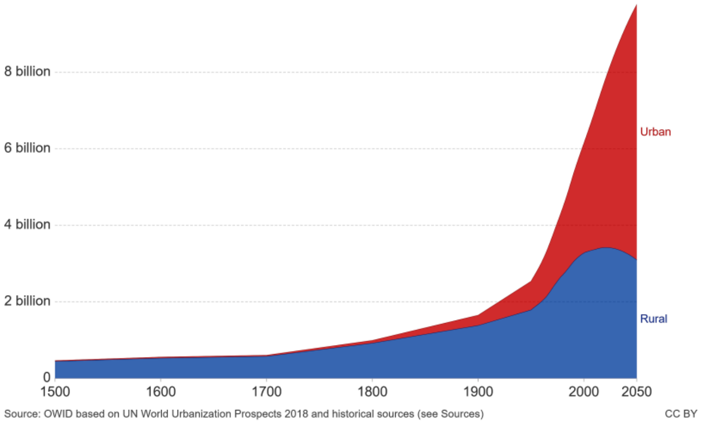
Projections were performed via a statistical regional downscaling procedure in which two climate change scenarios (RCP2.6 and RCP8.5) were simulated by two global climate models (CanESM2 and IPSL-CM5A-MR). The projections showed clear reduction in stream flow and changes in temporal distribution of water balance components and in hydrological regimes. Moreover, the projected changes in evapotranspiration, stored water, and soil moisture were found to be dependent on soil and land use characteristics and the climate scenario.

3. Challenges and Opportunities for in Improving Water Supply

Water has vital role for sustaining life on earth by regulating ecosystem functioning, preserving environmental quality, and supporting human health and welfare [37,38]. To date, the sustainable use of water resources faces grand challenges arising from population growth, fragile economic context, increased water demand, need to ensure food security, quality deterioration, and ageing infrastructures [19]. These challenges are not addressed effectively in the existing water governance plans, underlining the need for developing more sophisticated water management schemes adapted to changing conditions and requirements. Current insights in water resource management stress the importance of integrated, multi-sectoral, and (inter) national management plans, considering background specialties of the areas and motivating all the involved actors from governmental services and agencies, the private sector, the academy, and the public [17,39,40].

3.1. Growing Population and Urbanization

The world population will approach 10 billion in the next 30 years, and a significant proportion of this growth will take place in developing countries. Today, more than half of the world population is living in urban areas, particularly in highly dense cities; by 2050, more than two-thirds of the population will live in urban areas (Figure 1) [41]. On the basis of the facts that the available fresh water supplies on earth will remain the same, being unevenly distributed, these urban areas will become water-stressed [42,43], enhancing the conflicts among users, particularly among the urban, agricultural, and industrial sectors. At the same time, significant impacts are expected on availability and quality of water resources [44,45], quality of soil resources [46], potential water demand increases [47–49], flood intensity and frequency [50], and ecosystem functioning and derived services (e.g., food security) [51–54] impacts that are tightly inter-connected and influenced by background climate and terranean (land use/cover, geomorphology, and hydrologic) characteristics of the areas as well as by human activities. These factors should carefully be considered in the long-term planning of water resources [33,49,54]. Considering the above, it is urgent to improve water resource management by considering the option of alternative water supplies as well as by adopting strategies and measures promising improved water use efficiency by the potential users. Both options are discussed below in detail.



Source: OWID based on UN World Urbanization Prospects 2018 and historical sources (see Sources)

Figure 1. Urban and rural population projected to 2050 [41].

3.2. Climate Change (and/or Variability)

Climate change has already begun to affect water resources worldwide, through warming, shifts in precipitation patterns, and occurrence of extreme weather events (droughts, heat waves, floods) [55,56]. These impacts are not uniformly distributed, but they show strong spatial and temporal variations following climate variation [49,57]. For instance, in the Mediterranean basin, the pace of warming has been significantly greater than the global mean [58], which will likely lead to significant changes in water resources availability and water demands to cope with the higher frequency of droughts [59].

Pertinent studies reveal either intensification of the global hydrological cycle, i.e., increases in both evaporation and precipitation fluxes, or alterations from intensification to de-intensification with corresponding fluctuations on precipitation and evaporation patterns and an overly decreasing trend of global humidity [57,60,61]. Despite the general agreement regarding the climate model projections at global and regional scales [62,63], downscaling of these projections at scales that allow planning and effective management of water resources (e.g., watershed scale) still remain a methodological challenge [64]. Even at larger scales, uncertainty of global climate models and global hydrological models remains large [65].

Apart from the availability of water resources, it still remains highly uncertain as to how climate change will affect water use, particularly in the agricultural and domestic sector. Early studies' observations have shown increases in the WUE of agricultural crops [66], but this positive effect of elevated CO_2 may be eliminated under intense droughts due to the greater leaf area [67]. The effect of climate change on irrigation needs depends on climate change scenario and irrigation method [68]. A 9% increase in evaporative losses was reported that, however, was nearly counteracted by a reduction of non-evaporative losses. Moreover, projected increases in the aridity index [69] raise questions about the future of rainfed agriculture. High water deficits will require additional volumes of water to be allocated to rainfed agriculture to maintain its economic viability and the development of rural areas; however, ensuring additional water supplies for agriculture remains highly uncertain under the existing water management plans, policies, and existing infrastructure.

The situation is also comparable in the domestic sector. Accurate estimation of future demands requires information on the relationships between temperature and water consumption. Xenochristou et al. [70], using a combination of smart water metering data, household characteristics, and socio-economic data, developed such relationships, which could potentially be used for the planning of water use in the domestic sector. These relationships were complex and showed seasonal and weekly variations as well as strong dependencies on socio-economic status and household characteristics (e.g., presence or absence of gardens). More studies are needed to allow accurate estimation of domestic water needs in different climatic backgrounds.

3.3. Improving Water Use Efficiency

A major issue in water resources management is the reduction of water losses and the improvement of WUE. This issue is becoming more challenging nowadays due to population growth, need for economic recovery, and climate change. The main targets for improving WUE are the agricultural and domestic use, which account for the majority of water use (>95%) worldwide. Significant gains, in certain cases, can also be achieved in the industrial sector.

Although only marginally covered in this issue (Tzanakakis et al., 2020), significant water savings can be achieved through methodological and technological innovations in the agricultural sector. New methods of evapotranspiration (ET) estimation (eddy covariance towels), deficit irrigation, smart technologies for soil moisture monitoring, and user-friendly software can substantially improve WUE in the agricultural sector [71]. The currently used methods of ET do not account for the effect of deficit irrigation, resulting in overestimation up to 30% of the irrigation demands [72]. Investments in infrastructure and particularly in the maintenance of irrigation networks will result in significant water savings. Considering the fact that agriculture is the largest water user with a share up to 75% in (semi)arid climates, small improvements in WUE can result in significant gains in water availability, allowing for the adaptation of the sector to climate change and the ameliorating of the conflicts between users. In addition, the pressure on surface and ground water bodies will be alleviated decreasing the risk of ecological degradation as in the case of lake Chile [20].

Regarding the domestic water use, household-centered measures have the potential to result in significant reduction (30%) of drinking water consumption with small effort and without limitation of comfort, or even more (50%) if they are combined with effluent reuse and RWH [73]. Significant savings in domestic use can be achieved by decreasing the application of potable water for landscape irrigation [39]. In addition, technological innovations, updated policy frameworks, and market-based solutions that increase water supply and decrease demand will be needed to meet the challenge of sustainable domestic water supply. More specifically, provision of incentives and a flexible regulatory framework for promoting the adoption of appropriate technological solutions and tools, applicable at different levels of organization (e.g., households, urban infrastructures in conjunction with the effective motivation and education of end-users) will result in positive results. Taken together, optimizing WUE across different sectors poses as an important measure to mitigate or prevent water overconsumption and to improve water balances at either the regional or global level; the importance of WUE of terrestrial ecosystems on global water and carbon cycles is already under consideration [74,75].

3.4. Alternative (Non-Conventional) Water Resources

3.4.1. Wastewater Reuse

Water recycling has been proven to be a reliable solution to increase water availability in many areas of the world, especially in those suffering from water scarcity, serving agricultural, urban (non-potable and potable), industrial, and environmental needs and at the same time protecting human health and the environment [76–79]. Water reuse is also recognized as an adaptation solution to climate change [80,81], compatible with the concept of circular economy that is highly promoted in developed countries [15,82–84]. However, water reuse still lacks widespread implementation in several areas of the world, among them the EU [16], due to often strict regulations, social-economic issues, lack of awareness for the potential benefits, and economic constrains arising from value chain adaptation needs and product marketability [13,17,83]. Currently wastewater treatment plants (WWTPs), particularly in the developed world, are upgraded with new, more reliable, and more energy-sustainable processes, providing high-quality effluent and meeting the requirements, even for unregulated yet emerging pollutants and agents (pharmaceuticals, antibiotic resistance) [85,86] and decreasing significantly (or even eliminating) risks for public health and the environment [87,88]. Promoting water recycling for various beneficial uses instead of discharge to surface water bodies provides significant advantages to control pollution, preserve the spreading of antibiotic genes and emerging pollutants, maintain biodiversity, and improve the adaptation and resilience of urban and rural communities to climate change. There is a need, however, to effectively include the recycled water within the water management plans. The example of Spain is in the right direction, wherein a database with information about the treatment processes treatment costs, recycled water quality and volumes, and reuse activities in every autonomous community allows for the effective use of water [89].

3.4.2. Rainwater Harvesting

Rainwater harvesting is an alternative water supply that can have a significant contribution in meeting future water demands and to maintain/improve the quality of water resources. It has been proven to be a cost-effective solution in urban and sub-urban areas [27,28,90–93]. In recent years, there is a growing interest in both developing and developed countries (the EU, the USA, the United Kingdom, Japan, South Korea, Australia, and Africa) for RWH systems [27], driven mainly by their cost efficiency and potential benefits to different sectors of the economy, environment, water resources, and human health [94–96]. A comparative advantage of RWH is its flexibility for adaptation in various types of collection systems., ranging from small private-owned and managed structures to large-scale structures (multi-stores, schools, stadiums, airports and others), as well as to storm water collection systems from urban, suburban, industrial, and rural areas [27,95,97]. Further developments in the domains of technology, research, and education [27,98]; urban and water planning [91,95]; policy and legislative framework [27,91,95,99]; economic viability [100,101]; and public health risks [98] are still required.

3.4.3. Desalination

Desalination poses an important alternative water source, at least locally, to meet the water needs of the growing population in urban areas. It has been also used in intensified agriculture activities in order to cope with water pollution and it is a viable adaptation practice, particularly for urban areas to climate change [102,103]. Current advances in the field (membranes, decreasing costs of operation, lower energy) [104–109] have expanded desalination applications worldwide [110]. However, the potential environmental impacts of desalination processes is still a great challenge that imposes constrains in the expansion of the systems, particularly for developing countries [103,108]. Besides optimization of the current desalination technologies, promising alternatives include the use of small-scale desalination plants, combined use of seawater with brackish water where feasible, and energy recovery during desalination processing [17,108]. Such options may boost the adoption of desalination systems in the near future, corroborated by the ever-increasing needs for alternative water sources and the updates in applied technologies.

In summary, promoting the use of alternative water sources and effectively integrating these resources to existing management plans of (conventional) water resources will undoubtedly result in significant benefits (social, economic) and helping to cope with the challenges of the changing word (global warming, population growth, food security, environmental protection, public health).

3.5. Preserving Water Quality

Protecting the quality of water is a principal goal for humanity in the 21st century in order to preserve water availability and sustain life on the planet [111]. Despite the current knowledge of potential sources of pollution of water resources and adverse effects on the environment, biodiversity, and human health [30], critical issues still remain to be resolved with relation to inefficient policies, economic pressures, and competitions; lacking knowledge about the fate of emerging pollutants and contaminants and their impacts on biodiversity and humans; and knowledge transfer issues across policymakers, the research sector, and stakeholders [17,112,113]. Thus far, the emphasis has been placed on chemical pollution, particularly on inorganic and organic pollutants [30], and waterborne diseases (pathogens) [88,114,115], particularly in developing countries, arising from spreading of contaminants from various water sources [116]. In these areas, it is urgent to improve sanitation by applying early warning and prevention at source to mitigate pollution of freshwater resources [117,118].

The growing demands for alternative water resources to cope with the water scarcity phenomena, whether for agricultural and local irrigation or for industrial use and drinking water, underscore the need to implement safeguards. Technological insights in water treatment as well as updating existing reuse criteria for different types of reuse to integrate emerging pollutants should be of high priority [13,88]. For developing countries to improve sanitation and supply the population with safe drinking water, it is necessary to develop and implement cost-effective sanitation systems and household-centered sanitation, especially in rural areas [30]. Finally, it is necessary to develop technological tools and new approaches to identify and address the challenges arising from a growing population and climate change. The latter is likely to cause changes in pollutant/contaminant spreading patterns and in the frequency of infectious disease outbreaks due to intensified rainfall and flooding events [30,119].

4. Epilogue

As century continues, increased freshwater resources will be required in many parts of the world to meet the growing needs of the population and the uncertainties and consequences of climatic variability. At the same time, more efforts will be needed to identify and address the challenges that arise, including new threats to the quality of resources and ecosystems, as well as emerging needs to adapt and mitigate detrimental factors, especially in the regions under water scarcity. This Special Issue, "Water Supply and Water Scarcity", by considering historical and current research data, evaluates, discusses, and highlights most these challenges, providing in parallel general guidelines and possible solutions to improve water management. The main messages of the issue can be summarized as follows:

(a) There is an urgent need to review water management, particularly in areas with demographic changes and vulnerability to climatic conditions, in order to ensure sustainable and safe water supply. Implications by climate fluctuations should be carefully evaluated, covering a wide range of human activity and environment. Water management should address the emerging conflicts between water users by providing primary options and alternatives in distribution and use of water resources while protecting the sustainability of water resources.
(b) The adoption of advanced technological solutions and practices that improve water use efficiency by users should be a primary goal for water management to reduce water loss, support the sustainability of water resources, and increase the economic profitability of water.
(c) Increasing the use of alternative (non-conventional) water resources is an important option for the protection of water resources, especially in areas that are already experiencing water scarcity. In developed countries, new developments in WWTP technology provide the basis for expanding water reuse and reducing the competition between water users. Rainwater harvesting and storage, and desalination, especially of brackish water, also remain strong alternatives, depending on local conditions.
(d) Degradation of water quality should be of a global concern due to its impact on human health, biodiversity, and the sustainability of ecosystems. For developing countries, sanitation and supplying the population with safe drinking water should be of high priority, being supported by cost-effective and household-centered sanitation systems. The potential impacts on water resource quality by growing demands and climate change and/or variability arising from changes in spreading pattern of contaminants should be considered and evaluated.

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