BALANCING DEMANDS AND SCARCITY OF WATER: CASE STUDY OF GUJARAT STATE, INDIA

Vivek Kapadia[1]

ABSTRACT

Water scarcity has been a global issue, and India has actually entered a state of water stress. Gujarat is one of the most severely affected states located on the west coast of India. India's average water availability indicates water stress but situation of Gujarat is far worse. With approximately 6% of the land area of India and the same share in the population of India, the aggregate water availability of Gujarat is hardly 2.5% of India's. Thus, overall water stress in Gujarat is too high on the one hand, and, on the other is the lopsided distribution of water resources adding to the severity of water crisis in many parts of the state. Depending on groundwater is also not really feasible as the longest sea coast length, i.e., 1664 km, poses a challenge of sea water intrusion. All these constraints lead to a compelling requirement of water governance that is founded on the philosophy of balancing conflicting demands to spread evenness in the severity of scarcity. Domestic, agricultural, and industrial demands are always conflicting besides spatial and temporal conflicts across the state. Attainment of water use efficiency, technological advancement, selection of cropping patterns, etc., could be some additive mitigation measures, but water governance as the key step towards sustainable development has been utmost important. Conflict management is always art, but in the domain of water management, it is the most difficult task. Water professionals and policy makers of Gujarat have been engaged in taking strategic measures envisioning the future challenges posed by climate change. The paper discusses in detail the water stress, constraints on the way to implementation of the balancing act along with the element of sustainability at the centre of the water management and the results obtained so far. Balancing act essentially requires techniques like supply side and demand side management. Supply side management encompasses storage potential, basin level planning, cross-cutting of basins, integration of storages, enhancement in conveyance efficiency, recycling of water, supplementary irrigation, etc. Demand side management requires technological and social interventions. As the real world problems are very complex, different techniques are required to be introduced selectively in specific regions and at opportune time which forms a real test for the water managers. The paper aims at showcasing how practically demands and scarcity of water are balanced in the context of existential value of water.

Key Words: *Balancing act, Conflicts in demands, Existential value, Scarcity, Water governance*

1. WATER STRESS: INDIA'S CASE

Water is an essential resource required for sustaining life and livelihoods: safe water is required for drinking, hygiene and providing food; and adequate water to produce energy and support economic activities such as industry and transportation. Water in

[1] Director, Sardar Sarovar Narmada Nigam Limited, Gujarat, India, vivekpkapadia@gmail.com

the natural environment ensures the provision of a multitude of ecosystem services to meet basic human needs and support economic and cultural activities. For too long water has been an issue that is at once everywhere and nowhere: it is the lifeblood of our planet and of the human societies that flourish upon it, but is frequently taken for granted, with decisions at all levels and across all sectors made without full consideration of the potential impacts on water resources and other water users. The challenge for twenty-first century governance is to place water at the heart of decision-making at all levels – horizontally across departments and sectors, and vertically at local, national, regional and global scales (Connor et al. 2012).

Water stress is the point at which the aggregate impact of all users impinges on the supply or quality of water under prevailing institutional arrangements to the extent that the demand by all sectors, including the environment, cannot be satisfied fully (United Nations, 2012).

According to the international norms, a country can be categorized as 'water stressed' when water availability is less than 1700 m^3 per capita per year whereas classified as 'water scarce' if it is less than 1000 m^3 per capita per year. In India, the availability of surface water in the years 1991 and 2001 were 2309m^3 and 1902 m^3. However, it has been projected that per capita surface water availability is likely to be reduced to 1401 m^3 and 1191 m^3 by the years 2025 and 2050, respectively. The Per capita water availability in the year 2010 was 1588 m^3 against 5200 m^3 of the year 1951 in the country (Ministry of Jalshakti). Per capita water availability in India is continuously declining, and it suggests the looming water stress.

India's total annual renewable fresh water resources are estimated at 1953 BCM against estimated annual precipitation of about 4,000 Billion Cubic Meters (BCM) including snow fall. Almost two-thirds of India is facing water stress. No state of India is at present in a comfortable situation, but those which are naturally deprived regions are the worst sufferers. The consequences of water stress are far-reaching in the domains of food security, animal husbandry, industrial growth, etc. Not only the economy but also the sustenance comes under a threat of the water stress goes beyond a certain level, and therefore water professionals have taken this issue seriously.

2. GUJARAT: WATER SCARCITY AND MANAGEMENT CONSTRAINTS

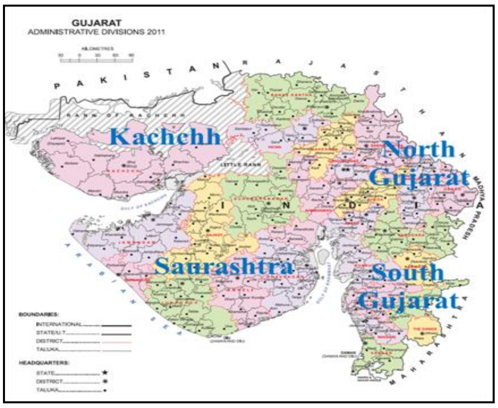

Figure 1. Regions of Gujarat (Political Map by Revenue Department, Government of Gujarat)

One of the most critical states of India from a water-scarcity point of view is Gujarat. It is divided into four regions - South Gujarat which also includes Central Gujarat, North Gujarat, Saurashtra and Kachchh. South Gujarat is water-rich and is also having clayey soil, North Gujarat is water-stressed and has alluvial soil, Saurashtra is facing water shortage and has a mix of black cotton soil with gravels whereas Kachchh has sandy soil and a large area of desert. The coastal length of Gujarat is the greatest in India which is 1664 Kilometres.

Except in South and Central Gujarat there has been scanty water in the entire state. If compared to the per capita water availability, it is much less than India's average. The decline in water availability had been observed from 1990 onwards because of population growth, development of industries, and climate change.

Table 1. Water availability of Gujarat estimated by Water Resources Department, Government of Gujarat

Region	Area in % of Geographical Area of Gujarat State	Water Resources of State in Percentage	Per Capita Per Annum Availability in m^3 in 2011 and (2001)
South and Central Gujarat	25	71 %	1695 (1880)
Saurashtra	33	16 %	487 (540)
North Gujarat	20	11 %	309 (343)
Kachchh	22	2 %	658 (730)

There are many small and non-perennial river basins coupled with low yields due to scanty rainfall in Saurashtra and Kachchh. In South and Central Gujarat, a few but big and perennial river basins are there. More rainfall and a few river basins suggest big and perennial river basins and vice versa (Kapadia 2016).

Table 2. Rainfall Distribution of Gujarat reported by Water Resources Department, Government of Gujarat

Name of Region	Annual Rainfall in mm	No. of River Basins
North, Central and South Gujarat	800 to 2000	17
Saurashtra	400 to 800	71
Kachchh	Less than 400	97

Another constraint is the geographical condition owing to which transfer of water from surplus regions to the deficit ones is very challenging. Albeit, to some extent, it is feasible yet expensive.

Water scarcity and lopsided distribution of water resources are the main issues. Climate change related occurrences are increasingly being reported, which can be learnt from the average number of rainy days and the average number of dry days on annual basis. It is also reported that there is a significant increase in number of heavy rainfall days and of dry days in two-thirds of Gujarat. In a nutshell, Gujarat has a large arid area of

62,180 km^2 which is 31.72% of its geographical area, and a larger semi-arid area of 90,520 km^2 which is 46.18% of its total geographical area. The frequency of deficit rainfall, i.e., less than 75% of average rainfall, is once in three years.

There is a lot of variability in the regions affected by deficit rainfall. Variations of rainfall across the state are so large that any region may receive deficit rainfall anytime. Not only the water scarcity but also the randomness of rainfall patterns has been the real challenge for the state.

3. STORAGE AND SUPPLY MANAGEMENT INITIATIVES FOR BALANCING SCARCITY

Scarcity management essentially comprises of storage, supply, and distribution related initiatives. Storage creation and management depend on rainfall pattern and geographical situation. Supply management, i.e., transfer of water from surplus regions to deficit regions, depends on the topographical conditions between the source and the terminal points. However, such supply management wherever feasible has some cost. This is an act of balancing water resource availability in some cases but in some other cases it might be for balancing scarcity as well especially when water transfer is from a less deficit to a more deficit region. Distribution amongst stakeholders is the most challenging task and mainly depends on institutional abilities developed by the water managers.

Every state or province might have its own strategic moves to roll out the management interventions. Management initiatives implemented so far by Gujarat essentially contain four basic elements of water resource management – conservation, integration, conveyance and usage.

3.1 Exploring all scales for creation of storage potential

The importance of freshwater, and hence water storage, will only increase as populations grow and the impacts of climate change become more pronounced. This is recognized in many national adaptation strategies, where water storage is identified as an adaptation mechanism (McCartney 2022).

A few perennial and many non-perennial river basins are there in Gujarat, and, therefore, harnessing storage potential sites wherever of whatever size was available became a wise proposition for the water managers of the past. Because rainfall occurs during a specific period and a short duration in Gujarat, saving a part of it can provide a buffer that could be used during the rest of the time was the first strategic move.

In order to implement this plan, 206 major and medium dams were constructed in a period of about 35 years. This facilitated a large storage potential of 25,224 million cubic meters (MCM). Where the sites permitted small water potential by creating small structures like checkdam or stream-plug, such sites were also harnessed, and 5,49,902 small structures were constructed, and storage potential of about 1100 MCM was created. 33,304 small water bodies or ponds got remodelled to create a storage potential of about 500 MCM. In aggregate, a storage potential of approximately 26,500 MCM has been created, which amounts to 425 MCM per capita.

On the one hand, there is Sardar Sarovar Dam with a gross storage potential of 9,460 MCM, and, on the other, there are small reservoirs having only 0.1 MCM storage potential. But every bit of storage has its own significance in balancing the scarcity and adding resilience to the system.

3.2 Basin level planning and integration of water resources

Storage potential is always created in a phased manner, and, therefore, utmost care is required to be taken to ensure that existing storages are not affected due to the subsequent creation of upstream storages. This is the biggest advantage of using the basin as a unit of planning for water resource management which is a part of Integrated Water Resource Management (IWRM).

In case the planning of the storage potential creation is done in a standalone mode, benefits of a particular individual structure are considered but the response of the basin would be as a single entity and would depend on all the structures within the basin, and, therefore, the estimated benefits would be far off the real ones – either on lower or higher side. The same way, it may happen that some storage potential that is created for a specific size of catchment and subsequently another one is created which intercepts the catchment of the former, and, therefore the former remains underutilised. Such kind of standalone mode of working results in to futile expenditure and eating in to the benefits of the existing infrastructure. Social implications of such issues are even worse. Contrary to it is the concept of integrated basin planning which requires basin to be treated as a unit. Not only the planning agency but also the operating agency would follow the same concept and accordingly the cost and benefits would be optimised through integration.

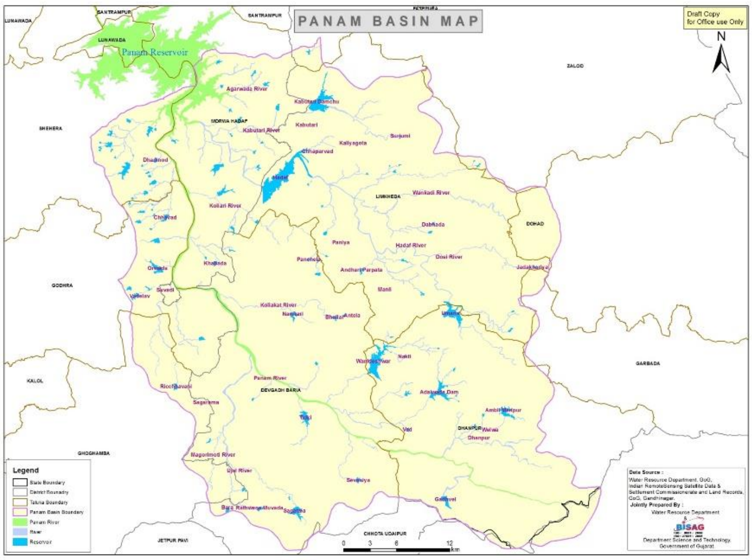

Figure 2. Basin map of Panam river (Water Resources Department, Government of Gujarat)

Policies for the use and protection of water resources in a country are set by national governments. Although the implementation of these policies is effective at many scales, where policies are implemented at the basin scale, there is the opportunity to deliver 'whole basin' solutions and to resolve upstream-downstream (for a river) and region-to-region (for a lake or groundwater resource) controversies. The 'whole basin' approach allows the assessment of impact at a system level (GWP & INBO 2009). IWRM seeks to tackle some of the root causes of the management crisis, namely the inefficiencies and conflicts that arise from un-coordinated development and use of water resources (Patrick, M et al. 2004).

Principle of integrated basin level planning and operation has been best utilised in Gujarat, and, therefore, according to the site situation, the storages of various sizes are created in context of the existing ones and the future planning. As an example, in Panam river basin, besides a dam having storage potential of 578 MCM, 5 medium sized reservoirs and 73 checkdams have been constructed having total storage potential of 133 MCM. This development has been done with the basin as a unit of planning. Panam dam was constructed, followed by the construction of 5 medium dams, and subsequently, 73 dams were constructed. Phased manner of construction in an integrated fashion provided an opportunity to monitor and ensure that no adverse effect on the downstream structure occurs by constructing a storage. An added advantage was of silt trapping. In large and medium dams in this basin, even after 35 years, no significant siltation has been found. No issues related to riparian rights have occurred as every structure spills over without significantly stalling the flow of the stream.

3.3 Cross-cutting basins for surface water integration

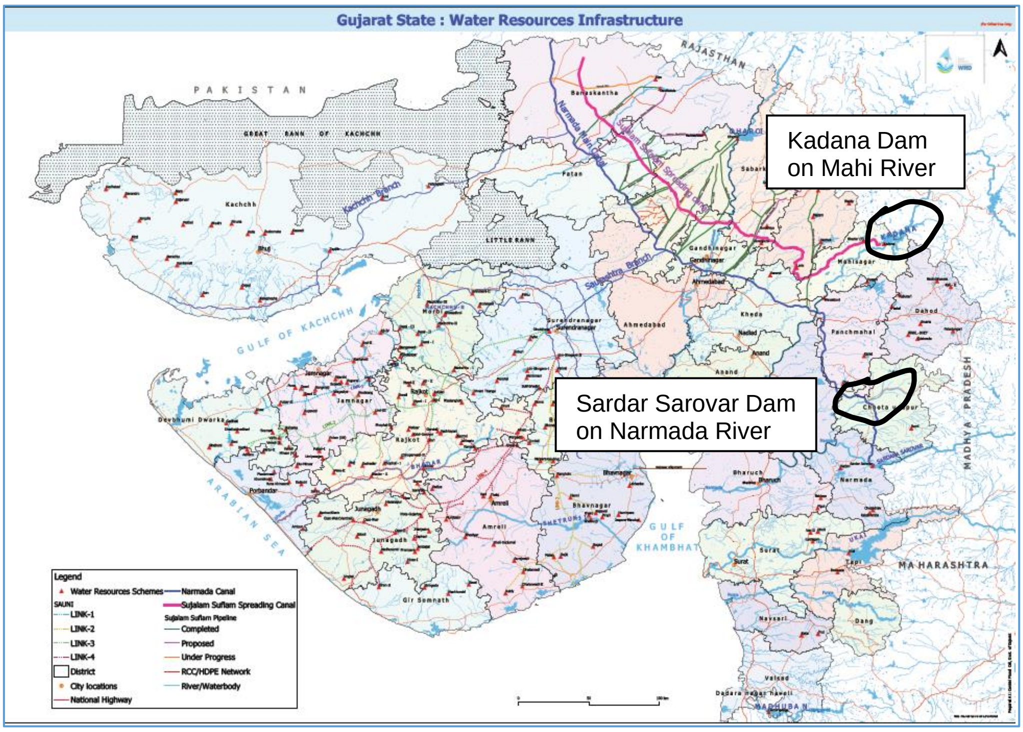

Figure 3. Water Resource Infrastructure Map, 2022 of Water Resources Department

Wherever feasible, the transfer of water across the basin is done though at a very high cost. North Gujarat is the thirstiest part of Gujarat. It covers almost 30% of the area of the state. As the main canal of the Sardar Sarovar Project traverses through this region, surplus water in case if any during any year is feasible to be transferred to this region. The same way if there is any surplus water in Mahi basin, it can also cater to the needs of this region. A canal parallel to the main canal of the Sardar Sarovar project has been constructed to carry the Mahi water known as Sujalam Sufalam Canal. Pipelines transverse to both these canals are laid and equipped with pumping stations such that 7 major dams and over 1100 small water bodies can be supplemented by Narmada and Mahi waters. In Figure 3, blue is the Narmada Main Canal, red is the canal carrying Mahi water known as Sujalam Sufalam Canal, and green are the pipelines carrying water from both of them. This entire scheme by augmenting water resources to the North Gujarat basins alleviates the water stress.

Methods of irrigation for agriculture can be classified from their objective as protective irrigation and productive irrigation. The objective of protective irrigation is to protect the crop from adverse effects of soil moisture deficiency which may often means that irrigation acts as a supplementary source of water over and above the rainfall. Productive irrigation is meant to provide sufficient soil moisture in the cropping season to achieve high productivity. In such irrigation the water input per unit area of cultivated land is higher than protective irrigation. As an essential component of planning for deficit management irrigation philosophy of the Sardar Sarovar Project which is the largest project of Gujarat has been selected as supplementary and protective irrigation rather than productive irrigation, and therefore providing surplus water to the thirsty areas instead of the command area is actually balancing scarcity. There are a few such schemes implemented in other parts of Gujarat.

3.4 Vertical integration of storage receptacles and their reusability

Long interstate rivers have a series of dams that not only retain water during monsoon but also generate hydropower during the non-monsoon period, and that is how the tail-ending dams receive periodical flows from the upstream reservoirs. This aspect provides an opportunity to refill and reuse the same reservoir as the depletion occurs due to water usage therefrom during the non-monsoon period. Sardar Sarovar Dam is an example of having such a reusable reservoir. Gujarat being a tail-ending state benefitted from a few interstate rivers, and therefore this aspect has been a redeeming feature for water resource management.

Some medium-sized reservoirs which are located on higher elevations get evacuated soon after the monsoon i.e., during winter itself. However, water that has travelled down those levels to go into some large reservoir located at lower elevations is still usable for both purposes – to satiate the demand of its own command area and to be lifted to the reservoirs at higher elevations. This type of vertical integration with lifting is expensive but helps reuse the same reservoirs on higher elevations to provide life-giving domestic and irrigation water to otherwise deprived areas. As higher elevations do not permit large reservoirs, this type of vertical integration becomes a boon in the time of crisis. This concept is actually similar to the pumped storage, but the objective is different. Pumped storages are constructed on the same river stream with an objective of optimising the power generation whereas reservoirs constructed on different streams are vertically integrated to make reuse of the same receptacles with an objective of balancing the water scarcity.

There are a few schemes with vertical integration implemented in Gujarat. An example of Panam dam that is earlier described as a solution worked out using basin as a unit of planning is worth referencing here. Panam basin is a sub-basin of the Mahi basin. A dam known as Kadana dam has a large reservoir of 1,542 MCM and is situated across Mahi river at a lower elevation. A piped connectivity with a lifting mechanism has been established to integrate 5 medium-sized reservoirs of the Panam sub-basin, and that is how during the non-monsoon periods, the same medium-sized reservoirs are refilled and reused to satiate their local needs. Such schemes are designed to appreciate existential value of water.

Method of cross-cutting basins also make the reuse of the same reservoirs. Integration – horizontal and vertical, in both ways provides for reusability of the reservoirs. Either the reservoirs which are smaller than requirement or which do not receive sufficient water are integrated with larger reservoirs in both cases – within the basin or cross-cutting basins. This is an effective way to balance the scarcity.

3.5 Conveyance efficiency

Water scarcity management requires higher conveyance efficiency at the system level as conveyance losses are a major flaw in the water systems. Except for one or two projects, all the canal systems of Gujarat are lined or piped. Gujarat has a large canal network of approximately 1,02,000 km, out of which 94,000 km length of canals is lined. The lining ensures avoidance of seepage losses to a great extent besides enhancing velocity and hence the higher efficiency.

Figure 4. Canal lining with geomembrane

Lined canals have another benefit. Because they supply water with greater velocity, a smaller cross-section is needed to supply the same discharge. This reduces the size of the canal, and therefore the evaporation losses are also reduced. This also contributes to the enhancement of efficiency.

Where the soil is problematic i.e., swelling or leaching, geomembrane is used in canals of various sizes along with concrete lining. This has helped avoid waterlogging within the command areas though the canals have been supplying water for last about 20 years.

3.6 Supplementary irrigation instead of regular irrigation

Supplementary irrigation is a good strategy where there is the scarcity of water. But the same can be used for balancing scarcity, too. Sardar Sarovar Project serves a large command area of 1.8 million hectare which is not entirely in water-scarce regions of the state, but the irrigation philosophy of the Sardar Sarovar Project is supplementary and protective irrigation. This is how, out of 3.6 million hectares of irrigation through large and medium dams, half is supplementary irrigation right from inception. All small reservoirs, check dams, etc., are also meant for supplementary irrigation. Almost two-thirds of the irrigation command of the state is covered under protective irrigation.

3.7 Water recycling and desalination

Water recycling for industrial and domestic effluents is done on a large scale in Gujarat. All industrial estates have the concept of a common effluent treatment plan. All municipal corporation have their own effluent treatment plans. For industrial effluent and urban effluent treatment, business models have been established. Now the concept of zero waste village is trying to be spearheaded in the state. In order to make this concept self-sufficient, the cleared water after proper treatment is used for recharge purposes, and the solid waste, which is organic by nature, is converted into manure and sold to the farmers. This model is in the inception stage.

Because Gujarat has a long coast of 1,664 km, desalination to supply domestic and industrial water has also been practiced. At present, the installed capacity is of 370 million litres per day and is being augmented in the coming days.

Recycled water or desalinated water alleviates the shortfall of water to some extent, but the benefit is immense because these techniques work for the areas which are difficult to be reached out to.

4. MEASURES FOR DEMAND MANAGEMENT

Demand management is much more difficult than supply management. In three main water use domains – domestic, agriculture, and industry, demand management is essential to harness the benefits of efficient supply management. As such, the demands are conflicting – on the one hand, food security is a matter of growing concern, and, on the other, the domestic water requirement is rising besides industrial growth eating into the water allocation for irrigation. Efficient use of water in all three domains is the key to sustenance, and therefore management interventions to balance water demands in all the three domains have been rolled out.

4.1 Domestic demand management: challenges and interventions

Domestic water supply has a share of about 16% of annual consumption of water, but because it is increasing with time, demand management is really required.

Out of total domestic water consumption, 60% is in urban areas. Metered water supply to all upcoming town planning schemes has been made mandatory, and many existing ones have been equipped with the water meters. This metering is at the colony level. The colony dwellers pay their bills to the municipal corporations. Only the poor habitations are yet to be covered in the metered supply system. All municipal corporations and municipalities are also supplied with measured water and bills are generated on monthly basis. This has helped control the water consumption. However, household-level metering is yet to take place. A long walk in domestic water metering is needed.

4.2 Irrigation demand and management: challenges and interventions

The largest part of water consumption is in the irrigation sector, and therefore, even a small saving through demand management would be very large from a quantity point of view and would help reduce the pressure from domestic and industrial sectors.

The biggest challenge with demand management in large irrigation projects is that the command area is developed in phases due to several reasons like land acquisition, financial constraints, technical bottlenecks, etc. Because the part of the command area that has been developed initially has ample of water available for use, the beneficiaries tend to grow water-intensive crops and use more quantity of water than their eligibility. By the time other parts of the command area get developed, due to perpetuation of practices of beneficiaries of earlier developed part, the habit of lavishly using water gets deeply ingrained in the mindset, and then their de-conditioning of such minds for using only what is their legitimate pie becomes a challenge.

Amongst several limitations, irrigation demand management has been done to some extent by Gujarat. Micro irrigation has been implemented on over 2.5 million hectares. There has been an institution named Gujarat Green Revolution Company which is instrumental in extending subsidies to the farmers and encourage micro irrigation. Another attempt is in the form of rotational water supply in the irrigation project, which has also reduced the demand significantly. As an example, in the command area of Panam dam, a rotational water supply system has been implemented through the activation of Water Users' Association. As a result of this, out of 553 MCM of total live storage, 510 which was allocated for irrigation purpose could be reduced to 300 MCM for irrigating the entire command area of 32,800 hectares, and the saving of 200 MCM could be utilised for expansion of the command area to the tune of 12000 hectares. Thus, in total the command area that could be served is now 44,800 hectares with the same water allocation. On many irrigation projects, the same type of efforts are going on and a lot of work is awaited.

4.3 Industrial demand management: challenges and interventions

Out of total annual consumption, 8% is the industrial water usage. But because it is a big source of income for the government, all industrial water supply is given in a metered way, and bills are charged. This has controlled the industrial water consumption to a great extent. Water guzzling industries are not given permission to tap groundwater as a policy. Industries are promoted in different regions according to their type of production and the effluent they generate. There has been an Industrial Policy which is revised periodically to ensure that appropriate types of industries go in specific parts of the state.

5. CONCLUSION

Balancing water scarcity across the state and balancing demands amongst various water use patterns and users have been the objectives of water management at the government level in order to ensure the sustainable existence and growth of the citizens. Management initiatives aim at optimizing the benefits of water within given constraints. Water scarcity in itself is a big limitation, but appropriate management interventions make it feasible to sustain and grow, and there lies the role of the government.

Strategies for balancing the scarcity and demand are required to be implemented in the consortium, and no strategy can work in a standalone mode. For example, the creation of small reservoirs as a part of distributed water resource management serves the objectives of groundwater recharge, i.e., vertical integration and supplementary irrigation as well. Finally, scarcity management and demand management go hand in hand.

When two-thirds of the world is going to face water crisis owing to climate change, the world would have to gear up for scarcity and demand management as an innate part of water resource management. Strategies could change from place to place. That would help us not only to sustain but grow as well. It can be safely said that, to some extent, scarcity is a perception that can be overcome by the implementation of proper management practices.

REFERENCES

Connor, R. & Stoddard, H. 2012 Recognizing the centrality of water and its global dimensions, The United Nations World Water Development Report 2012, 22-42

United Nations. 2012 Water Security, http://www.un.org/waterforlifedecade/security.shtml

Ministry of Jalshakti, Government of India, India's Water Wealth http://www.indiawris.gov.in

Kapadia, V.P., 2016 Groundwater Management through Recharge Interventions: A Case Study of Gujarat, India Water Week 2016

McCartney, M. 2022 Declining freshwater storage: A hidden crisis, International Water Management Institute (IWMI), https://www.iwmi.cgiar.org/2022/04/declining-freshwater-storage-a-hidden-crisis

Global Water Partnership (GWP) & the International Network of Basin Organizations (INBO), 2009 A Handbook for Integrated Water Resources Management, ISBN: 978-91-85321-72-8

Patrick, M., Butterworth, J. & Batchelor, C. 2004 Integrated Water Resources Management And the domestic water and sanitation sub-sector, IRC International Water and Sanitation Centre, The Netherlands, 3-11