WATER RESOURCES MANAGEMENT: PATHWAYS FOR SUSTAINABLE ECONOMIC GROWTH AND POVERTY ERADICATION

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ABSTRACT: Water is essential not only for sustaining quality of life on the earth, but also for economic growth and poverty eradication. Due to rapid increase in population, the demand for water will increase over time. The nations that are well endowed in fresh water resources have an economic advantage over those less fortunate. Water resources management is a cost effective strategy; contributing to the economic prosperity and poverty reduction through several pathways, while strengthening systems and capacity for longer-term climate risk management. The access to safe and adequate water improves health, fulfills multiple needs of households, contribute to food and fiber production and poverty elimination. The prime purpose of present paper is to enhance the understanding of the factors that influence water demand by deeply examining the water use in domestic, agricultural and industrial sectors in Pakistan. The driving forces and key issues, related to socio-economic development, that influence the future water availability and demand are also examined. Pakistan is a country that is facing a water crisis not because of physical scarcities of the resources, but because of lack of knowledge, experience, technology and co-ordination among different institutions. The empirical evidence shows that better management coupled with effective policy, intensified political will, appropriate investments, awareness, climatic change adoption and institutional strengthening are promising pathways for sustainable water resources management. In order to meet the water demand for environment, economic and people's life, there is scope for significant improvement in the efficiency of water utilization, which if achieved should enhance the overall sustainability.

***Keywords*:** Water management, Socio-economic, Poverty reduction, Sustainability

1. INTRODUCTION

Water is essential component for sustaining quality of life on earth and for sustainable country's socio-economic growth. The united nation in their Millennium Declaration draws attention to the importance of water and water related activities in supporting development and eradicating poverty [1]. The economic, environmental and social development of our communities co-evolves with the availability and quality of water and we need to enrich and deepen our understanding of these relationships [2]. Water resources management is a political and socio-economic issue as well as a scientific, technological and engineering concern [3]. The sustainability of socially sensitive good such as water depends on effective and efficient use of available water resources. The success of integrated water management strategies depends on striking a balance between human resource use and ecosystem protection[4]. Water management, water infrastructure planning and design rely on an understanding of the water cycle and hydraulics as they apply to particular sites [5]. The emphasis on managed and balanced utilization of available water resources is more than ever before. The extensive use of water has increased globally and the efficacy of supply side measure is questionable. The water consumption trends change from region to region, country to country and within one country, from area to area, depending on correlated factors including climate change, technological advancement, water pricing, culture and social values, incentives and laws. Water systems are transformed through widespread land cover change, urbanization, industrialization and engineering schemes like reservoirs, irrigation and inter-basin transfers that maximize human access to water [6]. In today's environment of growing scarcity, the incompatible claims for more and more irrigation water are imposing pressure on available water resources. The available water resources are becoming fully committed and the irrigation expansion option will be difficult to pursue because many river basins have already been developed to their maximum capacity. For sustainable water resources management, it is imperative to know that how much water are we using, how much will we

need in next years, what is water use efficiency and how to manage water resources for green growth. Water demand is usually categorize into fiver major sectors: domestic, agriculture, industrial, energy and environment. Water use trends and water forecast requires the evaluation of a wide range of spatially and temporally referenced data. However, in developing countries the spatio-temporal data is either missing or don't represent the clear picture. In the present paper the effort has been made to highlight driving forces and key issues that influence sectoral water availability in Pakistan. In the conclusion, suggestions were made for sustainable water resources management to cope with water scarcity and poverty.

2. WATER AVAILABILITY and DEMAND GAP

In Pakistan, the gap between water demand and supply has increased manifolds, while the options for new development of water resources are limited. The total population has increase from 34 million in the year 1951 to 180 million at present and will raise to approximately 200 million by the end of year 2020. Rapid urbanization and high population growth rate directly impact the water demand for domestic, industrial and agricultural sectors. In Pakistan, about 96 percent of available water is being used for agriculture, 2% for industrial and the remaining 2% is used by the domestic sector. The Indus River and its tributaries (the Jhelum, Chenab, Ravi, Sutlej, Beas and Kabul) have an average combined potential of 190 billion m³ of water *[5]*. Beneath the Indus River basin is an aquifer extending over an area of 160,000 km². While the safe yield is estimated to be about 68 billion m³, the volume of groundwater abstraction by different sectors, including domestic consumption, is already approaching 62 billion m³ [7]. Over the last two decades, groundwater has played an important role in sustaining irrigated agriculture in Pakistan, with more than 50% of the irrigation water coming from more than one million privately owned wells. The assessment of the water supply and demand requires the development of model and tools harmonized across the region. The water demand forecast model was developed and the subsequent sessions discuss the sectoral water use and issues in Pakistan.

2.1 Domestic sector : Water for people

Domestic water demand include the amount of water used by households for different activities in house as well as outside including drinking, cooking, bathing, washing, water use for kitchen, laundry, and gardening etc. The total requirement of water for domestic use in the world is about 200 km^3/year, which is some 0.5% of the average total runoff [8]. It is possible to meet the present and future water demand; however, the uneven distribution of water and its availability impedes to bridge the gap between demand and supply. The domestic water demand is function of econometric variables, behavioral changes, housing characteristics, accessibility to the water source, economic class, water quality, climate and hydrology, water pricing and water policy. Major issues facing by the domestic water supply sector in Pakistan are; i) Inadequate, inequitable and inefficient distribution on water resources, ii) No clear policy and guidelines for operation and maintenance of municipal infrastructure, iii) High capital investment with low or no rate of return, iv) High ratio of unaccounted for water and low revenue collection efficiency, and v) Lack of water awareness as an economic good. The domestic water demand in Pakistan is forecasted as presented in table 1 (*detail in Asif et al., 2010)*[9].

2.2 Agriculture Sector : Water for food

The major challenge for the agriculture sector is to produce more food with less water for present generation without sacrificing the needs of future generations. Irrigation water use is complex and depends on many factors such as climate, soil type, arable area, type of crop and cropping pattern, water pricing, water policy, climate and hydrology. However, livestock water use can be estimated from the number the number of animals and water use per animal. Pakistan's agriculture is mostly dependent on irrigation from surface and groundwater resources. Annually, out of total available water for irrigation, about 84 percent flows during summer (*Kharif season*) and only 16 percent flows occur in winter (*Rabi season*). Nearly 81% of river flows and 65% of precipitation occurs during the June to September monsoon *[5]*. The issues in agriculture sector are same in Pakistan as in many arid and semi arid countries. Inadequate availability of water at the critical time of crop growth hinder efforts to become food sufficient. In Pakistan, 220,000 km² of land (approximately 27% of the country) is cultivated. Irrigation is used on 80% of arable land nationwide, and is practiced mainly in the Indus River basin. While agricultural yield grew at an average annual rate of 4.5% over the last decade, it's contribution to gross domestic product (GDP) has been steadily decreasing over the years. A social problem linked to irrigation is the inequity of water distribution. In developing countries such as Pakistan where most of

people lives under the poverty line. To grow more food or to bring more food on table for "bottom millions" under changing socio-economic scenario is a frontline challenge. It was forecasted under business-as-usual (BAU) scenario the agriculture water demand will increase and additionally 2.52 BCM water would be required to feed the population by the year 2030. However, by opting best agriculture practices and new technologies not only crop yield will increase but also the gap will vanish. The high stress scenario depicts the worst situation as depicted in table 1. Proper attention is needed to address high dependence on irrigated agriculture, less water use efficiency, less crop productivity and community participation in decision making.

2.3 Industrial Sector: Water for utilities

Industrial water use consists of water used for processing and manufacturing operations, power generations and other uses in the industrial sector. Industrial water use is relatively litter as compared to the domestic and agriculture sectors; however, it does require an accessible, consistent supply of adequate quantity and quality. Pongsak et al. 2009, estimated industrial water demand as tabulated in table 1 [10].

2.4 Environmental Sector (Water for nature)

The environment is a significant user of freshwater and environmental flow is the widely accepted term encompassing the whole flow regime required to maintain a river ecosystem in a state that delivers its ecological functions and services. National water policy [11] mentioned the environmental flow requirement for Pakistan as illustrated in table 1.

2.5 Climate Change

Resources managers and policy makers require information regarding future climate changes and it's adverse impacts on natural resources. There is already concern about forecasts that increasing temperatures may reduce grain yields in Asia by 15% to 20% by 2050 [12]. Himalayan glaciers are the major source of the freshwater that feeds the Indus River and its tributaries. According to climate change scenarios, following an initial period of high flows caused by accelerated glacial melt, it is predicted that the amount of water flowing into the Indus River system may decrease by 30% to 40% within the next two decades *[5]*. Furthermore, the effects of climate change and siltation may reduce already low reservoir capacity in the basin by 30%. The overall reduction in water availability may potentially have a serious impact on irrigation. This, in turn, may affect food security nationwide. Climate change is also expected to affect the South Asian monsoon. Concerns about the impact of climate change on the Indus River basin forecasted temperature changes in line with global climate change projections [13], have given rise to expectations of dramatic decreases in river flow [14]. According to the Intergovernmental Panel on Climate Change (IPCC), an increase in rainfall of up to 24% may amplify the frequency and magnitude of floods. In the summer of 2010, for example, approximately one-fifth of Pakistan was inundated, affecting more than 20 million people in the flooded areas along the length of the River Indus. Flooding also destroyed more than 1.6 million acres of crops [15]. Climate change will affect all aspects of the water environment, but there remain many uncertainties about the impacts and magnitude.

Table 1: Present & Future Water Requirement of Pakistan from 2010-2030 (*Billion Cubic Meter, BCM*)

Sr. #	Sector	Scenarios	Present & Future Water Requirements					Additional Water Requirement in 2030
		Water Demand	2012	2015	2020	2025	2030	
1	Domestic	Low	8.63	8.95	9.32	9.48	9.38	0.75
		Constant	8.63	9.57	10.79	12.04	13.27	4.64
		High	8.63	10.94	13.80	16.97	20.35	11.72
2	Agriculture	Business-as-usual	206.20	206.50	206.95	207.84	208.72	2.52
		Best practices	199.05	197.58	195.22	193.44	191.66	-
		High stress	211.6	218.50	230	246.50	263	51.4
		Climate impact	226.4	227	228	229	230	3.60
3	Industrial	Low industrial growth rate	1.80	-	1.60	-	1.10	-
		Medium	1.98 (2010)	-	2.61	-	2.56	0.58
		High	2.10	-	3.60	-	4.70	2.60
4	Environmental		1.80	1.90	1.95	2.0	2.1	0.3

3. DISCUSSION

In Pakistan, there is no water scarcity. What exists is water mismanagement. Rapid population growth and evolving claims of more and more water is causing water scarcity leading towards food insecurity. Water is the key to food and sustainability. The triple food, fuel and financial crisis has highlighted the importance of better water resources management, which if achieved may enhance the sustainability of overall system and reduce poverty. Moreover, water related disasters pose major impediments to achieve green socio-economic growth. We are at the mercy of the nature, the only option left is managing water sustainably and to initiate precautionary approaches to address water scarcity. Water management in Pakistan is more complex due to agrarian nature of country's economy. Complex, evolving and interrelated water security challenges include competing demands for water, agriculture diversification, water conflicts among water users, uneven distribution of water, water quality issues, urbanization, industrialization, seasonal shortfall, vulnerability to climate change, and low water use efficiency. Also, the amount of water required for bio-fuel plantations is particularly devastating to regions where water is already scarce such as Pakistan. The arguments in past such as "water is the basis of life" and is "beyond price", and assess to safe water is "basic human right" and it's the governments responsibility to provide "safe and adequate supply of water" to all citizens have caused severe problems and people don't consider water as an economic good. The four major direct factors determining the water footprint of a country are: volume of consumption (related to the gross national income); consumption pattern (e.g. high versus low meat consumption); climate (growth conditions); and agricultural practice (water use efficiency) [16]. Pakistan is among eight countries that contribute fifty percent to the global water footprint (water required to sustain a population). Lack of access to safe and adequate water is an indicator of poverty and are inter-linked, but role of water in human well-being is far more complicated. Major concern from the view point of agriculture water management are high irrigation water demand at the critical of crop growth, lack of awareness and lack of advanced technologies to produce more crop per drop. The main question is what has already been done and what is needed to be done. What is the duty of planners and policy makers to cope with water scarcity and how better water management may help to eradicate multiple dimensions of poverty. There is huge gap between the integrated water resources management approach and how most water resources planning is actually done and what needs to be done and who has to do that planning. Water-use projections show clearly that under a business-as-usual scenario, water demand will exceed supply by the year 2025. Climatic variations and climate change, coupled with low water storage capacity, may further aggravate this situation. Sustainable management (i.e. development, allocation and utilization) of water resources is therefore a process element of sustainable human development and can address poverty, improved well-being and enhance people's living.

Water, food and land have become vitally strategic resources, more interlinked than ever before. The water-food-land balance will be key component in developing countries such as Pakistan. The productivity per unit of water is 40% lower than in neighboring parts of India and 50% lower than in the United States *[14]*. As already mentioned, the choices are limited to become sufficient in food production and to defeat poverty. The nation with more water have economical advantages over those less fortune. Water-rich countries export water to water-short courtiers. The consumption and cropping pattern needed to be selected keeping in view the available resources and economic factor. Economic growth and improved living standards has caused diet shift from less water diet to the diet which require more water. Selection of crops on the basis of water use and economic productivity is needed in future. For example, producing 1 kg rice, for example, requires about 3500 liters of water, 1 kg of beef 15000 liters of water and a cup of coffee about 140 liters *[5]*. The production of cereals requires large amount of water with the ratio of up to 1,000 tons of water/ton of cereal [17]. It is dire need to develop strategies and multidimensional approaches to replace high water demanding and low market value crops with low water demanding and high market value crops. Introduction of high value crops with low water demand will increase farmers income and will protect the livelihoods of the poor. Lack of consistent and credible water resources data and information is also hindering the development of policy and tools towards prosperity. In case of domestic and industrial water, the water supply is not consistent, un-metered water connections, flat water tariff and uneven distribution are constraints towards sustainability. Industries use relatively little water but requires an accessible, reliable and environmentally sustainable supply. However, the present practices and water infrastructure is not sufficient to meet the industrial sector demand. The people are willing to pay for water but for reliable supply of water. To meet

domestic water need, rich people have not only access to water supply schemes but also divert water from nature without any state interference. There is no mechanism for allocating and/or regulating its use. At the same time, the majority of people don't have access to safe, reliable and adequate water. This inequality, leaving some people a the top with more water and more people at the bottom of the ladder without water, is hampering efforts to poverty reduction. Moreover, the poor maintenance of water supply schemes is deteriorating water quality. The water revenue is not enough to make the system sustainable. In agriculture sector, groundwater has been a key contributor in enhancing agriculture productivity. The flexibility, reliability and timely access provided by groundwater has largely helped in giving confidence to the farmers. In Pakistan, the average cost of irrigation with groundwater is 30 times higher than that of surface irrigation [18], but the farmers having access to groundwater attained 50–100 % higher yields as compared to those who are completely dependent on surface water [19]. However, this over-drafting, results in declining water table, making pumping more expensive and wells are going out of production. Business-as-usual is not an option and first step is to move forward with new tools and technique. The way surface and ground water is being used will have to change and the current strategies and policies needed to be redesigned. The suggested pathways for sustainable development, economic growth and poverty eradication are:

- Water is essential not only for sustaining quality of life but also for peace building
- It is better to provide some water for all rather to provide more for some
- Reallocation of water from those who need it less to those who need it more
- Ensuring reliable and secure access to water
- Water can be the entry point for community empowerment
- Empowering people to use water efficiently
- Increasing productivity and equity of existing systems and promoting crop diversification
- Linking policymakers to end-users
- Water tariffs for poverty alleviation require differentiation between consumer/user groups
- Water for basic human needs for health, hygiene and livelihood should be available at low cost
- Free water or subsidized water may not be available to all consumers
- Keeping sectoral balance between water supply and demand without compromising the sustainability of vital ecosystem
- Bringing water discharge into balance with water recharge
- To shift production from areas with low water productivity to areas with high water productivity, thus increasing global water use efficiency
- Water smart food production
- To shift to cropping /consumption patterns that require less water
- Technological improvement in water systems, agriculture use practices and water technologies
- Shift from blue water use to green water use
- Shift towards green growth, green economy and green water supported by green societies
- Shifting from short term water resources planning to more strategic and long-term planning
- To develop water - food - energy - environment - climate nexus
- To Strengthen governance of water resources
- Knowing what is unknown and sharing knowledge and skills
- Developing new systems without repeating the mistake done in the past
- Integrated strategies to support systemic changes in integrated, complementary and mutually reinforcing ways

Responsible water management coupled with advanced resources consumption techniques and environmentally sound approaches may contribute to country's prosperity. Groundwater abstraction needs to be dealt carefully. Farmers should be encouraged and financially supported to opt high-efficiency irrigation systems for productive and sustainable patterns of water use to alleviate poverty. In industrial sector, to overcome water shortage, water should be recycled and reused. Also, the treated waste water should be returned to the nature. Reliable, adequate and high quality water is vital for economic development and well-being. Coupling climate information and climate knowledge in strategic planning and adaptive decision is crucial to tackle future water resources challenges.

4. CONCLUSION

In the present paper the pathways for sustainable water resources management and poverty alleviation are suggested. The authors discussed that demand for water will soar in the future and this leads to the economizing water use in an integrated water management framework. In Pakistan, to meet food demand of more than 200 million people by the year 2020, water has to be managed and developed equitably and in harmony with nature. There is dire

need to shift the focus from increasing the supply of water to decreasing the demand for it and from maximum to optimum water use. Integrated water resources management framework based on pro-poor and gender balanced policies is emphasized. Managing water scarcity and food security requires meaningful co-ordination and exchange of knowledge between institutions, policy makers, politicians and end users. Water sustainability will depend on concerted action and how well freshwater resources are harnessed and how efficiently they are used. Access to safe and adequate water not just access, ensuring the right to secure access of not too much and not too less water, shifting to raising productivity per drop of water from per hectare food production, improving water governance and water pricing are pathways for future prosperity of Pakistan. To change existing mind-sets, water education and capacity building are essential element of strategies for sustainable water resources management. To allocate water for high value uses and move it out of low value uses particularly in arid region. Approaches to groundwater management needed to be expanded and there is dire need to impose groundwater law. Moreover, the potential positive or negative impact of climate change on water resources and environment is needed to be investigated in detail. Finally, water, food and poverty should be treated as single entity for the purpose of planning and management to enhance sustainability.

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