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Water Policy for Sustainable Management: A Review

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Abstract
Water is essential for life and sustainable development. The demand for the world's increasingly scarce water supply is rising rapidly, challenging its availability for food production and putting global food security at risk. Managing water resource is essential for the international community to deliver the promise of the 2030 Agenda for Sustainable Development. Water is the foundation of sustainable development as it is the common denominator of all global challenges: energy, food, health, peace & security, and poverty eradication. This research review addresses the factors for increasing global fresh water use per year, global water policy for sustainable management, challenges, traits and opportunities with the conclusion of determining the best practice of water policy for the future generation. The world population increased from year to year due to increasing population, economic development and climate change. As a result, water resource policy which encompasses the policy-making processes that addresses provision, use, disposal and sustainability decisions, as well as, how policies created, executed, and amended by adopting set of best management practices to govern water management is the primary concern. Thus, to achieve sustainable water management; planning, development and management of water resources with best water policy that includes a multi-disciplinary and holistic approach in which technical, environmental, economic, landscape aesthetics, societal and cultural issues addressed.
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1. INTRODUCTION

Water is the foundation of sustainable development as it is the common denominator of all global challenges: energy, food, health, peace and security, and poverty eradication [24]. Only 3% of the Earth's water is fresh water the remaining 97% is found in seas and oceans. While all lakes, rivers and swamps combined only account for a small fraction 0.3% of the Earth's total freshwater reserves [21]. Demand of this fresh water that is vital to life increasing due to the world's population growth, for this matter both direct and virtual water (water embedded in a product) use is also increasing as the same time. Water plays an important role in the world economy, such as in agriculture, in domestic, in industrial sector, in fishing, in transportation aid (long-distance trade of commodities, such as oil, natural gas, and manufactured products transported by boats through seas, rivers, lakes, and canals), in cooling, in heating and in many sports and other forms of entertainment; such as, swimming, pleasure boating, boat racing, surfing, sport fishing, diving, ice skating and skiing, etc. Overall, it is critical for socio-economic development, healthy ecosystems and for human survival.

Demand for the world's increasingly scarce water supply is rising rapidly, challenging its availability for food production and putting global food security at risk. Managing water resource is essential for the international community to deliver the promise of the 2030 Agenda for Sustainable Development [27]. Agriculture, upon which a burgeoning population depends for food, is competing with industrial, household, and environmental uses for this scarce water supply. Even as demand for water by all users grows, groundwater is being depleted, other water ecosystems are becoming polluted and degraded, and developing new sources of water is getting costlier [1].

Water resource policy which encompasses the policy-making processes that affect the collection, preparation, use and disposal of water to support human uses and protect environmental quality study is very important. This water policy addresses four decisions such as provision, use, disposal and sustainability decisions. The first decision was provision decisions; that include identification, access, preparation for use and distribution. Secondly, use decision that includes direct human consumption, agriculture, industry and ecosystem protection. The third decision was disposal decisions that involves wastewater treatment and storm water /flood management. The last decision that should have to be addressed in water policy was sustainability decision issues, such as aquifer depletion, reservoir management and mineral buildup. Water policy, therefore shows us, how the policies created, executed and amended, since water resources cross political boundaries and it must often be negotiated among multiple political entities (nations, states, etc.). Policy makers typically should adopt a set of best management practices (BMPs) to govern water management. When we say best management practices it will cover everything, like from dam construction to wastewater treatment protocols.

Sustainable water management is a critical component of water policy and sustainable development. For

meeting of current water demand for all water users without impairing future supply best water policy is mandatory. Achieving sustainable water management requires a multidisciplinary and holistic approach in which technical, environmental, economic, landscape aesthetic, societal and cultural issues addressed. Though, water is a prime natural resource, a basic human need and a precious world asset, planning, development and management of water resources need to be governed by worldwide perspectives.

2. WHY IS IT NECESSARY TO STUDY WATER POLICY?

Is that possible to feed 8.1 billion populations in 2025? Or 10 billion populations in 2057? [23]. The answer is impossible unless, better water policy created, amended and executed for sustainable water management since water have big role specifically in the production of food and generally in economic development. As different research finding shows that global water use is increasing per year due to increasing population, economic development with shifting consumption patterns, combined with a more erratic and uncertain supply and climate change which aggravate the situation of currently water-stressed regions, and generate water stress in regions where water resources are still abundant today [8,17].

2.1. Population

The world population increased from 2.77 billion to 7.794 billion since 1955 till end of 2020 with the growth rate of 1.88% to 1.05 % respectively. The yearly population percentage change also increased at increasing rate from 1955 up to 1970, whereas from 1970 up to 2020 increased at decreasing rate. The density of population per kilometer square and urban population also increased from 1955 up to 2020 (Vide Table.1). These increments of population in addition to other factors have impact on the demand of water for both direct consumption and virtual use [23]. Thus, the water policy affected due to increasing of global population that needs amendments to bring water resource sustainability on the globe.

Table 1. World population (2020 and historical), According to United Nations Population Division of the Department of Economic and Social Affairs

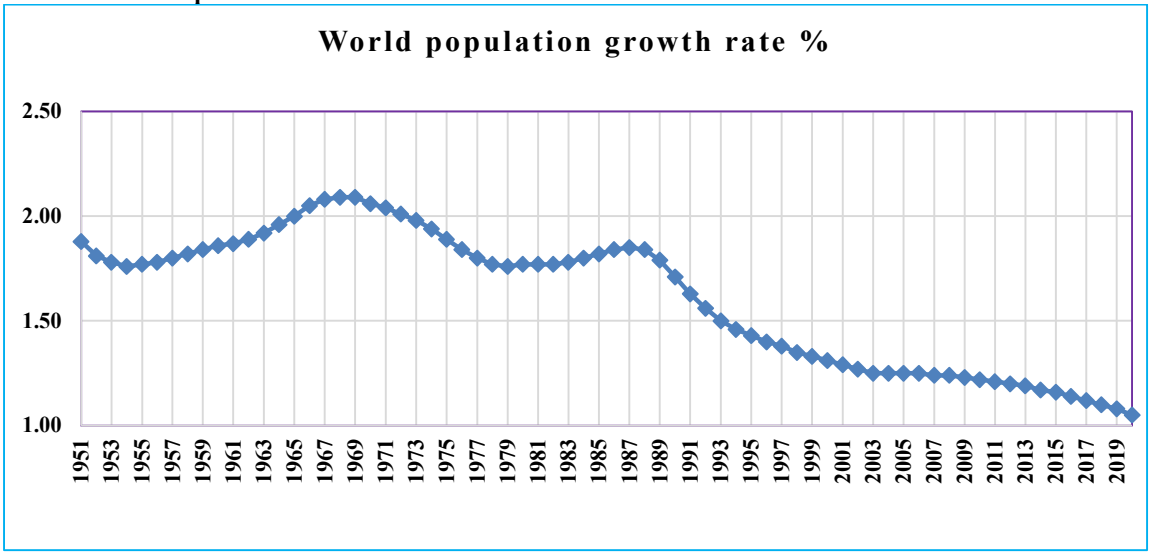
Year	World Population	Yearly Change	Net Change	Density (P/Km²)	Urban Population	Urban Population %
2020	7,794,798,739	1.05%	81,330,639	52	4,378,993,944	56%
2019	7,713,468,100	1.08%	82,377,060	52	4,299,438,618	56%
2018	7,631,091,040	1.10%	83,232,115	51	4,219,817,318	55%
2017	7,547,858,925	1.12%	83,836,876	51	4,140,188,594	55%
2016	7,464,022,049	1.14%	84,224,910	50	4,060,652,683	54%
2015	7,379,797,139	1.16%	84,506,374	50	3,981,497,663	54%
2014	7,295,290,765	1.17%	84,708,789	49	3,902,831,934	53%
2013	7,210,581,976	1.19%	84,753,917	48	3,824,990,329	53%
2012	7,125,828,059	1.20%	84,633,758	48	3,747,842,586	53%
2011	7,041,194,301	1.21%	84,370,698	47	3,671,423,872	52%
2010	6,956,823,603	1.22%	84,056,510	47	3,594,868,146	52%
2005	6,541,907,027	1.25%	80,747,638	44	3,215,905,863	49%
2000	6,143,493,823	1.31%	79,254,768	41	2,868,307,513	47%
1995	5,744,212,979	1.43%	81,062,552	39	2,575,505,235	45%
1990	5,327,231,061	1.71%	89,789,503	36	2,290,228,096	43%
1985	4,870,921,740	1.82%	86,910,119	33	2,007,939,063	41%
1980	4,458,003,514	1.77%	77,497,414	30	1,754,201,029	39%
1975	4,079,480,606	1.89%	75,686,434	27	1,538,624,994	38%
1970	3,700,437,046	2.06%	74,756,419	25	1,354,215,496	37%
1965	3,339,583,597	2.00%	65,605,259	22	1,188,469,224	36%
1960	3,034,949,748	1.86%	55,373,563	20	1,023,845,517	34%
1955	2,773,019,936	1.77%	48,173,195	19	877,008,842	32%

The Population of the world is currently (2020) growing at a rate of around **1.05%** per year (down from 1.08% in 2019, 1.10% in 2018, and 1.12% in 2017). The current average population increase is estimated at **81 million people per year (Vide Figure.1)**.

World population will therefore continue to grow in the 21st century, but at a **much slower rate compared to the recent past**. World population has doubled (100%) increase in 40 years from 1960 to 2000 by 3 billion to 6.1 billion respectively (Vide Table 1). It is now estimated that it will take another nearly 40 years to increase by another 50% to become 9.1 billion by 2040 as shown in Table 2. The latest world population projections indicate

that world population will reach 10 billion persons in the year 2057 (Vide Table.2) [23].

Figure 1. World Population Yearly growth rate percentage, According to United Nations Population Division of the Department of Economic and Social Affairs



The world population projection 2020 to 2100 will increase from 7.79 billion to 10.87 billion with the yearly percentage change of increasing at decreasing rate. The median age, Fertility rate, density of population per kilometer square and urban population is also increasing from 2020 up 2100 according to the population projection (Vide Table. 2).

Table 2. World population forecast (2020-2100), According to United Nations Population Division of the Department of Economic and Social Affairs

Year	Population	Yearly % Change	Yearly Change	Median Age	Fertility Rate	Density (P/Km²)	Urban Pop %	Urban Population
2100	10,874,902,318	0.03%	3,090,840	73	N.A.	N.A.	N.A.	N.A.
2057	10,038,871,455	0.40%	39,793,139	67	N.A.	N.A.	N.A.	N.A.
2050	9,735,033,990	0.53%	50,646,143	36	2.95	65	68.60%	6,679,756,162
2045	9,481,803,274	0.61%	56,591,207	35	2.85	64	66.60%	6,312,544,819
2040	9,198,847,240	0.69%	62,264,605	35	2.77	62	64.60%	5,938,249,026
2035	8,887,524,213	0.78%	67,807,363	34	2.7	60	62.50%	5,555,833,477
2030	8,548,487,400	0.87%	72,809,988	33	2.62	57	60.40%	5,167,257,546
2025	8,184,437,460	0.98%	77,927,744	32	2.54	55	58.30%	4,774,646,303
2020	7,794,798,739	1.10%	83,000,320	31	2.47	52	56.20%	4,378,993,944

World population by region wise indicated that, the large population was found in Asia with 4.6 billion which was 59.50 % of world share and followed by Africa with 1.34 billion or 17.20 % of world share, whereas Oceania was the least populated region with 0.50 %. The yearly percentage change was high in Africa with 2.49 % and less in Europe with 0.06 %. The higher density of population per kilometer square found in Asia by 150 people per kilometer square. Europe was the oldest populated region with Median age of 43 and Africa was the youngest population with the median age of 20 as shown in Table.3.

Table 3. World Population by region According to United Nations Population Division of the Department of Economic and Social Affairs

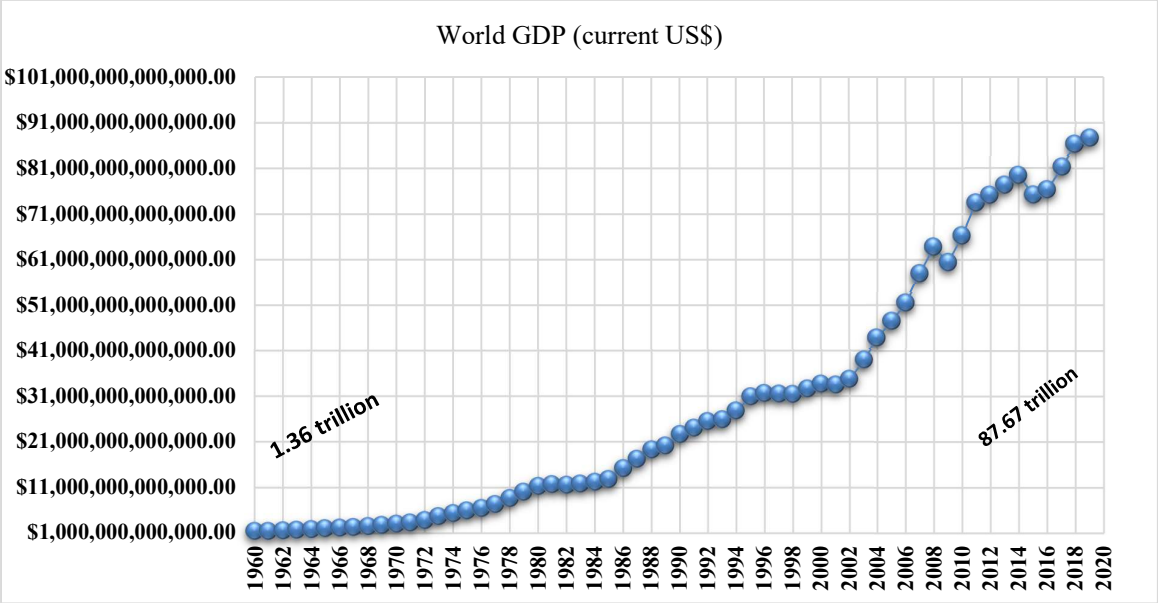
S. N	Region	Population -2020	Yearly Change	Net Change	Density (P/Km²)	Land Area (Km²)	Migrants (net)	Fert. Rate	Med. Age	World Share
1	Asia	4,641,054,775	0.86%	39,683,577	150	31,033,131	-1,729,112	2.2	32	59.50%
2	Africa	1,340,598,147	2.49%	32,533,952	45	29,648,481	-463,024	4.4	20	17.20%
3	Europe	747,636,026	0.06%	453,275	34	22,134,900	1,361,011	1.6	43	9.60%
4	Latin America	653,962,331	0.90%	5,841,374	32	20,139,378	-521,499	2	31	8.40%
5	N. America	368,869,647	0.62%	2,268,683	20	18,651,660	1,196,400	1.8	39	4.70%
6	Oceania	42,677,813	1.31%	549,778	5	8,486,460	156,226	2.4	33	0.50%

2.2. Economic development

The Gross Domestic Product (GDP) of an economy is a measure of total production. More precisely, it is the monetary value of all goods and services produced within a country or region in a specific time period.

The World Gross domestic product from 1960-2019 increased from 1.36 trillion U.S. dollar to 87.67 trillion U.S. dollar respectively (Vide Figure. 2). Global growth is projected at –4.9 percent in 2020, 1.9 percentage points below the April 2020 according to World Economic Outlook forecast. The COVID-19 pandemic has had a more negative impact on activity in the first half of 2020 than anticipated, and the recovery is projected to be more gradual than previously forecast [11]. In 2021 global growth is projected at 5.4 percent. Overall, this would leave 2021 GDP some 6½ percentage points lower than in the pre-COVID-19 projections of January 2020. The adverse impact on low-income households is particularly acute, imperiling the significant progress made in reducing extreme poverty in the world since the 1990s.

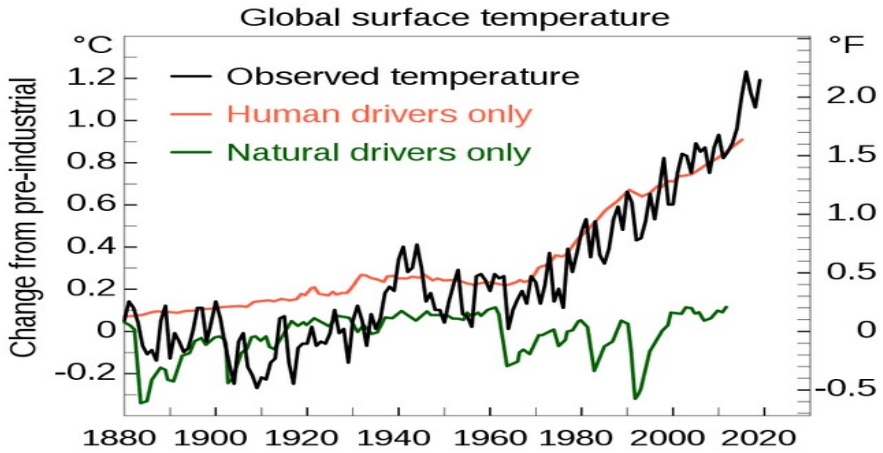
Figure 2. World GDP (current US$) 1960-2019, World Bank



2.3. Climate change

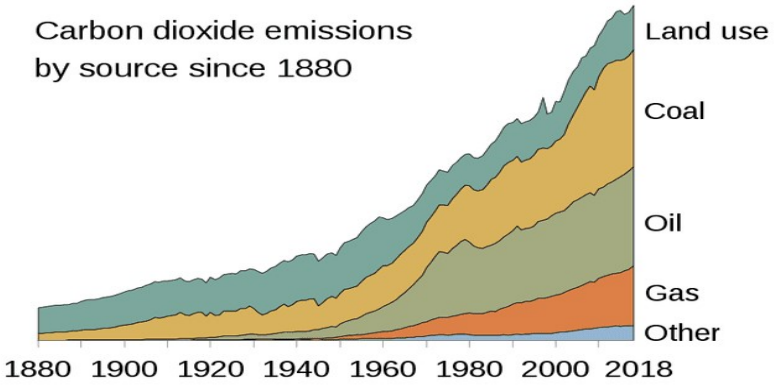
The main driver for increased global temperatures in the industrial era was human activity, with natural forces adding variability as shown in Figure 3, as observed temperature from NASA (National Aeronautics and Space Administration) versus the 1850–1900 average as a pre-industrial baseline.

Figure 3. Global Surface Temperature, World Meteorological organization,2020



In 2018, the concentrations of CO_2 and methane had increased by about 45% and 160%, respectively, since 1750 [25].

Figure 4. Carbon dioxide emissions by source since 1880, WMO

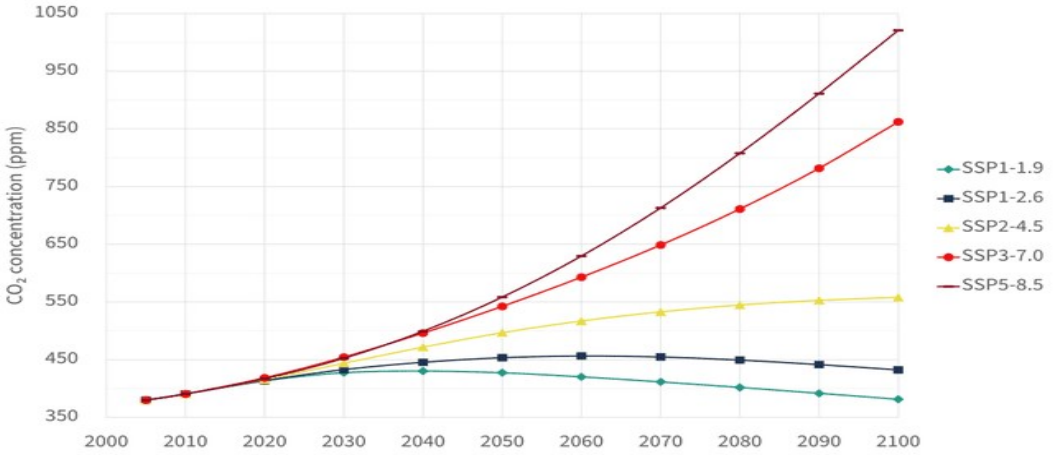


Intergovernmental panel on climate change (IPCC) develop Shared Socioeconomic Pathways. The Shared Socioeconomic Pathways (SSPs) are scenarios of projected socioeconomic global changes up to 2100 [13]. They are used to derive greenhouse gas emissions scenarios with different climate policies. The scenarios are:

1. SSP1: Sustainability (Taking the Green Road): The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, educational and health investments accelerate the demographic transition, and the emphasis on economic growth shifts toward a broader emphasis on human well-being. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries. Consumption is oriented toward low material growth and lower resource and energy intensity.
2. SSP2: Middle of the Road: The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Global and national institutions work toward but make slow progress in achieving sustainable development goals. Environmental systems experience degradation, although there are some improvements and overall, the intensity of resource and energy use declines. Global population growth is moderate and levels off in the second half of the century. Income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain
3. SSP3: Regional Rivalry (A Rocky Road): A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialized and high in developing countries. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions
4. SSP4: Inequality (A Road divided): Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries. Over time, a gap widens between an internationally-connected society that contributes to knowledge- and capital-intensive sectors of the global economy, and a fragmented collection of lower-income, poorly educated societies that work in a labor intensive, low-tech economy. Social cohesion degrades and conflict and unrest become increasingly common. Technology development is high in the high-tech economy and sectors. The globally connected energy sector diversifies, with investments in both carbon-intensive fuels like coal and unconventional oil, but also low-carbon energy sources. Environmental policies focus on local issues around middle- and high-income areas.
5. SSP5: Fossil-fueled Development (Taking the Highway): This world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated. There are also strong investments in health, education, and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively

manage social and ecological systems, including by geo-engineering if necessary.

Figure 5. Atmospheric CO_2 concentrations by SSP across the 21st Century (MAGICC IPCC)

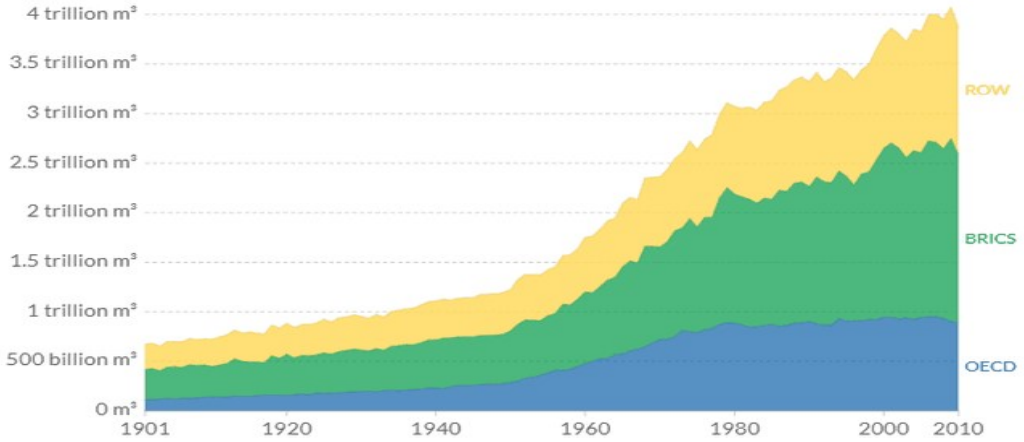


3. GLOBAL WATER RESOURCE, USE AND POLICY FOR SUSTAINABLE MANAGEMENT

The Global freshwater use since 1900 by broad regional groupings (Vide Figure 6) were;

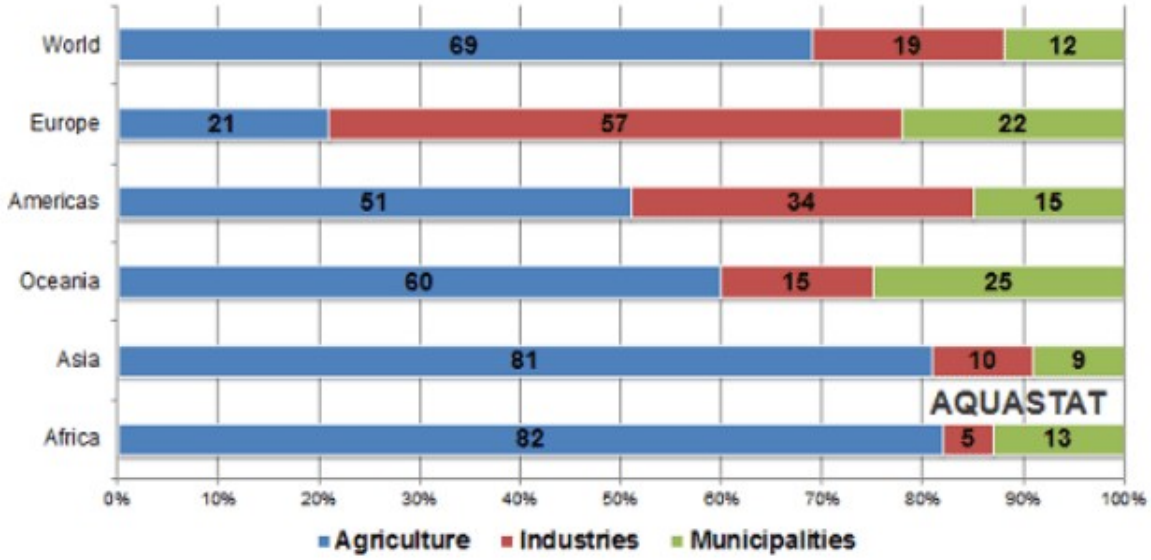
- OECD nations (Organizations for Economic for cooperation and development, uses approximately 20-25%.
- BRICS countries (Brazil, Russia, India, China and South Africa) use the largest share at approximately 45%.
- Rest of the World (ROW) nations use at 30-33% [9].

Figure 6. Global fresh water use, Global International Geosphere-Biosphere Programme



The 2018 edition of the United Nations (UN) World Water Development Report (WWDR) has provided an update on the present trends of clean water availability and future expectations. Water security, the capacity of a population to safeguard sustainable access to adequate quantities of water of acceptable quality, is already at risk for many, and the situation will become worse in the next few decades. Clean water scarcity is a major issue in today's' world of 7.7 billion people. The strain on the water system will grow by 2050 when the world population will reach between 9.4 and 10.2 billion, a 22 to 34% increase. The strain will be aggravated by unequal population growth in different areas unrelated to local resources. Most of this population growth is expected in developing countries, first in Africa, and then in Asia, where scarcity of clean water is already a major issue [19].

Figure 7. Water withdrawal ratios by continent AQUASTAT (FAO)



3.1. Global water policy for sustainable management

a. Integration of Sustainable Development and Sustainable Water Management.

Sustainable development and Sustainable water management are inherently related due to the requirement of water for development. Water is a fundamental requirement for human life and well-being, thus proper management of water is a means to improve food production, reduce poverty and water-related diseases.

b. Urban Water Development

Access to potable water is among the most important prerequisites for healthy and productive development. Water and socioeconomic development are integrally connected. Sustainable urban water management include broader adoption of water reuse and green infrastructure practices [6,7,16].

c. Agricultural Water Development: Sustainable agricultural water management by increasing irrigation productivity through improvements to technical, managerial, institutional, and agronomic methods [20]. There are clear opportunities for improving water productivity in the agricultural sector.

- improving water allocation; and
- improving application efficiency.

d. Environmental Protection

Evaluation of environmental sustainability is required concurrently with development planning to protect ecosystem services. “Strategies to reduce poverty should not lead to further degradation of water resources or ecological functions and services” [14].

e. Millennium Development Goals for sustainable management

- Eradicate extreme poverty and hunger; (Halving the proportion of people living on less than $1 a day and halving malnutrition).
- Achieve universal primary education; (Ensuring that all children are able to complete primary education).
- Promote gender equality and empower women; (Eliminating gender disparity in primary and secondary schooling, preferably by 2005 and no later than 2015.
- Reduce child mortality; (Cutting the under-five death rate by two-thirds).
- Improve maternal health; (Reducing the maternal mortality rate by three-quarters).
- Combat HIV/AIDS, malaria, and other diseases; (halt and begin to reverse HIV/AIDS and other diseases).
- Ensure environmental sustainability; (Cutting by half the proportion of people without sustainable access to safe drinking water and sanitation).
- Develop a global partnership for development; (Reforming aid and trade with special treatment for the poorest countries).

f. The 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) are highly dependent on improved water management. Social, economic and environmental, as well as important aspects related to peace, justice and effective institutions will be considered [2,3].

3.2. Global sustainable development goals on water

- Goal 1: achieve, by 2030, universal access to safe drinking water and sanitation for all.
- Goal 2: by 2030, reduce the water use in agricultural irrigation by 20%, industrial water uses by 20%, and domestic water use by 15% and increase water productivity by 50% in all sectors, by adopting the water demand management approach, less water demanding crops, water saving technologies and increasing safe reuse of wastewater.
- Goal 3: by 2030, increase by 50% the number of countries that have adopted and implemented policies and programmes for the public registration of water rights.
- Goal 4: by 2030, reduce water pollution from main sources by 30% at the country level this target aims to reduce freshwater pollution by human activities by reducing the emissions at the source of the discharge.

4. CHALLENGES, TRAITS AND OPPORTUNITIES

Main challenge

- Poor resource management.
- Corruption.
- Inappropriate institutional arrangements.
- Bureaucratic inertia.
- Insufficient human capacity.
- Shortages of finances for investments.
- Undermine the effective governance of water.

Traits to

- The availability, quality and quantity of water for basic human needs,
- Energy, food, health, peace and security, and poverty eradication.
- Sustainable management of water resources.
- Ecosystem and human health

Opportunities

- Resource endowment identification,
- Balance competing social, economic and environmental demands for ocean resources.
- Balance of timely policy measures and more research-informed policies.
- Local, regional and global perspective
- Prospects and challenges of multi-disciplinary research
- Science to fill knowledge gaps; but solutions rely on political will
- Coordination between water policy and specific sector policies (e.g., agriculture, energy).
- Increase water use efficiency and improving water allocation.
- Fight against corruption, inappropriate institutional arrangements and Bureaucratic inertia
- As local demand for water rises above supply in many regions, the effective governance of available water resources will be key to achieving water security, fairly allocating water resources and settling related disputes.
- In Water policy, Water law should have to be set properly because, landowners have the right to use as much of the water beneath their land as they want without any regulation or control.
- Follow better water policy through best water management practices and measurement, because we don't have plan B.

5. CONCLUSION

Water is not just about development; it is a basic human right and essential to peace and security around the world. Addressing the issue of water is not a task to be taken lightly. We must rise to this challenge if we are to leave behind a world that future generations can live in. Planning, development and management of water resources need to be governed by common integrated perspective considering local, regional, State, national and international context having an environmentally sound basis, keeping in view the human, social and economic needs. The water policy should focus on water productivity. Given the limits on enhancing the availability of utilizable water resources and increased variability in supplies due to climate change, meeting the future needs will depend more on demand management, and hence, this needs to be given priority, especially through; evolving an agricultural system which economizes on water use and maximizes value from water and bringing in maximum efficiency in use of water and avoiding wastages. The impact of climate change on water resources availability must be factored into water management related decisions. Although, Sustainable water management of urban, agricultural, and environmental systems is integral to continued development and will vary with geography and economic capabilities, though all regions should manage water resources in a way that supports sustainable social, economic, and environmental development. We must estimate the amount of water that can be taken without

adversely affecting other users and the environmental eco-systems. Water-scarce countries should minimize the export of relatively water intensive products precisely to prevent large quantities of water from being exported to different parts of the world. In general water policy needs multidisciplinary and holistic approach to bring water management sustainability in the long run.

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