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INVITED ARTICLE

Water is Our Life: Manage Water Sustainably

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Dr K Yella Reddy has 33 years of experience in Teaching, Research, Project Management and Administration. He joined 'ANGR Agricultural University' (ANGRAU) in 1985. He was Principal Scientist & Project Manager of the US$ 4.6 million, FAO funded AP Water Management Project during the period 2008-2011. Since April 2012 Dr Reddy is working as Director of 'Water and Land Management Training and Research Institute' (WALAMTARI), Hyderabad and involved in many international projects. Guided successfully the Norwegian funded Rs 30 million (US$ 0.5 million) 'ClimaAdapt' Project in Nagurjuna Sagar project area Krishna Basin during 2112-17. Dr Reddy Received 'Food and Agriculture Organization (FAO) Fellowship' in year 2000, ii) ANGR Agricultural University 'Meritorious Teacher Award' for the year 2002 iii) 'ISAE Best Chapter Award' 2003 received as Secretary of ISAE AP Chapter iv) 'Engineer of the Year Award' 2005 of Institution of Engineers and Govt of AP v) 'Jain Irrigation Award' of the Indian Society of Agricultural Engines (ISAE) for the year 2008 vi) 'WatSave Technology Award 2008' of ICID at 20th Congress held in Lahore, Pakistan in 2008. vii) IEI (India) Agricultural Engineering Division Prize and Presidents Medal 2008-2009. viii) 'Bharat Ratna Sir Mokshagundam Visveswaraya Award' 2011 of IEI and Govt of AP ix) 'INCID-JAIN Award' of the Central Water Commission, Ministry of Water Resources, GOI, 2015. He published more than 100 research papers in the national and international journals.

Next to air, the other important requirement for human life to exist is water. It is the Nature's free gift to human race. The use of water by man, plants and animals is universal. As a matter of fact every living soul requires water for its survival. The water plays important role in the agriculture, manufacture of essential commodities, generation of electricity, transportation, recreation, industrial activities, etc. The water can certainly inexhaustible gift of nature. But to ensure their services for all the time to come, it becomes necessary to maintain, conserve and use these resources very carefully in every sphere of life. When you know that nothing on Earth can live without freshwater, that a human can't survive after three days without it, you see how precious this resource is – and how much we need to protect it.

Limited Fresh Water

Average annual precipitation over the whole globe is about 86 cm, of which 77% falls on the oceans and 23% on land. Evaporation (including transpiration by plants) from the land accounts for 16% of the total precipitation it receives, and 7% of global precipitation returns to the sea as river and groundwater flows. Although water is the most widely occurring substance on Earth, only 3 % of it is fresh water and the remaining 97 % is saltwater (Fig 1). Of the small amount of freshwater, only one third is easily available for human consumption, the large majority being locked up in glaciers and snow cover.

Water Usage

Water is vital for sustaining life on earth. It is crucial for economic and social development, including energy production, agriculture and domestic and industrial water supplies. Therefore each unit of water should be used efficiently, equitably and soundly. Water is intrinsic to our lives and to the ecosystems on which we all depend. Water is essential to life in every way, we need clean water for drinking, adequate water for sanitation and hygiene, sufficient water for food and industrial production, and much of our energy generation relies on or affects water supplies. Demographic and urban growth over the next century will mean a far greater demand for water for industrial production. Competition between users, and sectors, is therefore becoming increasingly important. World's water usage pattern in the previous century, which is growing at alarming rate, is shown in Fig 2. During the past century, the world population has tripled, and water use has increased six-fold. These changes have come at great environmental cost: half the wetlands have disappeared during the 20th century, some rivers don't reach the sea anymore, and 20% of freshwater fish are endangered. The variation of water use for agriculture, industry and domestic use across the continents is shown in Fig 3.

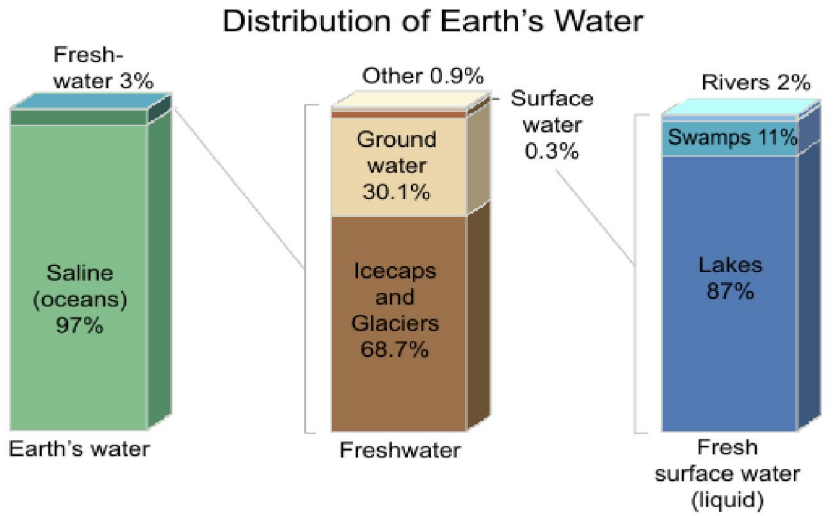
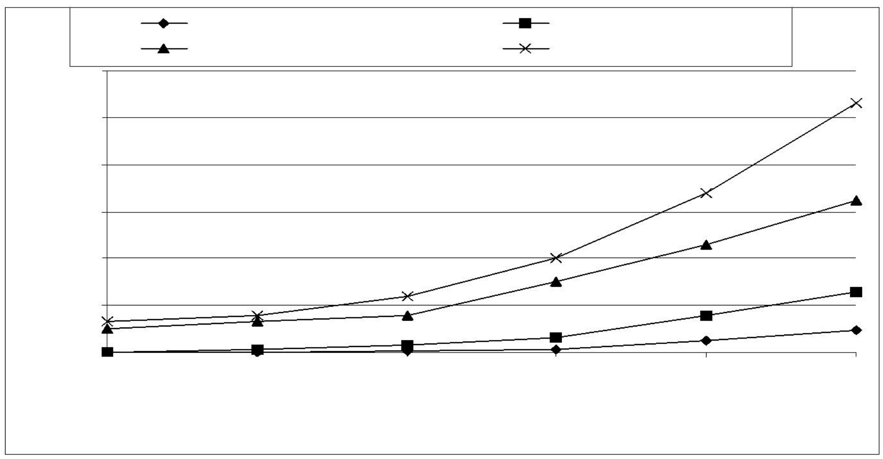


Fig 1. Distribution of earth's water showing limited fresh water for direct use Water Usage.



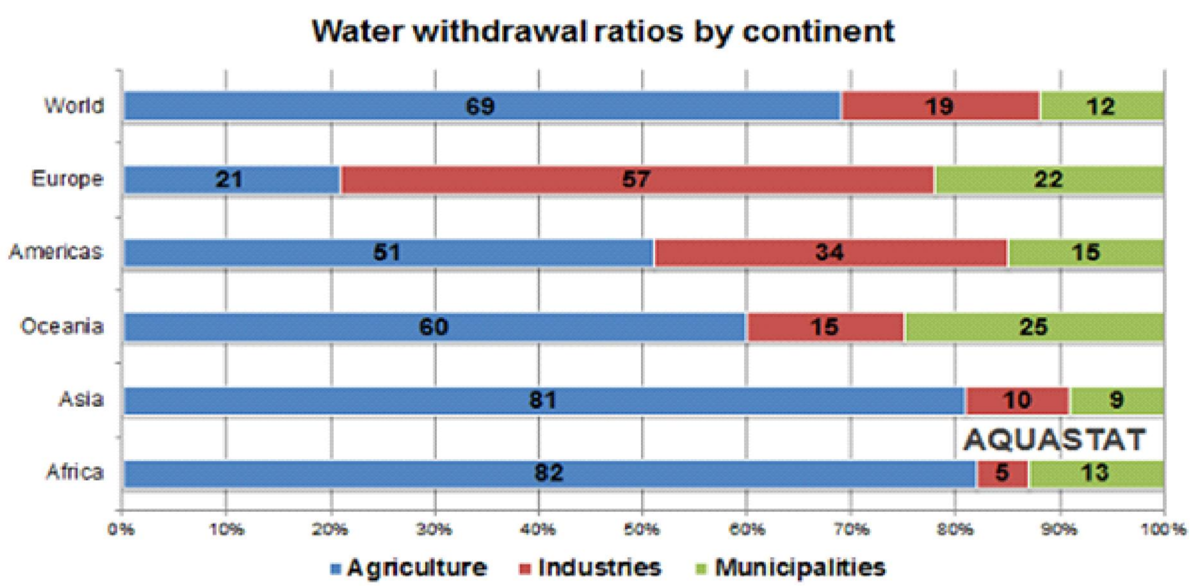


Fig 3. Continental wise water usage pattern for important sectors

In India more than 82% of the total water is used for agriculture with very low irrigation efficiencies. It is expected that in the next 7-8 years, there will be cut of about 10% irrigation water for meeting ever-increasing demand from domestic, industrial and other sectors

Water Scarcity

When country's renewable water supplies drop below about 1700 cubic meters per capita, it becomes difficult for that country to mobilize enough water to satisfy all the food, household, and industrial needs of its population. Countries in this situation typically begin to import grain, reserving their water for household and industrial uses. At present, 34 countries in Asia, Africa, and Middle East are classified as water stressed, and all but two of them-South Africa and Syria are net importers of grain. Collectively, these water stressed countries import nearly 50 million tons of grain a year. By 2025, the number of people living in water stressed countries is projected to climb from 470 million to 3 billion- more than six fold increase. The growing water scarcity by the year 2050 is shown in Fig 4.

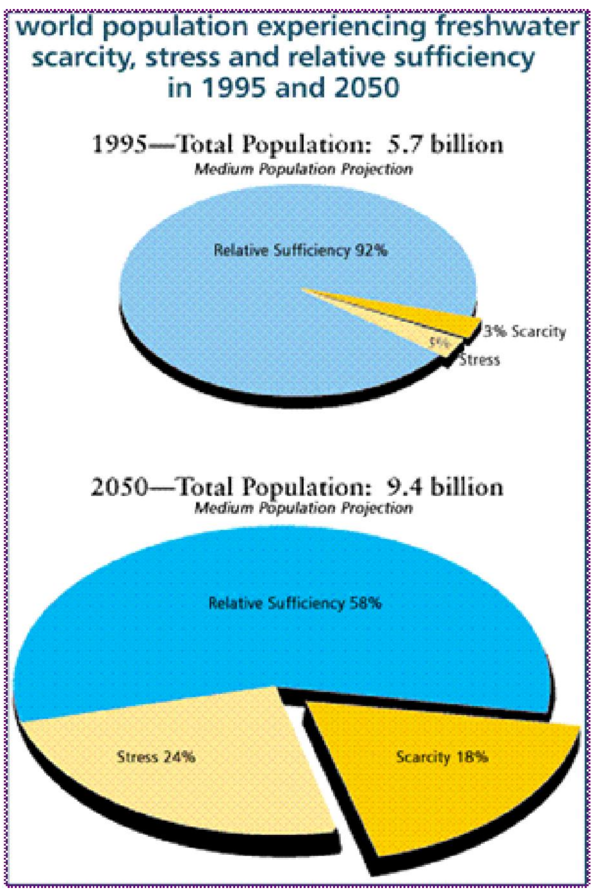


Fig 4. Growing water scarcity

Increasing population and higher levels of human activities, including effluent disposals to surface and groundwater sources, have made sustainable management of water resources a very complex task throughout the world. In addition, per capita demand for water in most countries is steadily increasing as more and more people achieve higher standards of living and as lifestyles are changing rapidly. Table 1 shows the population growth, annual renewable freshwater available and per capita availability for selected countries (Biswas, 1998). India, with 2085 km^3 of renewable water resources stands 7^{th} in the world, but due to its huge population over 1 billion, it attained 133^{rd} position in terms of per capita availability of water. India has moved from the relative sufficiency level to stress and heading towards scarcity.

Resource under Pressure

Groundwater is one of the most valuable natural resources possessed by many developing nations. Without pro-active management and protection there is a serious risk of irreversible deterioration on an increasingly widespread basis. Groundwater has many advantages over surface water for water supply:

i) It is reliable in dry seasons or droughts because of the large storage.

ii) It is cheaper to develop, since, unpolluted, it requires little treatment.

iii) It can often be tapped where it is needed, on a stage-by-stage basis.

iv) It is less affected by catastrophic events.

As a result groundwater has become immensely important for human water supply in urban and rural areas in developed and developing nations alike. Groundwater is now being abstracted at unsustainable rates in many areas, seriously depleting reserves. This happens when uncontrolled drilling of wells causes the overall rates of withdrawal from aquifers greatly to exceed their replenishment from rainfall and other sources over decades or more. This 'over-abstraction' causes many serious problems. Often the yield of wells is reduced and the cost of pumping increased. In extreme cases, this may lead to the wells being abandoned, with premature loss of infrastructure investment.

Table 1. Population and per capita water availability for selected countries.

Country	Population, Millions			Fresh water, km^3	Per capita fresh water, 1000 m^3		
	1994	2025	2050		1994	2025	2050
Brazil	150.1	230.3	264.3	6950	46.30	30.18	26.30
Canada	29.1	38.3	39.9	2901	99.69	75.74	72.70
China	1190.9	1526.1	1606.0	2800	2.35	1.83	1.74
Indonesia	189.9	275.6	318.8	2530	13.32	9.17	7.94
USA	260.6	331.2	349.0	2478	9.51	7.48	7.10
Bangladesh	117.8	196.1	238.5	2357	20.00	12.02	9.88
India	**913.6**	**1392.1**	**1639.1**	**2085**	**2.28**	**1.50**	**1.27**
Argentina	34.2	46.1	53.1	994	29.06	21.56	18.71
Japan	124.8	121.6	110.0	547	4.38	4.50	4.97
Turkey	60.8	90.9	106.3	203	3.34	2.23	1.91
UK	58.1	61.5	61.6	120	2.07	1.95	1.95
Egypt	57.6	97.3	117.4	59	1.02	0.60	0.50

Table 2. Virtual water of some important products.

Commodity	Virtual water
1 cup of coffee	140 liters
1 liter of milk	800 liters
1 kg maize	900 liters
1 kg of wheat	1100 liters
1 kg of rice	3000 liters
1 kg sugar	3200 liters
1 kg chicken	6000 liters
1kg beef	16000 liters

Effects of falling water tables

Lowering the groundwater level by one metre adds one metric ton of load per square metre to the subsoil.

i) In Gujarat in northern India, groundwater supplies most domestic and more than three quarters of irrigation water. Over-abstraction has caused the water table to fall, in some places by as much as 40 metres. This has deprived many poor farmers of water since they can afford only dug wells, which are usually limited to depths of 10 metres.

ii) In Mexico City the water table has fallen so low that there has been widespread ground subsidence, involving costly rebuilding.

iii) Parts of the Las Vegas valley, in the United States have fallen by more than 1.5 metres as a result of over-abstraction in an area where annual rainfall averages only 100 mm. Arizona is marked by a series of hundreds of fissures in the ground, which have disrupted roads, railways and housing.

iv) In the southern province of Brabant, in the Netherlands farmers are not allowed to use groundwater for irrigation in part of the year, as over-abstraction is causing drying out of the local ecology.

v) Bangkok is suffering from severe water problems as a result of the over-exploitation of the water table beneath the city.

vi) In Beijing recently, over-abstraction caused the water table to drop by more than four metres in a year.

vii) In many places of the world salt water has been moving in land and polluting coastal aquifers. This saltwater intrusion problem is for example happening in India, China, Mexico and the Philippines.

viii) In Madras in India salt water intrusion has moved 10 km inland, causing many irrigation wells to be abandoned.

Virtual Water

The Water Footprint and Virtual Water approaches are gaining importance for effective planning , development and management of water resources to improve the water use efficiency and enhance its productivity.

The concept of virtual water links a large range of sectors and issues that revolve around relieving pressures on water resources, ensuring food security, developing global and regional water markets. The concept of virtual water emerged in the early 1990s and was first defined by Professor J.A. Allan as the 'water embedded in commodities'. Producing goods and services requires water; the water used to produce agricultural or industrial products is called the virtual water of the product.

Virtual water is an essential tool in calculating the real water use of a country, or its water footprint, which is equal to the total domestic use, plus the virtual water import, minus the virtual water export of a country. A nation's water footprint is a useful indicator of the demand it places on global water resources. By importing virtual water, water poor countries can relieve the pressure on their domestic water resources.

At the individual level, the water footprint is equal to the total virtual water content of all products consumed. A meat diet implies a much larger water footprint than a vegetarian one, at an average of 3,500 liters of water per day versus 2,500. Being aware of our individual water footprint can help us use water more carefully. Virtual water of some of the important products is shown in the Table 2.

For example, growing one ton of grain or wheat requires about 1,000 m^3 of water; growing the same amount of rice requires up to thrice as much. The value of the water used for producing these food staples in water-poor countries turns out to be many times higher than the value of the product. Thus, instead of using their scarce water resources for water-intensive products, such countries can import cheap food, and relieve the pressure on their own water resources. Already a number of countries, such as Israel and Jordan, have formulated policies to reduce export of water-intensive products. Currently, 60 to 90% of Jordan's domestic water is imported through virtual water. Still, some countries are afraid of becoming dependent on global trade – those with large populations, for example, such as China or India. What would happen if, for some reason, their food demands could not be met? This explains why they are trying, as far as possible, to fill their own food needs.

Trade in virtual water

Water moves from one country to other in the virtual form through goods and services. About 15% of the water used in the world is for export, in virtual form. Out of this

i) 67% of the global virtual water trade is related to international trade of crops

ii) 23% is related to trade of livestock and livestock products

iii)10% is related to trade of industrial products.

Sustainable Development

The World Commission on Development (known as Brundtland Commission) in 1987 coined a term 'Sustainable Development' and defined as 'Development that meets the need of the present without compromising the ability of the future generations to meet their own needs'. For example, if sustainable water development is considered, it has been known for more than a century that irrigation without appropriate drainage would result in water-logging and salinity, which would, in turn, progressively reduce agricultural yields over a period of time. Since, main objective of introducing irrigation is to increase agricultural yields, clearly any system that does not fulfill this purpose over the long term cannot be considered sustainable.

Dublin Principles

International Conference on Water and Environment (ICWE) held in Ireland in 1992 has made the following recommendations (Dublin Principles) indicating the importance of water for sustainable development.

1. Freshwater is a finite vulnerable resource, essential to sustain life, development and environment

2. Water development and management should be based on a participatory approach involving users, planners and policy makers at all levels

3. Women play a central part in the provision, management and safeguarding of water.

4. Water has an economic value in all its competing uses and should be recognized as an economic good.

Valuing water

National Water Policy also makes a mention about the value of water. At present the farmers pay about Rs 200 towards water charges for irrigating one acre of paddy. If water is charged on volumetric basis at 1 paisa a liter, it costs about Rs. 1, 20,000 for growing paddy in one hectare land (Rs 48,000 per acre). It tells how valuable the water

Table3. Gross water availability and requirements of all water use in India under different scenarios.

Source	Average Annual Utilizable Water Availability* (BCM)	Requirements** (BCM)						
		1997	2010		2025		2050	
		Last Assessed	Low	High	Low	High	Low	High
Surface Water	690	399	447	456	497	545	641	752
Ground Water	433	230	247	252	287	298	332	428
Total	**1123**	**629**	**694**	**710**	**784**	**843**	**973**	**1180**
Return Flows (SW+GW)		96	116	110	107	125	123	169
Unutilized Surface Water		334	295	284	263	219	140	42
Unutilized Ground Water		219	203	202	146	149	96	33
Unutilized Total		553	498	486	409	368	236	75

Source: * - CWC & CGWB; ** - NCIWRD

Table 4. Project wise WUE values of 12 MMI schemes of AP &Telangana.

S.No.	Name of the project	Water Use Efficiency, %			
		Reservoir storage	Canal conveyance	On-farm application	Overall efficiency
1	Krishna Delta System	100	87.40	46.18	40.36
2	Godavari Delta System	100	83.21	46.09	45.05
3	KC Canal	NA	62.25	45.15	28.10
4	NSP	100	55.96	38.93	21.80
5	Nizamsagar	76	87.00	45.32	39.43
6	RDS	100	82.83	51.51	42.66
7	Somasila	72	56.30	31.84	18.00
8	SRSP	95	77.98	57.28	44.66
9	TBPHLC	43	80.90	58.32	47.13
10	TBPLLC	100	72.13	44.80	32.23
11	Vamsadhara	100	90.50	58.47	52.91
12	Yeleru	28	50.00	28.42	14.21

is and highlights the importance of arresting wastage of water in irrigation. By considering the present scarcity and growing demands of domestic, industry and other sectors, it is required to save water in irrigation and allocate to other sectors. One centimeter of water saved in one hectare area under irrigation projects is worth Rs 5,000, if that is supplied to other sectors @ 5 paisa a liter.

Water Resources Development in India

India is endowed with water as a precious natural resource; however, its variability in different regions and over time limits its use for different purposes. Central Water Commission (CWC) has assessed India's surface water potential at 1869 billion cubic meters (BCM), of which 690 BCM is considered utilizable; Central Ground Water Board (CGWB) has assessed additional replenishable groundwater resource as 433 BCM. The National Commission on Irrigation and Water Resources Development (NCIWRD) projected both low and high water use requirements for three scenarios of 2010, 2025 and 2050 as given in Table 3 and concluded that India would fully utilize its water resources by 2050.

Studies by the International Water Management Institute (Amarasinghe et al, 2007) found that as a result of rising water demand many river basins will be physically water scarce by 2050. Of the 19 river basins in India, 8 already have a potentially utilizable water resource of less than 1,000 m^3/capita, with a further 7 currently with less than 1,500 m^3/ha. Only the Narmada (2,448 m^3/capita) and the Mahanadi (2,341 m^3/capita) river basins have adequate water resources available into the foreseeable future. By 2050 10 river basins, with 75 percent of the total population, will have developed all of the potentially utilizable water resources with the consequence that water reallocation between sectors will be a necessary and common occurrence in these basins. It is predicted that in many basins groundwater, with the current levels of recharge and groundwater use patterns, will be in severe crisis; some already are at catchment and sub-basin level.

Lower Performance of Irrigation Schemes

The Central Water Commission (CWC) carried out Water Use Efficiency (WUE) studies for 30 major and medium irrigation (MMI) schemes which were analyzed and reviewed.. Improving the performance of completed MMI schemes has been the main focus of the National Water Mission (NWM) and the 12th Five Year Plan and set a target of increasing the WUE by 20%. The 12th FYP quotes figures from WUE studies carried out by the CWC on 30 MMI schemes in which the WUE on nine schemes was found to be less than 30 percent and the average 38 percent. The WUE values of 12 MMI schemes of Andhra Pradesh and Telangana states are presented in Table 4.

With the NWM and 12th FYP target the average figure would need to rise to 46%. In the CWC summary report (CWC, 2010) the results of the studies for each scheme are summarized and an overall summary provided of the common reasons for low water use efficiency and common recommendations for improvement (Table 5).

National Water Policy (2012)

India recognizes water as a scarce national resource fundamental to life, livelihood, food security and sustainable development. Recognizing that the availability of utilizable water under further constraints is leading to competition among different users, there is a growing concern on spreading scarcity due to its life sustaining characteristics and its economic value, mismanagement, poor governance, minimum ecological needs, inefficient use and rising pollution. The National water Policy (NWP) thus takes cognizance of the situation and has sketched a framework of creation of a system of laws and institutions and has drawn a plan of action considering water as a unified resource.

a) Priority on use of water

NWP recognized the need for different use and suggests optimized utilisations for diverse use for which awareness on water as a scarce resource should be fostered. Governance institutions must ensure access to a minimum quantity of potable water for essential health and hygiene to all its citizens at their household. Ecological needs should be determined through scientific studies and a portion of water in rivers should be kept aside to

Table 5. Common reasons and recommendations for low WUE from studies of 30 Irrigation systems (CWC, 2010).

Common reasons for low WUE	Common recommendations for improvement of WUE
i) Damaged structures	i) Rehabilitation and restoration of damaged/silted canal system
ii) Silting in the canal system	ii) Proper and timely maintenance of the system Selective lining of the canal and distribution system
iii) Poor maintenance	iii) Realistic and scientific system operation
iv) Weed growth in the canal system	iv) Revision of cropping pattern, if needed
v) Seepage in the system	v) Restoration/provision of appropriate control structures
vi) Over-irrigation	vi) Efficient and reliable communication system
vii) Illiterate farmers	vii) Reliable and accurate water measuring system
viii) Changing the cropping pattern	viii) Conjunctive use of ground and surface water
	ix) Regular revision of water rate
	x) Encouragement for formation of Water Users' Association
	xi) Training to farmers
	xii) Micro-credit facilities
	xiii) Agricultural extension services
	xiv) Encouragement to farmers for raising livestock

meet ecological requirements. Regulated use of ground water should also consider contribution of base-flow to the river during lean seasons through regulated ground water use.

b) NWP on impact of climate change

NWP recognizes the importance of adaptation to the impacts of climate change by the community through resilient technologies and endorses adaptation to strategies on increasing storages, demand management, stake holder's participation, and paradigm shift in design of river valley projects in coping with strategies to mitigate the impacts of climate change.

c)Enhancing water availability for different use

The availability of water should be periodically and scientifically reviewed and reassessed in various basins every five years considering changing trends in climate change and accounted for in the planning process. Integrated watershed development activities with groundwater perspectives need be adopted to enhance soil moisture, reduce sediment yield, and increase overall land use productivity of rural development schemes.

d) Demand management

The policy recommends evolution of a system of benchmarks for water uses for different uses, water footprints, and water auditing to promote and incentivize efficient use of water with clear emphasis on improving 'project' and 'basin' water use efficiencies through appropriate water balance and water accounting studies. Institutional arrangements for promotion, regulation and evolving mechanisms for efficient use of water at basin/sub-basin level need be established.

e) Regulation of water prices

A water regulatory authority should be established in each state to fix and periodically review and regulate the water tariff system and charges according to the principles of NWP. Volumetric assessment and allocation, entitlement and distribution should be the criteria to ensure equity, efficiency and economic principles. WUAs need be given statutory powers to collect and retain a portion of water charges and reuse of recycled water should be incentivized.

f) Project planning & implementation

The policy document recognizes the need for planning the water resources projects as per efficiency benchmarks to address the challenge of impeding climate change factors. The projects should incorporate social and environmental aspects in addition to the techno-economic aspects through consultative processes with governments, local bodies, project affected people, beneficiaries and stakeholders.

g) Data base and information needs

The policy stresses the need for establishing a 'national water informatics centre' to collect, collate and process all hydrologic and water related information and maintain all information in an open and transparent manner on a GIS platform.

h) Capacity building, research and training needs

The NWP emphasizes on the need for continuous research and advancement of technology, implementing newer research findings, importance of water balance in spatial and temporal context, water auditing for projects and hydrological systems, bench marking and performance evaluation. Need for regular training of the manpower for skill in water management is also recognized.

The provisions of the new NWP are clearly endorsing the principles of IWRM and suggesting that the framework for water planning, development and management should be clearly governed by these principles.

ICID Vision 2030 : A Water Secure World Free of Poverty and Hunger

The International Commission on Irrigation and Drainage (ICID), established in 1950 is a leading scientific, technical, international not-for-profit organization. ICID is a professional network of experts from across the world in the field of irrigation, drainage, and flood management. The main mission is to promote 'Sustainable agriculture water management' to achieve 'Water secure world free of poverty and hunger through sustainable rural development'. ICID is a knowledge sharing platform dedicated to issues that covers the entire spectrum of agricultural water management practices. In addition, drainage of agricultural lands forms the core theme of commission's activities. Floods and drought; the two extremes of increasingly variable climate as a result of potential climate change, also form the focus of activities. Presently, ICID country membership network is spread over 76 countries across Africa, Americas, Asia and Oceania, and Europe, covering over 95% of the irrigated area of the world.

Water being a direct or indirect part of 7 out of 17 Sustainable Development Goals, assumes inclusive dimension both as a natural resource for rural development and an essential input commodity for industrial and human (life-style) consumption. Due to increasing industrial prosperity over the last several decades and demographic changes taking place around the world, urban oriented socio-economic considerations have started attracting greater attention of policy makers and investors at the direct cost of rural water issues. The newly emerging and competing demands for water, coupled with the uncertainty of impact of climate change on food productivity, have challenged the ICID stakeholders and partners to redouble their efforts. ICID Vision 2030 for a water secure world free of poverty and hunger through sustainable rural development through its mission to facilitate prudent AWM by encouraging interdisciplinary approaches to irrigation and drainage management is an expression of intent of the network to help various stakeholders in moving towards a 'World we Want'. ICID network, which serves National Committees (NCs), irrigation and drainage professionals, farmers, policy makers, irrigation and drainage industry, researchers and the academia, and the society at large, aims to advocate an enabling integrated policy environment for facilitating multi-disciplinary innovations to increase land, water and crop productivities in a sustainable manner in a changing climate.

Way Forward

In view of the ever growing water demands for domestic use and commercial sectors, and by considering the present status of water use in the irrigation projects, there is an urgent need to improve water resources management and water productivity across all sectors. State Specific Action Plans are required to be developed based on the guidelines of the National Water Mission and Vision documents of organizations like International Commission on Irrigation and Drainage etc.

In order to reduce water withdrawals for irrigation, upgrading of irrigation infrastructure through rehabilitation and modernization should be given priority. Other aspects like timely maintenance of irrigation and drainage infrastructure, investment in water storage and water saving technologies, combating the twin menace of water logging and salinity through drainage are required.

Maximizing basin water productivity through multi-objective decision making process, developing a rapid innovative research agenda, capacity building at all levels and building of institutional support for local, regional and international markets will go a long way in achieving food and water security. External factors, like impacts of climate change, virtual water trade, changes in agriculture markets and the prices of commodities will influence agriculture growth and allied activities. Such changes will require additional adaptations in the development of water management measures to sustain global food production to desired levels and avoid the probability of a severe crisis in the coming years.

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