Chapter

Global Water Mapping, Requirements, and Concerns over Water Quality Shortages

Aijaz Panhwar, Rashid Abro, Aftab Kandhro, Abdul Rauf Khaskheli, Nusrat Jalbani, Khadim Ali Gishkori, Atta Muhammad Mahar and Sofia Qaisar

Abstract

Water is a blessing and reason forsurvival on earth for human beings. Without water, it is not difficult to live on earth, but it is impossible. Water fulfills domestic, drinking, agricultural, and industrial requirements and makes everything useful for us. Unfortunately, rapid increase in population, unplanned agriculture practices, and industrial sector have become a serious issues for environment and for future needs. Water will be a very important issue for next generations to face. Safe water access up to 50–100 liters per day for drinking and sanitation is a right of every human being, recognized by the United Nations General Assembly in July 2010. Approximately, six billion people may suffer from scarcity of clean water by 2050. The agriculture sector is the largest consumer of freshwater around 70% followed by industry and domestic of 19 and 11%, respectively. The global demand for water is gradually increasing by 1% per year. Global demand for water is predicted to increase by 55% between the years 2000 and 2050. Existing global water demand has been projected to about 4600 km^3 every year and estimation may increase up to 20–30%, in range of 5500–6000 km^3 every year by 2050.

Keywords: agriculture, crops, environment, fertilizers, global, irrigation, population, pollution, sanitation, wastewater treatment

1. Introduction

Water is life; without water, survival is not possible. No water, no survival on earth. The safe water is right of all human beings on earth, to provide 50–100 liters of water for each person/day, for use in domestic and other necessities. It is fact that water is a precious gift on earth for us; 4000 km^3 of water withdrawal is done by human each year at rate of 1.6% of groundwater deposits. For unplanned increase in population, it is expected that water demand may increase up to 55%, 2000–2050. It will put more pressure on groundwater resources. The reason of the demand/pressure on groundwater resource is rapid urbanization, industrialization, and old

practices in agriculture sector. This means that millions of vulnerable families around the world do not drink, cook, or bathe with clean water. Groundwater is a major and important source for drinking purpose, irrigation, and industrial sectors. Major portion of groundwater around 65% is used as a drinking water, 20% for irrigation and livestock (agriculture), and 15% for industrial sector. The majority of the population depends on groundwater source. Groundwater resources are severely affected by unplanned increase in urbanization and traditional irrigation practices. This act does not decrease quantity of groundwater only, but it is also deteriorating its quality. The requirement of a person is 2–4 liters/day drinking water and up to 200 liters for sanitation and other necessities as described in **Figure 1**. Safe drinking water has become a dream for millions of people on the earth. Millions of populations have no access to safe drinking water and sanitation and are living without substantial supply of water. Around 4.5 billion (61%) have no access to proper sanitation and 2.1 billion (29%) no access to safe water [1]. Around minimum 200 liters of water is needed for feeding of one person per day [2]. Burek et al. [3] have estimated the requirement of water in different agriculture crops water needed by 2050, up to 23–42% above the level in 2010 [4]. Agriculture/irrigation is the biggest consumer of freshwater, as its share is 70%, and **Figure 2** describes the sector wise use of freshwater. As per report, water demand is gradually increasing at 1%/year. Scarcity of clean water has become serious issue of entire world population. If this increase of population pressure continues, it may reach up to 9.4–10.2 billion around 22–34% increase. Almost 50% of the population of entire world is living in mega cities called urban areas. The ratio of migration from rural to urban is more than expectations. The reason of migration is less facility of jobs, clean water, sanitation, poor education, and health system. Due to more facilities, the life of urban areas is easier as compared to rural area life. Presently, around 47% of the population is living in urban areas. Rapid migration to urban areas seems by 2050 around 52–65% of the population will be shifted in urban areas; every 07 out of 10 or 2/3 of the population may live in urban areas [5]. By 2050, the water quality and availability depend upon increase of population migration, industrial development, living standard, and quality of life. Around 57% of population may suffer for scarcity of water for 1 month in each year. In developing countries, this issue still only discusses water quantity and quality but no control. The situation is deteriorating and will be difficult/hard to control over the situation [6]. The consumption of water in United States of America has decreased dramatically in all sectors such as Domestic/Municipal, Industrial as well as agriculture [7]. The General Assembly by

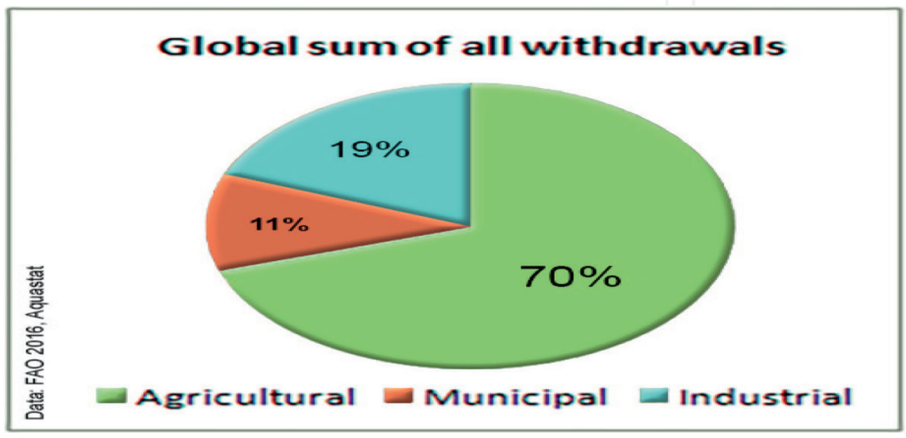

Figure 1.
Basic water requirements (per person) for human needs.

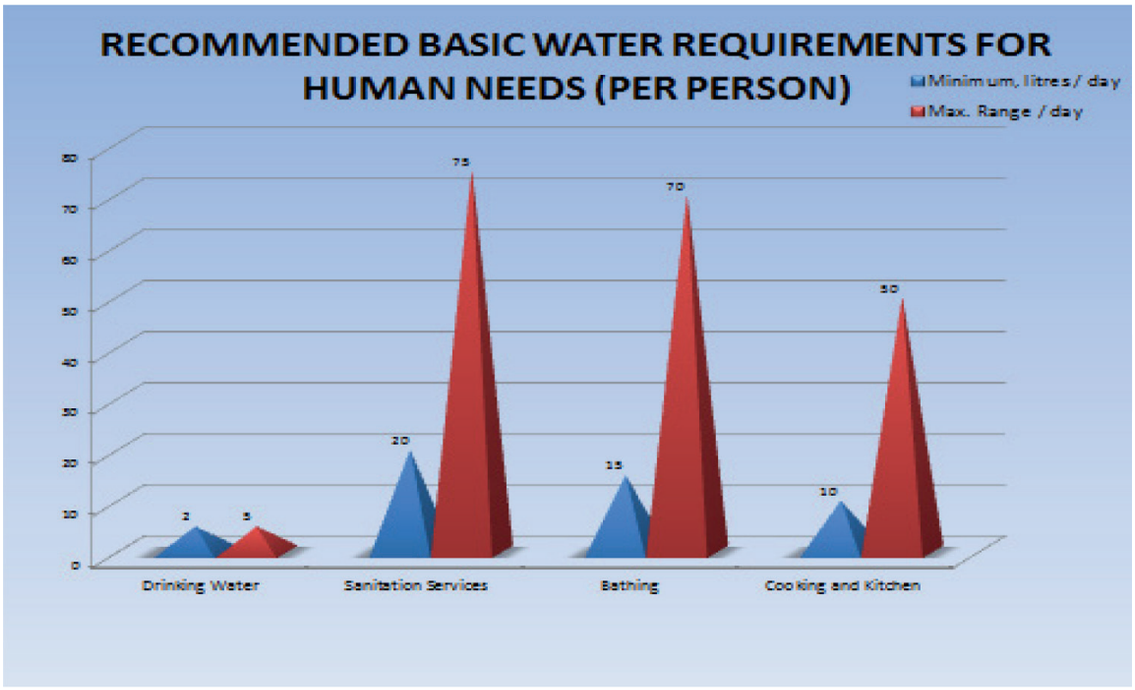

Figure 2.
Global sum of all withdrawals.

the UN recognized a historical decision for access to water and sanitation. The water costs should be within 3% of the income. The safe water should be in access, not away more than 1000 meters or within 30-minute distance from home. In 2016, India was the highest user of groundwater and the usage was more than China and even United States America [8]. The draw of groundwater in India 109–245 m^3, and the major share was used in agriculture sector; around 90% public of rural areas are used for house as well as for drinking purpose. In the last 50 years, the human population has more than doubled. This rapid growth with its accompanying economic development and industrialization has transformed water ecosystems around the world and resulted in a massive loss of biodiversity [9]. Nearly 50% of the world population is already living in potential water scarce areas and the number may increase for 4.8–5.7 billion in 2050. Almost 73% of the affected people are living in Asia (69% by 2050). As of 2015, 2.1 billion people (29 percent of global population) lacked access to safely managed drinking water and 4.5 billion people (61%) lacked properly managed sanitation. Due to advancement of technology, excess use of fertilizers is the main source of deterioration of water quality and has created serious concerns for environment, such as our drinking water containing various impurities of different nature such as biological, chemical, and physical. The utmost hazardous contamination is of biological nature, which causes serious human health problems and may cause death in many cases. About 10 billion tons of freshwater used by human result in severe pollution return to environment. It is estimated that about 80% of wastewater discharged from industries and municipal is directly released to the environment without any prior treatment, subsequently in a growing deterioration of overall water quality with the detrimental impacts on human health and ecosystems. Throughout world about 2.2 million people die every year by diarrheal disease. In developing countries, the main cause of 80% diseases is water related. The high-income countries treat about 70% of wastewater generated by industrial and municipal wastewater. The ratio of treatment is different for upper middle-income countries, and 38% of generated wastewater is

treated but very worst situation prevails in lower middle-income countries of up to 28%, while only 8% in low-income countries undergoes for treatment for reuse.

2. Global drinking water availability

Table 1 shows the water availability and distribution on the earth. Due to the rapid and unplanned growth of population, industrial development has changed the way of use [5]. Since last 100 years the consumption of water has increased up to 600% [11]. The demand of water may grow in the next three decades in all three important categories, such as agriculture, industry, and domestic, with some variations and the agriculture sector will be the same largest consumer of freshwater [5]. At present, there is around 4600 km^3/year demand of water for use and it may increase up to 20–30% by 2050. It is estimated up to 5500–6000 km^3/year [3]. The largest population growth/increase will be seen in Africa (13,000 million) or more than 100% of present population [12]. It is expected that GDP of the world may increase around 2.5% [13]. The demand of water for manufacturing sector may increase up to 400%, while use of energy can also increase over 20% during the period of 2010–2035. By 2050, the North America and Western Europe will be the largest user of the industrial water. This increase will go up to 800% in African continent. While at present there is nominal use of water in this continent, other side is of about 250% in Asia continent [11]. The use of domestic water scenario is different out of 100, which will be 10%. Definitely it will increase as population increases. The situation will be more different by 2050 in Asian and African countries; around 300% demands will increase, while in South and Central America up to 200% increase. The demand can increase dramatically throughout the continent and will be difficult to handle.

Water distribution	Percentage (%)
Rivers	0.0001
Atmosphere	0.001
Soil moisture	0.005
Inland seas	0.008
Freshwater lakes	0.009
Groundwater	0.61
Glaciers and other ice	2.15
Ocean water	97.2
Percentage earth's surface covered by water.	71
Available water on the planet (Cubic Miles)	326 million
Freshwater on earth is unavailable: protected up in glaciers, atmosphere, polar ice caps, and soil; either it is highly polluted; or rests too far off the earth's surface and to be extracted at an affordable cost.	2.5
Availability of freshwater on surface of earth	0.5

Table 1.
Distribution of the water on earth [10].

3. Global water demand

Figure 2 shows that agriculture is the largest consumer of freshwater uses, and there is around 70% of the world's accessible freshwater, but some 60% of this is wasted due to leaky irrigation systems. Agriculture and energy sectors are very important for human and both are water intensive. It is estimated the increase around 60% and 80% in both sectors [14, 15]. The rivers and lakes are in worst condition and almost polluted in Asia, Latin America, and Africa. Due to industrialization, climate change may change/increase in pollution level, which is a great threat to environment, aquatic system, human health, and hurdle in sustainable development goals [16]. The major reason of water quality deterioration is loading of nutrient and pathogen. There is also great impact of chemicals on water quality. The pollutant will increase more in lower- and lower middle-income countries, due to rapid and unplanned increase in population, uncontrolled economic activities, and lack of funds as well as the management of wastewater [16]. The withdrawal at present is at the highest level, of around 4600 km^3/year [17, 18]. Presently around 800 million people are suffering from food; by 2050 the need/demand of food production will be increased 50% for the feeding of more than 09 billion population, estimated on earth [19]. Around 800 km^3/year groundwater is used for agricultural irrigation sector in 2010. India was the largest consumer followed by USA, China, Iran, and Pakistan. These countries are using 67% of the total groundwater [3]. It is projected that groundwater withdrawal may increase more 39% amounting to 1100 km^3/year by 2050.

4. Water scarcity

As population is increasing, the use of water also increases. This situation creates shrinking position of the water resource availability. The drinking water quality is already affected by industrial development due to physical, biological, and chemical impurities. Among these, some impurities such as biological may lead to death [20]. Many countries are facing water shortage conditions and will face more wore worst conditions in reduction of water availability by 2050 [21]. In 2010, 27% or 1.9 billion of the population was living in water shortage areas. The population ratio may go up to 42–95% or 2.7 billion of the population. The majority of affected water shortage areas are living in Asia, and the ratio is around 73% of the global population [5]. Groundwater usage has become common without groundwater reality for its depletion [22]. Presently 3.6 billion people around 50% of the world's population is residing in water scarcity areas, which may increase up to 33–58% with 4.8–5.7 billion population by 2050 [21]. Almost 1100 million people around the world have lack of access to water; approximately 2700 million have water scarcity issue at least for a month in the whole year. Over a 2400 million people are exposed to diseases such as cholera, typhoid fever, and other water-borne diseases due to the improper sanitation. Considering 02 million people most of them are children per year and die from diarrheal diseases alone. About 2/3rd of the world's population may face the water scarcity problem by 2025 as per the current consumption rate, making the ecosystem of the world to suffer more. Inadequate access to freshwater already influences the development opportunities and lifestyle in water scarce areas [23]. Water (per capita) consumption changes considerably around the world. Countries or regions that are already developed may consume an average of 200 L/per person/per day.

Internationally adopted value for consumption of water is around 50 L/per person/per day, shown in **Figure 1** [17]. Recently, a report was published on USA's water consumption reduction in almost all sectors, municipal, agricultural, industrial, and thermoelectric power, but the report concludes that while substantial progress has been made, current water use trends are not sustainable in the face of population growth and climate change [7]. By the year 2025, as much as 60% of the global population may suffer from physical water scarcity [24, 25].

5. Water pollution

The treatment and wastewater management is reflex of the country's commitment, development, and its income level. Water pollution comes from many sources including pesticides and fertilizers that wash away from farms, untreated human wastewater, and industrial waste. Even groundwater is not safe from pollution, as many pollutants can leach into underground aquifers. Some effects are immediate, as when harmful bacteria from human waste contaminate water and make it unfit to drink or swim in. In other instances such as toxic substances from industrial processes, it may take years to build up in the environment and food chain before their effects are fully recognized. The rapid increase in population and unplanned use of surface and groundwater is a major reason of water pollution. In 2003, the wastewater generation was estimated around 1500 km^3/year, which was more than six times of water in rivers and lakes of the world [26]. Around 2.4 billion people (30%) of the population are living without sanitation facility [27], because the water pollution is connected with population and industrial development [27]. The lack of facility for sanitation is also source of water contamination, which is one of the major reasons of pollution. The developing countries are the major contributor of water pollution. These countries are discharging 90% of sewage water directly in surface water bodies without any proper treatment [27]. About 730 million tons of waste is discharged into the water [28]. The share of industry in waste is 300–400 tons/year. It is estimated that due to degradation of resources of freshwater around 30% of global diversity has been lost so far [29]. Excess use of fungicide, insecticide, and herbicides are equally responsible for water resource pollution, contain toxic and carcinogenic substances, and heavily affect human and wildlife. Pesticides are also equally responsible for biodiversity and destroying insects and weed, which have negative impacts further on the food chain. About 120 million tons of nitrogen converts from the atmosphere in form of reactive nitrogen each year and around 2/3 of its goes to water bodies [30]. The fertilizer is very important source of phosphorus, nitrogen, and other macro- and micro-nutrients for agriculture, and as per reports use of fertilizer was 90 million ton/year in 2000 and may increase dramatically up to 150 million/year to increase the production to feed the population by 2050. The use of phosphorus and nitrogen can also increase up to 150–180% by 2050 [15]. Eutrophication in lakes of European countries such as Rhine, Danube, and Elbe Rivers is becoming a serious issue during 1970s–1980s. Water quality is failing to meet the standards and cause of oxygen-level depletion. Yet in 2009, around 20% of European lakes suffered from nutrient enrichment. Not this but nitrate concentration is increasing in groundwater resources [31]. Water is a basic need of all industrial sectors in different operational processes. It is estimated that around 5–20% of used water in industries turns into the polluted water and enters into the surface water bodies, rivers, canals, and pollute freshwater, as well as sea. Around 7% of untreated industrial wastewater is directly discharged into

water and ultimately affects freshwater resources [32]. The largest portion of waste producer is countries from high-level income group. The share of these countries is around 70 percent in wastewater treatment; dramatically it is 38 percent share of countries from upper-middle income, while there is 28 percent share in wastewater treatment by lower-middle income countries and the lowest share is from low-income countries, which is only 8 percent of generated wastewater by industrial sectors [33].

The policies and seriousness of the countries are toward the main threat in the future; the share of the European countries in treatment is 71% from industrial and domestic/municipal sectors. Other side of around 20 percent shares of countries is from Latin America, while 51 percent the largest share is in treatment by Middle East and North Africa as shown in **Table 2**. Due to lack of funds by African countries, it is very difficult to treat the industrial and municipal wastewater generated by industries and domestic. It is reported that no data of wastewater generation, discharge, and treatment of 32 countries out of 48 from African countries are available in government- or water-related agencies [33]. Wastewater is the biggest threat for toxic and polluted wastewater from different industries, textile, sugarcane, pharmaceuticals, paper, food and some other industries. Around 2.2 million people die per year only by diarrhea diseases [38]. Around 10.4 million deaths of infants of about 17% are caused by the disease only. Among 80% of diarrhea cases, the reason behind is only lack of safe drinking water, poor facilities of sanitation, and unhygienic conditions. Use of nitrogen in different crops in agriculture sector is around 120 million tons converting from atmosphere into reactive nitrogen comprising of compounds every year [30]. About 2/3 of it goes into lands and in water sector bodies as well as in coastal zones. Approximately 150 million tons project the use of fertilizer by 2050, as compared to 90 million tons in year 2000 [39]. Due to the use of phosphorus and nitrogen, effluent will jump up to 150 and 180 percent by 2050, respectively [15]. The chemicals used in agriculture have enhanced up to 02 million tons each year, and around share of fungicides is 17.5 percent, insecticides 29.5 percent, and herbicides 47.5 percent and other's share is 5.5 percent. The economic growth and unplanned growth of population are also of great threats and main responsible for deterioration of quality of the water. Almost rivers of Asia, Latin America, and Africa are suffering from severe pollution level. Groundwater status in Europe was not perfect. Some stations of Europe were detected above level of nitrate in drinking water, recorded by the monitoring stations. As per reports, rivers around 30 percent and lakes 40 percent recorded eutrophic during the period of 2008–2011.The agriculture cultivation by wastewater is directly related to health issues, especially food (vegetables) in urban areas. About 10 percent of the population of world depends only on the food cultivated by polluted wastewater [40]. Around 26 percent productions of vegetables directly use wastewater in Pakistan; this situation prevails in all regions of the world [33]. Around 80 percent of total generated wastewater is directly discharged without fulfilling the requirements of regulatory bodies [41]. The treated wastewater usage is the largest and vital source for agriculture and other sectors. The use of safe-treated wastewater is gradually increasing its availability, especially in many Arab and other developing countries. It is reported that 71 percent of wastewater was effectively treated in Arab countries during 2013 and 21 percent out of 71 percent was utilized in agriculture sector (irrigation) and recharge of groundwater [41]. The treated wastewater use has become very important for water sector. At present, the market of wastewater is more than 700 billion dollars per year and increasing dramatically. In 2012, around 824,000 deaths occurred due to lack of the facilities of sanitation, drinking water, and proper hand washing in low- and middle-income countries. The

Counties	Treated municipal wastewater km^3 (Year)	Produced municipal wastewater km^3 (Year)	Direct use of treated municipal waste water in irrigation Km^3 (Year)
Japan	11.56 (2011)	16.93 (2011)	0.012 (2009)
Mexico	3.08 (2011)	7.46 (2011)	0.40 (2010)
China	26.61 (2009)	37.98 (2010)	0.48 (2008)
United States	40.89 (2008)	60.40 (2008)	0.33 (2004)
Germany	5.18 (2007)	5.30 (2007)	
Brazil	2.51 (2009)	9.73 (2009)	0.008 (2008)
Republic Korea	6.58 (2011)	7.84 (2011)	
India	4.42 (2011)	15.44 (2011)	
Egypt	3.71 (2012)	7.08 (2012)	
Canada	3.55 (2009)	6.61 (2009)	
Malaysia	2.60 (2009)	4.22 (2009)	
Thailand	1.17 (2012)	5.11 (2012)	
Turkey	2.72 (2010)	3.58 (2010)	
United Kingdom	4.05 (2011)	4.09 (2011)	
Italy	3.9 (2007)	3.93 (2007)	
France	3.77 (2008)	3.79 (2008)	
South Africa	1.92 (2009)	3.54 (2009)	
Iran	0.89 (2012)	3.55 (2010)	
Pakistan	0.55 (2011)	3.06 (2011)	
Spain	3.16 (2004)	3.18 (2004)	
Argentine	0.29 (2000)	2.46 (2010)	
Columbia	0.60 (2010)	2.40 (2010)	
Poland	1.36 (2011)	2.27 (2011)	
Vietnam	0.20 (2012)	1.98 (2012)	
Netherlands	1.88 (2010)	1.93 (2010)	
Australia	2.00 (2013)	1.83 (2007)	
Saudi Arabia	1.06 (2010)	1.55 (2010)	
Peru	0.10 (2012)	1.00 (2011)	

Table 2.
Municipal wastewater production, collection, and treatment in countries with the largest urban populations [33–37].

contaminated drinking water was one of the biggest sources of other causalities as well [42]. The water-related diseases are widely source of diarrhea in low middle- and low-income countries. Around 275,000 square kilometers of land was irrigated throughout world [34]. For example, the percentage of wastewater release without treatment has been estimated at 77% for Thailand (2012), 82% for Pakistan (2011), 84% for Armenia (2011), and 81% for Vietnam. Improving the efficiency of wastewater management would contribute to the achievement of the 2030 Agenda for

Sustainable Development in the region [41]. Approximately 15 percent of irrigated land can be cultivated by treated wastewater because around 330 square kilometers of municipal wastewater are generated per year in world and can be used for irrigation/cultivation on 40 million hectares (8000 m^3/hectares) [43]. Irrigation by wastewater or diluted wastewater is still fragmentary around 5–20 million hectares, almost lion share of China [44]. It is between the ranges of 2 and 7% of globally total cultivated area. Around 500 children's death is due to diarrhea-related diseases in India, which is contaminated water causing diseases. About 106 billion dollars or 5.2 percent of GDP is losing India from lack of sanitation and other facilities. On other side Israel has dramatically reduced its agricultural water budget from 70 percent to 55 percent and reduced to 15 percent in twenty years (1985–2005).

6. Conclusion

Economic development cannot declare whole reason for the detoriation of water quality as well as no solution for all problems. Some other steps are also very essential such as watershed management, which is very important for the water quality, water availability increase, and recharge of groundwater and helpful for reduction of other impacts. It is essential for managing irrigation water efficiency and protects the water quality. Allocation of water for agriculture is very hard/core issue and accurate data can play very important role for water conservation/saving and due to this many lives can be saved, which leads to cost reduction and minimizes other impacts on water resources/reservoirs. It is recommended to be a creative mind for the water management system such as municipal, industrial, and irrigation. The policy should be formulated on every country's basis, and should focus on less water requirement crops and latest techniques of irrigation system, such as micro-irrigation, and drip and sprinkler irrigation system, should be introduced/implemented to replace the traditional irrigation system. Crops with high yield on the lowest water use should be introduced to feed the population of around 9 billion by 2050, because population increase by 2050 will severely affect water resources and may reduce the availability of water. For policy making, it is necessary for data availability of wastewater generation, and its discharge without treatment or treated, without complete or proper information, is very difficult to make action plan and protection of environment resources from wastewater pollution. Given the importance of water we need to save water and change our life style to minimize use of water. It is difficult to imagine life on the earth without water. We should adopt agriculture mechanization, high-yielding seeds, and crops to be cultivated on less water, by replacing new irrigation techniques including drip irrigation and sprinkle irrigation, by water savings to cope with the growing population by 2050. With improving irrigation efficiency, the usage of freshwater can be reduced. It is recommended to monitor the entire water management system including agriculture to prevent from a severe crisis of water management and for that, we should be more creative than we ever were. For efficient usage of water, there is a need for the development of Global Monitoring Information System for water, which will provide us the necessary information on water management and progress monitoring of desirable targets. Development of this system will provide us the wide spectrum of information from different levels, like from local to national and ultimately the global level. Hurdles to research, technology, and innovation applications are due to the lack of financial resources for improvement of existing

technologies in developing countries but also the lack of awareness for promoting the research and innovation in the countries that are already developed to shift to the new and efficient technologies for large-scale applications. The high costs of high-end technologies hamper their widespread application, especially in developing countries. It is because of the quick depletion of the available resources of water and its impact on climate change, conventional irrigation systems must be revised because it cannot sustain in many areas around the globe. In brief, the demand for water will increase by 2050 but the availability of water will be reduced. Water resources will reduce. Pollution will further reduce the amount of clean freshwater.

Conflict of interest

The authors declare no conflict of interest.

Author details

Aijaz Panhwar[1*], Rashid Abro[2], Aftab Kandhro[3], Abdul Rauf Khaskheli[4], Nusrat Jalbani[1], Khadim Ali Gishkori[5], Atta Muhammad Mahar[1] and Sofia Qaisar[2]

1 Pakistan Council of Scientific and Industrial Research Laboratories Complex, Karachi, Sindh, Pakistan

2 Department of Chemical Engineering, Dawood University of Engineering and Technology, Karachi, Sindh, Pakistan

3 M. A. Kazi Institute of Chemistry, University of Sindh, Jamshoro, Sindh, Pakistan

4 Shaheed Mohtarma Benazir Bhutto Medical University, Larkana, Sindh, Pakistan

5 Pakistan Standards and Quality Control Authority, Karachi, Sindh, Pakistan

*Address all correspondence to: aijazap@yahoo.com

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References

[1] United Nation International Children Emergency Fund/World Health Organization. Progress on Drinking Water, Sanitation and Hygiene: Update and SDG Baselines. Geneva, Switzerland: WHO; 2017

[2] Food Agriculture Organization. Coping with Water Scarcity: Q & a with Food Agriculture Organization Director-General Dr Jacques Diouf. Newsroom: Food Agriculture Organization; 2007

[3] Burek P, Satoh Y, Fischer G, Kahil MT, Scherzer A, Tramberend S, et al. Water Futures and Solution: Fast Track Initiative (Final Report). IIASA Working Paper. Laxenburg, Austria: International Institute for Applied Systems Analysis; 2016

[4] Food Agriculture Organization. The State of the World's Land and Water Resources for Food and Agriculture: Managing Systems at Risk. Rome/London: FAO/Earthscan; 2011

[5] United Nation World Water Assessment Programme. The United Nations World Water Development Report. Geneva, Switzerland: United Nation World Water Assessment Programme; 2018

[6] Mekonnen MM, Hoekstra AY. Four billion people facing severe water scarcity. Science Advances. 2016;**2**(3):1-6

[7] Donnelly K, Cooley H. Water Use Trends in the United States. Oakland, Calif: Pac. Inst; 2015

[8] NGWA. Facts about Global, Groundwater Usage Compiled by NGWA. USA: NGWA; 2016

[9] CGWB. Ground Water Brochure, Medak District, Andhra Pradesh, India. 2013

[10] Where is Earth's water. United States Geological Survey. Available from: https://web.archive.org/web/20131214091601/http://ga.water.usgs.gov/edu/earthwherewater

[11] Wada Y, Flörke M, Hanasaki N, Eisner S, Fischer G, Tramberend S, et al. Modelling global water use for the 21st century: The water futures and solutions (WFaS) initiative and its approaches. Geoscientific Model Development. 2016;**9**:175-222

[12] United Nations Department of Economic and Social Affairs. World Population Prospects: Key Findings and Advance Tables – The 2017 Revision. Working Paper No. ESA/P/WP/248. New York: UNDESA, Population Division; 2017

[13] Organisation for Economic Co-operation and Development. Organisation for Economic Co-Operation and Development, Environmental Outlook to 2050: The Consequences of Inaction. Paris: OECD Publishing; 2012

[14] Alexandratos N, Bruinsma J. World Agriculture Towards 2030/2050: The 2012 Revision. ESA Working Paper No. 12-03. Rome: Food and Agriculture Organization of the United Nations (FAO); 2012

[15] Organisation for Economic Co-operation and Development. OECD Data: GDP Long-Term Forecast (Indicator). Paris, France: Organisation for Economic Co-operation and Development; 2017

[16] United Nation World Water Development Report. Nature Based Solution for Water. 2018

[17] Gleick PH, Palaniappan M. Peak water limits to freshwater

withdrawal and use. Proceedings of the National Academy of Sciences. 2010;**107**(25):11155-11162

[18] Hoekstra AY, Mekonnen MM. The water footprint of humanity. Proceedings of the National Academy of Sciences. 2012;**109**(9):3232-3237

[19] Food and Agriculture Organization of the United Nations/International Fund for Agricultural Development/United Nations Children's Fund/World Food Programme/World Health Organization. The State of Food Security and Nutrition in the World 2017: Building Resilience for Peace and Food Security. Rome: World Health Organization; 2017

[20] Park K. Preventive and Social Medicine. 25th ed. Prem Nagar, Jabalpur, India: M/s Banarsidus Bhanot; 2007

[21] Veldkamp TIE et al. Water scarcity hotspots travel downstream due to human interventions in the 20th and 21st century. Nature Communications. 2017;**8**:15697

[22] Scanlon BR et al. Global evaluation of new GRACE mascon products for hydrologic applications. Water Resources Research. 2016;**52**:9412-9429

[23] Qadir M, Sharma BR, Bruggeman A, Choukr-Allah R, Karajeh F. Non-conventional water resources and opportunities for water augmentation to achieve food security in water scarce countries. Agricultural Water Management. 2007a;**87**:2-22

[24] Pimentel D, Bailey O, Kim P, Mullaney E, Calabrese J, Walman L, et al. Will limits of the Earth's resources control human numbers. Environment, Development and Sustainability. 1999;**1**:19-39

[25] Rijsberman FR. Water scarcity: Fact or fiction? Agricultural Water Management. 2006;**80**:5-22

[26] United Nation World Water Assessment Program. Water for People, Water for Life: 3rd World Water Forum in Kyoto, Japan. Geneva, Switzerland: United Nation World Water Assessment Program; 2003

[27] United Nation International Children Emergency Fund/World Health Organization. Progress on Sanitation and Drinking Water 2015, Update and MDG Assessment. Geneva, Switzerland, 2016: JM Program; 2015

[28] The United Nations world water development report. Wastewater: The Untapped Resource. New York, United States: The United Nations World Water Development Report (United Nations Educational, Scientific and Cultural Organization; 2017

[29] United Nations, Water. Wastewater Management-a UN-Water Analytical Brief 1-52. Geneva, Switzerland: World Meteorological Organization; 2015

[30] Rockström J, Steffen W, Noone K, Persson Å, Chapin FS III, Lambin E, et al. Planetary boundaries: Exploring the safe operating space for humanity. Ecology and Society. 2009;**14**(2):32

[31] Ralf I, Kari A, Dietrich B, Benjamin B, Wera L, Evelyn L, et al. European Assessment of Eutrophication Abatement Measures across Land-Based Sources, Inland, Coastal and Marine Waters. European Environment Agency, European Topic Centre on Inland, Coastal and Marine Waters. ETC/ICM Technical Report 2/2016. Germany: Helmholtz Centre for Environmental Research GmbH-UFZ; 2016

[32] United Nations World Water Assessment Programme. The United Nations World Water Development Report. Geneva, Switzerland: United

Nations World Water Assessment Programme; 2009

[33] Sato T, Qadir M, Yamamoto S, Endo T, Zahoor M. Global, regional, and country level need for data on wastewater generation, treatment, and use. Agricultural Water Management. 2013;**130**:1-13

[34] AQUASTAT. Area Equipped for Irrigation. Infographic. Rome: Food and Agricultural Organization of the United Nations; 2014

[35] Water Resource Department of Land and Water Bureau. Water Resources in Japan. Japan: Ministry of Land Infrastructure, Transport, and Tourism Japan; 2012

[36] Environment Canada. Municipal Water Use Report: Municipal Water Use. 2006 Statistics. Gatineau: Environment Canada; 2010

[37] Jiménez B, Asano T. Water Reuse: An International Survey of Current Practice, Issues and Needs. London: IWA; 2008

[38] United Nation Development Program. Human Development Report, 2006. Beyond Scarcity: Power, Poverty and the Global Water Crisis. New York, United States: United Nation Development Program; 2006. p. 440

[39] Winiwarter W, Erisman JW, Galloway JN, Klimont Z, Sutton M. Estimating environmental loads of reactive nitrogen in the 21st century. Climatic Change. 2013;**120**:889-901

[40] World Health Organization/Food Agriculture Organization. Guidelines for the Safe Use of Wastewater, Excreta and Grey Water in Agriculture and Aquaculture. third ed. Vol. 1-4. Geneva: World Health Organization; 2006

[41] United Nations World Water Assessment Programme. The United Nations World Water Development ReportWastewater: The Untapped Resource. Paris: United Nations World Water Assessment Programme; 2017

[42] World Health Organization. Preventing Diarrhoea through Better Water, Sanitation and Hygiene: Exposures and Impacts in Low and Middle Income Countries. Geneva: Switzerland; 2014

[43] Mateo-Sagasta J, Raschid-Sally L, Thebo A. Global wastewater and sludge production, treatment and use (Chapter-02). In: Wastewater: Economic Asset in Urbanizing World. Netherlands: Springer; 2015

[44] Drechsel P, Evans AEV. Wastewater use in irrigated agriculture. Irrigation and Drainage Systems. 2010;**2010**(24): 1-3. DOI: 10.1007/s10795-010-9095-5