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Inclusive Sustainable Growth through Rational Water Resource Management: Efforts of Government of India

Dr. Kameswari Peddada
Professor, Department Of Business & Administration, Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia

***Corresponding Author:**
Dr. Kameswari Peddada
Email: thuppal2000@yahoo.com

Abstract: Water ('the elixir of life') is a basic need for life of all living organisms. Though the earth's water resources are abundant and renewable, 97% of water is saline and only 3% is fresh. Humans use water for 1. Agricultural, 2.Industrial, 3.Domestic, 4.Recreational and 5. Environmental activities and the vast majority of such uses require the less-abundant fresh water. As the world human population is growing and demands to support modern lifestyles are increasing, tremendous pressure is exerted on natural water resources leading to water stress and water crises. There is competition among nations and even among regions of a nation for the scarce water resources available. As agriculture accounts for an estimated 70% worldwide water use and rural India still predominantly depends on agriculture as the main source of income, suitable policies, strategies and plans to safeguard water resources need to be adopted for a sustainable and inclusive rural development. The present paper is basically a review of relevant literature. It shall: 1. focus on the world water scenario, 2. highlight the effect of water scarcity on sustainability and inclusiveness of development, 3. enumerate the available solutions for scientific and economic management of water resources and 4. elaborate the various attempts to tackle the water related problems by the Government of India with international assistance. The findings and conclusions may offer some useful hints, tips and guidance for nations of rest of the world to formulate their country-specific strategies of water management.

Keywords: Inclusive Growth, Sustainable Development, Water Crisis, Water Deficit, Water Scarcity, Water Stress, Water Resource Management

"The water crisis of today is not about having too little water to satisfy our needs, but about managing water so badly that billions of people & environment suffer." - ***World Water Vision Report***

INTRODUCTION

Global Water Scenario [1]

Though water appears to be an abundant and inexhaustible resource on earth, about 97% of it is saline and only 3% is fresh water (Fig-1). Most of the human uses require fresh water. Water resources mean all available sources of water that are useful or potentially useful for human use. Water supply implies water that is treated and fit for drinking. Just over 2/3 of earth's fresh water (67.8%) is frozen in glaciers and polar icecaps and the remaining unfrozen fresh water is mainly ground water (30.1%) and only a small fraction is above the ground (surface water, 0.3%) and in the air (others, 0.9%). The fresh surface water is in lakes (87%), swamps (11%) and rivers (2%). Fresh water is a renewable resource, but ground water supply is steadily decreasing and it is unclear, how much of usage can the natural renewal balance and how much can threaten the ecosystems.

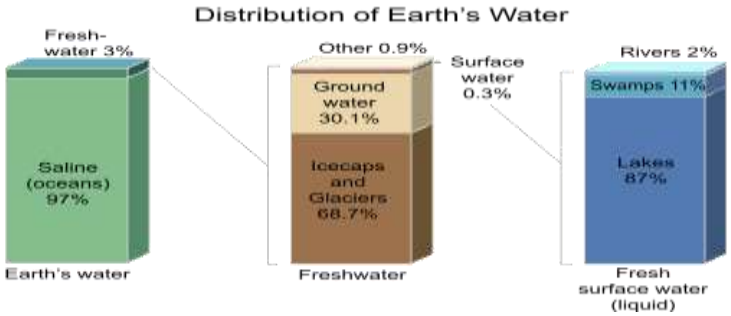

Fig-1: Graphic Distribution of Locations of Water on Earth
Source: from Wikipedia on water resources

Sources of Fresh Water: 1. Surface Water, 2. Under-river Flow, 3. Ground Water, 4. Desalination & 5. Frozen Water (sources 4, 5 are of minor significance & expensive to utilize).

Uses of Water: 1. Agricultural (70%), 2. Industrial (22%), 3. Household (8%), 4. Recreational (a small, but growing %) and 5. Environmental (a small, but growing %).

Water Scarcity [2]: It is the lack of sufficient available water resources to meet the demands of water usage within a region. It includes water stress, water shortage/deficit, and water crisis. Water stress is the difficulty of obtaining sources of fresh water for use during a period of time and may result in further depletion and deterioration of available water. Defining threshold for water stress in terms of per capita availability of water is a crude and imprecise measure. As per Falkenmark's Water Stress Indicator, a country or region is said to experience water stress, when its water supplies drop below 1,700 cu m per person per year. Between 1,700 and 1,000 cu m, periodic or limited water shortages/deficits can be expected. But below 1,000 cu m a country faces water scarcity, which begins to hamper its economic development and human health. Water crisis is a situation where the available potable unpolluted water within a region is less than that region's demand. Water scarcity is being driven by two converging phenomena: growing freshwater use and depletion of usable freshwater resources. Water scarcity may result from2 mechanisms: 1. Physical scarcity from inadequate natural resources to supply a region's demands, as evidenced by environmental degradation and declining ground water levels, and 2. Economic scarcity from poor management of sufficiently available water resources caused by a lack of investment in infrastructure or technology to draw water from water sources, or insufficient human capacity to satisfy the demand for water (Fig-2).

International Water Management Institute, Sri Lanka, has found in 2007 that of the 7 billion world population 1/5 (>1.2 billion) live in areas of physical water scarcity with not enough water to meet all demands, 1/3 (2.3 billion) do not have access to clean drinking water and 1.6 billion people live in areas experiencing economic water scarcity.

Causes of Water Scarcity: 1. Population growth, 2. Expansion of Business Activity (industries or services), 3. Rapid Urbanization, 4. Climate Change, 5. Depletion of Aquifers & 6. Pollution.

Fig-2: Contaminated Water Holes in Dry River Beds (Tanzania)
Source: Water Crisis, Wikipedia

World Water Supply and Distribution: Global coverage figures from 2002 indicate that out of every 10 people about 5 have connection to piped water supply at home, 3 make use of some other sort of improved supply, like protected well or public standpipe, and 2 remain unserved. 4 out of every 10 people live without improved sanitation. The governments at the Earth Summit in 2002 have approved a plan of action to achieve by 2015 the 'Millennium Development Goals' of reduction by half of the people unable to access safe drinking water and basic sanitation. The Global Water Supply and Sanitation Assessment Report-2000 (GWSSAR) defines "Reasonable Access" to safe water as at least 20 liters per person per day from a source within one kilometer of the user's home, and basic sanitation as private or shared facilities to separate waste from human contact but not public disposal systems.

Economic Considerations: Water supply and sanitation require a huge capital investment for new infrastructure, such as pipe networks, pumping stations and water treatment works, and for maintenance of the existing infrastructure. Besides, significant operating costs to cover personnel, energy, chemicals, maintenance and other expenses are incurred. The sources of money to meet these capital and operational costs are essentially either user fees, public funds or some combination of the two. The economics of water management becomes extremely complex as they intersect with social and broader economic policy. These critical water issues will also affect business and industry expansion in terms of their risks and opportunities.

Water Balance[3]

Water balance is the description of water levels at different locations from flow of water in and out of a system. The system may be one of several hydrological domains, like a soil column or drainage basin. Water balance equation uses the principles of conservation of mass in a closed system, whereby any water entering a system must be transferred into or stored in another

system. The equation requires the system to be closed, and where it isn't, it must be taken into account. A general water balance equation is: $\boldsymbol{P = R + E + \Delta S}$, where $\boldsymbol{P}$ is precipitation, $\boldsymbol{E}$ is evaporation/transpiration, $\boldsymbol{R}$ is stream flow and $\boldsymbol{\Delta S}$ is the change in storage in soil, bedrock or ground water. Water balance equations can be used in water supply management to predict water shortages, irrigation requirements, run-off assessment, flood control, pollution control, design of subsurface drainage systems and estimation of drainage requirements. Water balance can be illustrated using water balance graphs (often monthly) and other models, which use precipitation/rainfall, rainfall & temperature, rainfall & potential evaporation as inputs or daily input data.

Water Situation in India [4, 7]

India, with 2.4% of world's total area and 16% of world's total population, accounts for only 4% of the total available fresh water. More than 90% of ground water is used for agriculture and industrial water use accounts for > 6% of total fresh water abstraction of about 50 billion cubic metres (BCM), which is expected to rise dramatically in coming decades with enormous industrial growth. India is in a man-made water crisis with demands exceeding supplies.

Fig-3: Drinking water for slum dwellers from a submerged hand-pump after heavy rains (Allahabad, India)

Source: http://www.youthkiawaaz.com/2016/03/water-crisis-in-india-world-water-day/

Table 1: Per Capita Water Availability in India

Year	Population (in millions)	Per Capita Water Availability (in m^3)
1951	361	5177
2001	1027	1820
2025 (projected)	1394	1341
2050 (projected)	1640	1140

Source: Strategic Plan for the Ministry of Water Resources, 2011

Table 2: Projected Demand for Water for Various Uses (in BCM)

Use	2010		2025		2050	
	Projected Demand	% of total demand	Projected Demand	% of total demand	Projected Demand	% of total demand
Irrigation	557	78	611	72	807	68
Domestic	43	6	62	7	111	9
Industries	37	5	67	8	81	7
Environment	5	1	10	1	20	2
Others	68	10	93	12	161	14
Total	710	100	843	100	1180	100

Source: Strategic Plan for the Ministry of Water Resources, 2011

As per the World Bank report of 1997 the available underground water was approximately 600 cu km per annum and the level of surface water was approximately 300 cu km per annum. The demand was almost equal to the availability. By 2050 the level of ground water will be below 100 cu km per annum mark and the level of surface water would fall to 50 cu km per annum, but the demand will rise to 1200 cu km per annum. This crisis is not just the mismatch of the demand and supply curve but indicates a gross mismanagement of water resources. A major contributor is water pollution from a combination of sewage disposal, industrial effluents and chemicals from farm runoffs. The other factor is the over-usage of ground water for agriculture as surface water gets scarce, which has led to a tremendous fall in ground water levels. The global warming has further made rainfall erratic and unpredictable adversely affecting the agricultural sector.

MATERIAL & METHODS

The present study is of a review nature and depends on secondary published data. Based on the information gathered, conclusions are sought to be drawn on improving water management in the context of India as well as globally. The findings of the present study may also be of relevance to improve the water management practices of other emerging economies in the world.

DISCUSSION

Effects of Water Scarcity

On Economy:

1. Decline in agricultural output negates efforts for food security and aggravates poverty.
2. Decline in national health standards from malnutrition and water-borne diseases.
3. Rise in global food prices affecting food supply, if India becomes a net food importer.
4. Stagnation of industrial and service sectors [5]: Indian domestic companies, long used to minerals, energy and other primary material constraints, are now facing persistent and growing water shortage. The Federation of Indian Chambers of Commerce & Industry (FICCI) has constituted a Water Mission on water management. The preliminary findings of the study on "Water Risks for Indian Industries" with Columbia Water Centre indicated water availability and poor water quality are becoming important concerns for Indian businesses.

On Environment:

1. Increased salinity of water
2. Nutrient pollution
3. Loss of flood-plains and wetlands
4. Problematic rehabilitation of urban streams
5. Loss of habitat for many flora and fauna
6. Loss of protection from storms, landslides and flooding
7. Gradual sinking of landforms (called subsidence)

Management of World Water Resources

There is an increasing awareness that our freshwater resources are limited and need to be protected both in terms of quantity and quality. “Water is everybody’s business” was the key message of this World Water Forum.

Obvious solutions to worldwide water scarcity appear to be:

1. Waste Water Treatment: Despite being capital intensive, technology demanding and pitted against rapid population growth, developing nations should devise ways to minimize impact of pollution on drinking water and eco-systems. Sharing of cost-effective waste water management, water treatment and water transport technologies by developed nations is in the interests of global resources.
2. Reduction of Ground Water Overdrafting: Though politically unpopular and may impact farm economy and farm output in short term, it promotes sustainability on the long run.
3. Protection of Eco Systems: like wetlands and riparian zones. It protects biodiversity as well as makes water systems healthy for humans and other animals.
4. Avoidance of Overconsumption of Water: by developed nations
5. Local Low-tech Solutions: to extract water, like using solar and wind power (Fig-4)
6. International Water Sharing Disputes: through strong international institutions and cooperation through mutual consultation, inspection and exchange of data, instead of expensive litigations or wars.

Fig-4: Low-tech Solar Installation in a village in Madagascar for affordable safe water supply

Source: World Water Council, August 6, 2013, "Water Crisis: Toward a Way to Improve the Situation"

Efforts to Tackle Water Related Problems in India [6, 8]

Since independence India has made significant progress in developing its water resources and the supporting infrastructure. Post-independence years have witnessed large-scale investments in water storage structures which have contributed considerably in making India a self-sustaining economy. Today, India has the capacity to store about 200 BCM of water, an irrigated area of about 90 million hectares (Mha), and an installed hydropower capacity of about 30,000 MW, as per the World Bank Report, 2005.

Table 3: Ultimate Irrigation Potential and Irrigation Potential Created (in Mha)

S. No.	Description	Major & Medium	Minor		Total
			Surface Water	Ground Water	
A.	Ultimate irrigation potential	58.47	17.38	64.05	139.90
B.	Potential created	45.26	15.84	47.11	108.21
C.	Balance potential	13.21	1.54	16.94	31.69

Source: Strategic Plan for the Ministry of Water Resources, 2011

Table 4: Storage Capacity Created

1.	**Storage already created**	**225 BCM**
2.	**Storage in Projects under construction**	**64 BCM**
3.	**Estimated storages through projects under consideration**	**108 BCM**

Source: Strategic Plan for the Ministry of Water Resources, 2011

However, due to rapid urbanization and industrialization, exploding population growth and iniquitous distribution of water, the demand for this natural resource far outweighs its supply. In addition, the water sector in India has faced significant and problematic issues related to management. In spite of a sizeable water resource base and vast land resource, India continues to struggle to meet its water sector infrastructure requirements. With the present population of more than 1billion, the per capita water availability is around 1,170 cu m/person/year (National Institute of Hydrology, 2010 Report).

Some of the crucial issues faced by the water sector in India include (a) erratic distribution of rainfall both spatially and temporally, often leading to floods and droughts in different areas; (b) water use inefficiency; (c) unregulated groundwater extraction; (d) water pollution; and (e) decreasing water quality due to poor waste management laws, inter-state river disputes, growing financial crunch for development of resources and scarcity of safe drinking water. Inadequate institutional reforms and ineffective implementation of existing provisions also affect the performance level for water service delivery. Severe water shortages have led to a growing number of conflicts between users in the agricultural and industrial sectors, as also the domestic sector. The situation is exacerbated due to the effects of climate change. The lack of water availability and poor management practices have also manifested in poor sanitation facilities, a big environmental and social challenge for India. As per a recent study by the Water and Sanitation Programme (WSP) by the World Bank inadequate sanitation causes India 'considerable economic losses', equivalent to 6.4 per cent of India's GDP in 2006.

Despite large multipurpose dams water storage infrastructure in India remains one of the lowest in the world. The water resource governance structure needs to be more participative and inter-disciplinary rather than techno-centric, a hindrance to development. Hence newer strategies, like involving potential users in the management of water resources and planning and implementation of water projects, shall help in resolving conflicting demands and maintaining transparency. Cases of better demand management, ensuring balance among competing water demands, addressing water rights issues, fair and effective water governance, water-based partnerships, promoting sustainable use, water harvesting and management, all of these need to be addressed for better water management. The Millennium Development Goals (MDGs) in the context of sustainable access to safe drinking water and sanitation is related directly or indirectly to the issues of poverty, education, health and disease.

India's National Water Policy (NWP) was formulated in 1987 and was revised in 2002. The draft NWP of 2012 has been debated and criticized for absence of a commitment towards Right to Water (despite India being a signatory to the 2010 United Nations declaration of water as a right), reduction of State involvement and leaving space for market to operate and ignoring of growing inequity in water availability as the cause of present water crisis.

Key Policy Interventions for India

- Water conservation through development of watersheds and river basins, increase in storage capacity and linking of rivers;
- Effective water use through improved irrigation systems, water efficient crops and recycling of waste water;
- Prevention of water pollution (Fig-5) by banning the discharge of untreated sewage and effluent in river, judicious use of agrochemicals and regulation on over-exploitation of ground water;
- Water resources management and distribution through PPP, metered water supply, pricing of water for sustainability;
- Awareness and orientation of water users for conservation of water and change in lifestyle.

Fig-5: Water Pollution from Industrial Effluents
Source: Water Resources- Wikipedia

CONCLUSIONS AND SUGGESTIONS

1. New indices to measure accurately available water resources and access for policy decisions and devising workable solutions: The older per capita water availability index does not take into account the socioeconomic disparities in water access and

usage and also temporal and spatial variability in a vast country like India with varied socio-ecology.

2. Inter-sectoral conflicts with water demands far exceeding the supply: It is imperative to initiate efforts for designing an appropriate agricultural, industrial and domestic water use policies which could provide a framework for sustainability in water use and spares damage to environment. Multiple uses of water and traditional water allocation priorities and quantities also need to be revisited. The concept of scarcity and surpluses of water must look beyond State boundaries with a more disaggregated assessment.
3. Alarming levels of water pollution: Agencies responsible for checking industrial and domestic pollution have failed and the economic costs of pollution of fresh water leading to further water scarcity and ill health of the population shall be profound. The situation needs urgent attention, before things go beyond redemption.
4. Gender-sensitive water policies: The issue of gender disaggregated data needs to be taken up as priority by the state for any progress to be made in mainstreaming gender in water resources management.
5. Achieving convergence among various governmental schemes promoting water and soil conservation, effective and efficient use of water in a sustainable and responsible manner and preventing water wastage
6. Reorientation and capacity building required for technocrats and senior officials for a new vision for water management by changing the paradigm of water education
7. Awareness & orientation of water users for conservation of water and change in life style.

Responsibility for solution for this man-made mess-up rests on sensible human intervention. Though the conclusions and suggestions appear to have been drawn in the Indian context, they are applicable in varying measure for all emerging economies of the world.

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