Mitigating Freshwater Crises:
Individual and State Adaptive Measures in India

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Abstract

Global freshwater crises are compounding. Frequent droughts, crop failures, escalating conflicts over land and territories, endemic diseases, migration, ecosystem degradation are few of its cascading effects. Limited availability, increasing demands and unsustainable practices, have led to an increasing exploitation of surface and groundwater reserves. Renewed majorly through rainfall but being increasingly abstracted and contaminated, freshwater is one of the most contested resource. These contestations occur on account of its differential physical-economic accessibility. With each individual and system attempting to appropriate its rights over the freshwater resources optimally, India is witnessing multi-inter-trans disciplinary politics that constitutes surface, groundwater markets and inequitable water distribution networks. It is in this context that poor are likely to be affected most. Climate change, rapid urbanization, salinization, depleting water tables and poor countrywide institutional responses have further aggravated the gravity of crises. Giving a countrywide qualitative and quantitative over view of the surface and groundwater depletion, the present paper enumerates few successful historical and contemporary mitigating efforts. This is on part of individual, collective farmer groups and on part of State. Taking examples from arid and semi-arid regions of Rajasthan, Gujarat and Maharashtra, the paper brings indigenous, scientific knowledge and amalgamation of both in few cases. These include conservation agriculture, farm ponds, traditional bunding, shaft recharge and other historical manual and gravity based mechanisms to conserve water. The impact of these interventions is measured through an increase in water table, soil quality, increased agricultural yield and changing cropping pattern of farmers. Mitigating mechanisms adopted in view of geography, economic affiliation and more importantly co-operation among stakeholders are creating substantial differences. This micro-meso-macro model can therefore be replicated at a national level. The paper acknowledges the possible geographical, economic and political limitations but also concludes with policy and scientific guidelines that can prove useful for conjunctive surface and groundwater use.

Keywords: Freshwater crises, physical-economic accessibility, inequitable distribution, mitigation, policy, scientific guidelines.

1. Introduction

Freshwater crises are compounding globally. Frequent droughts, crop failures, escalating conflicts over land and territories, endemic diseases, migration, ecosystem degradation are few of its visible effects. Limited availability and increasing have led to an increasing exploitation of freshwater reserves. The magnitude and rate of exploitation however varies across geographies. This is largely in accordance with varying topography and rainfall regime. In addition to this, freshwater dependency is largely determined by economic and agricultural affiliation, population concentration, nature and rate of physical expansion of an area. There are two main sources of usable freshwater. This includes surface water and groundwater. Among the two, groundwater constitutes a larger proportion. However, both complement towards mutual availability. Water run-off from higher to lower gradient determines this proportionate relationship. For a long time, surface water reserves have continued to fulfill majority of human needs. Large and small storage structures, manual and gravity based mechanisms were constructed to store and channelize surface water. Cost incurred in these facilities tend to be high. Groundwater for a long time remained unused, partly because of its invisibility. Groundwater use largely started with the innovations of force and later on electrified pumping. These innovations made groundwater accessible and assured water availability at the point of pump installation. Consequentially, rate of groundwater use has increased and almost tripled particularly in last fifty years.

Groundwater use can be seen more in India. In fact, India is the largest user of groundwater (The World Bank 2010). This is both in terms of magnitude of use and density of coverage. Skewed distribution of surface water reserves, demographic and socio-economic drivers have enabled such extensive groundwater extraction. Groundwater extraction in India is estimated to be in the range of 200-350 km^3 /year (Central Ground Water Board 2014). This usage amount is far less than groundwater volume available in stock and in flux. The issue is however not of availability and use. The concern is for spatial imbalance in draft and recharge (Shah 2007). Excessive withdrawals, particularly in semi-arid and arid regions of the country, have gone beyond natural replenishment rates. This includes agricultural regions of Punjab, Rajasthan, Haryana, National Capital Region of Delhi and Andhra Pradsh. The average groundwater extraction rate in these areas is nearly 142 percentage (Central Ground Water Board 2014). Irrigation in these areas consume nearly 90 percentage of groundwater (Anderson 2009). But this extraction is dipersed over discontinuous land parcels. Urban areas, industrial clusters and energy sectors consume water in agglomerated manner. These are also the sites where effluent dumping is more. Out of 33 Indian cities having million plus population (Census of India 2011), nearly 21 cities are extensively dependent on groundwater. Hyderabad (with the stage of groundwater development to be 864 percentage), Jaipur (206 percentage), Bengaluru (197 percentage), Amritsar (179 percentage), Ludhiana (170 percentage), Indore (125 percentage) and Coimbatore (117 percentage) are few of the urban agglomerations that rely heavily on groundwater (Central Ground Water Board, 2008; 2013). Other million plus cities like Mumbai, Varanasi, Kanpur, Lucknow, Nashik with appropriated surface water reserves rely to a lesser extent on groundwater. However, degradation of groundwater reserves in these regions is substantial. This is due to disposal of wastes. In fact, most of the surface water reserves in these regions are contaminated with toxins beyond usable limits. Central Groundwater Board (2011-2012), estimated nearly fourteen states of the country to be affected with fluoride contamination and seventy-one districts facing saline intrusion. Also, it was illustrated that the water in major river basins of the country, Ganga, Krishna, Cauvery and Godavri, have been depleted by around 32 percentage in the last decade. The potential risks of life is maximum in Ganga-Brahamputra-Meghna river basin affected by high arsenic concentrations.

A larger implication of these urban-rural dynamics is thereby an increasing absolute, relative and economic water scarcity. This has also led to multi-stakeholder politics and commodification of water. To avail safe water in satisfactory quantity, one has to now pay some money. Global and local players operate to sell water and allied services. A large proportion of population however does not have the financial capacity to participate in these exchange processes. As such, water through market mechanisms is differentially accessible. On one hand, a large proportion of population still struggle for their Fundamental Right to have safe water and sanitation facilities. On the other hand, a single domestic household may be using water that is equivalent to consumption by many other households. Responding to the crises, a variety of coping mechanisms, water storage and conservation techniques have been devised. This is on part of individuals, community and State. The succeeding sections of the paper will discuss few of such mechanisms. Some of these measures do not result in resource conservation. But the idea is to reflect the emerging dynamics that is transcribed with depleting water. Also, majority of these cases are from arid and semi-arid regions. As such they revolve largely around groundwater dynamics.

2. Mitigating Mechanisms and Adaptations of Urban Domestic Households

Water management like other public utilities have social-spatial considerations. This includes, finance, technology, demand estimation, quality and quantity supply and locational analysis (Harvey 1973). Any intervention to supply and avail water is thus a weighted decision among these elements. The scale of these considerations varies from the level of State to organizations and individuals. Individuals and organizations generally are the end users. They have to invest in residential and working premises to avail water supply. In an urban area, the supply source can be either from municipal pipe system, public infrastructure, private investment or composite of these. Municipal water network is generally the largest available source. Majority of the domestic households also opt it. Municipal system involves collection of water from a source and then its distribution to classified zones. This municipal system is however, unevenly distributed. There are few residential and instituional pockets which are given preferences on supply side over the others. On a similar note, slum areas lie lower in preferential order. Income inequality, political and administrative power, illegal possession of land are cited as main reasons for service differentiation. These criteria segregate individuals on mass levels. As such slums in many of the urban areas generally receive freshwater at par with 40 liters per capita per day. This is a prescribed minimum quantity to avail freshwater as a Fundamental Right (UNPD 2012). There can be numerous debates in fixing this minimum standard too. The same municipal supplied quantity varies between 80-100 litres per capita per day (lpcd) in other zones. But on a larger note municipal supply also seems to be de deficit. Nearly, 65 percentage of domestic households in majority of million plus cities do not receive recommended 100 litres of water per capita per day. Mega cities of Mumbai, Kolkata, Chennai and Delhi are also water deficit (Sharma and Shaban 2006). This is largely due to population growth and agglomeration of anthropogenic activities. At all India level, per capita availability has decreased from 6008 cubic meter in 1947 to 1861 cubic meter in 2001. This further decreased to 1545 cubic meter in 2011 (Ministry of Water Resources 2015). Decreasing water supplies and increasing water consumption necessitates some alternative sources to be devised by individuals. This can be done either by installing a bore well or by ordering private tankers or using a public facility. In first two cases, groundwater is extracted. The depth of the borewell and frequency of ordered private tankers may again vary with the financial capacity of individuals and institutions. Luxury residential projects may offer 24x7 water supply through deeper pump installations. In addition to this the water appropriation mechanisms also vary across income categories. All this reflects differential mitigating efforts across income categories.

Above stated dynamics were examined further with a research study conducted in Jaipur urban area, Rajasthan in 2015 With non-perenial water sources, Jaipur region largely relies on groundwater. Groundwater draft in jaipur is estimated to be nearly 260 percentage (Central Groundwater Board Wetsern Region 2009). It is estimated that the dynamic groundwater reserves of the region will get exhautsed in next fifteen years. It was in this regard that a study was undertaken to examine houshold consumpiton pattern in Jaipur and its linkages with groundwater depletion in 2015. Nearly 146 domestic households were surveyed in Jaipur city[3]. These households had a propotionate sample of higher (32 domestic households), middle (32 domestic households), lower income groups (32 domestic households), slum residents (28 domestic households) and luxury appartments (22 residents). It was observed that a majority of sample households nearly 86 percentage avail municipal supply. However, in accordance with the growing needs individuals have been devising secondary sources also. Nearly, 47 percentage of households rely on groundwater as a secondary resource. This includes 28 percentage of domestic households having private bore wells and 19 percentage ordeing private tankers. Majority of owners (83 percentage) of private bore wells belong to higher income groups and luxury appartments. The depth of these bore wells also varied between 350 ft. to as much as 600 ft. In comparison to this, bore wells owned by two other middle class families had a depth of nearly 200 ft. Middle class also domestic households seem to adapt themselves to the supply. Only twenty eight percentage in the category sample use a secondary source. Age, number of family members and education are also other important elements that have played a deterministic role in case of these sample households. Slum residents on the other side seem to struggle a lot. All of these slum residents avail supply by municipal tankers and public taps. The distribution point of tankers and public taps can be as far as 50-100 meters. Location in slum areas therefore has its advantages. Covering such a distance on daily basis results in a loss of physical labor. In addition to this, there are always concern to be the first to procure water. Accordingly, slum residents have to plan their daily activity. Otherwise one has to wait in long standing queue. Loss of time also result in loss of wage opportunity. These experiences were reflected through one of the slum resident Monu:

> *"…I live in the end part of the slum here just beneath the mountains and due to terrain the common municipal tap supply does not reach in my near area….every day I have to come nearly 200 metres in the morning and since the terrain is tough, me and my children take bath in others houses… we are doing this since past two years....me and my wife have to carry water for drinking and other domestic purposes all the way long…."*

Apart from this, sanitation facilities in slum areas are not very good. They are also shared by many and not cleaned properly. During morning, there can be 5-8 residents waiting in line outside these public facilities. This also increases the risk of infection. Lack of physical space in domestic households and improper maintenance of common toilet facilities force slum residents

[3] A large number of studies generally take income as a criterion in segregating domestic households. But income may be under-reported or over-reported by respondents. Apart from income, class character is also reflected through the super-built up area of domestic households and wider locality. The study conducted in Jaipur therefore relied on the combination of income, super-built up area and locality as distinguishing variables. Super built-up area refers to the aggregate area of a premise enclosed within the external walls. Both super built-up area and locality (habitat) are observable entities. Minitsry of Housing and Urban Poverty Alleviation (2013) classifies income categories area as lower income group residing in super-built up area up to up to 500 sq. ft., middle income group (600-1200 sq. ft.) and higher income group (> 1200 sq. ft.) respectively. Slum residents have been identified in accordance with the understanding as enumerated by Census of India. Census defines slum as residential areas not suitable for human habitation on account of the absence of basic qualitative-quantitative amenities.

for open defecation. This is a stressful activity particularly for women, elder people and patients of any age-group. Many a times, it gives a sense of insecurity and loss of dignity. Situation gets worsened during nights, particularly in rainy and winter season. Responding to these crises, there have been some collective efforts. This was observed with respect to community bore wells and community toilet constructions. Within the sample, six middle income group and two slum residents avail freshwater through community bore wells. Comprising non-homogenous income categories, domestic households invest collectively in the maintenance and installation. These residents are then benefitted with an extra supply. This is particularly useful in summer season. Apart from ensuring adequate supply, water from these community bore wells provide qualitatively better water. A slum resident Iti narrates her experience:

> *"..Water from public tap in our locality was not good. It used to get mixed with near by sewage pipe. Also the quantity of supply was not sufficient to meet our demands. This made us to install a collective borewell by 25-30 houses. Nealry Rs. 2000/- was taken from each household. We are now getting good water. Number of cases of waterborne diseases has also gone down…"*

These interventions illustrate mitigating mechanisms on individual basis. They also assert the role of water and particularly groundwater as a social capital. But they do not take sustainability aspect into account. As such the larger concern for sustainability of urban landscape remains unaddressed. Functioining of urban areas has changed considerably over a period of time. Modern urban process seems to be always evolving, never done with and far from being perfectly realized (Lefebvre 1973). Today urban areas are characterized by their physical expansion, renewal activities, infrastructure projects, poly-centric environment and sub-urban led investment scenario. These activities have wider linkages with capitalism. However, this will be beyond the purview of the discussion. What becomes important in these changes is the way in which natural resources have been managed and used. Jaipur has often been cited to be the first planned city of the country. The city plan of Jaipur dates back to 1727 A.D. Principle architect Vidyadhar Bhttacharya planned the city with a grid system. This followed zoning, wide lanes and roads and separate spaces for market and public places. One of the distinguishing feature of this planning was water management. Entire emphasis was to tap rain water and conserve it for a long period. The objective was to build resilience in period of low rainfall and droughts. Entire ancient city was divided into four zones. Each of these zones had numerous step wells (called bawari). The size of these step wells varied from two three storeys to even 8-10 storeys. Slope gradient was constructed and used in a manner that rain water runs off to these structures. Also, each of these step wells used to have outlets. After a desired level, which was very rare, water could be diverted to nearby fields. Each of the four zones tend to be water self-sufficient with such arrangement. However, the distinguishing feature of Jaipur water management was Dravavati River. This non-perennial run through the middle of the city along a stretch of 25 kilometre. Terrains were shaped around the stretch to facilitate rain water run-off into the stretch. This used to be the largest water source for the city. Apart from this there were small dams in Amber and Jal Mahal. All these structures proved useful in summer exigency. Another implication of these structures was in maintaining groundwater table. As per the local respondents, groundwater table in open wells nearly 50-60 years ago was as mere as 40 ft. All these facilities are however non-functional. Dravavati River is now the largest sewage dumping ground. Most of the city waste water and other effluents are directly dumped into it. A large stretch of land here is also used for sewage agriculture. During the survey, not a single bawari and open well were found to be operational. These experiences put question the urban process and its linkages with natural resource management. It also posit us to examine these structures in detail and devise a possible methodology to deal with present water crises.

3. Mitigating Mechanisms and Adaptations of Rural Domestic Households

Significance of water crises aggravates further in rural areas. This is because water circumscribes both life and livelihood in rural settings. As such, freshwater is required both for drinking and agriculture. Depleting and degrading groundwater tables have forced rural communities to devise a number of mitigating techniques. Succeeding sections of the paper present few such cases. These cases have been taken from the intervention of an organization Aga Khan Rural Support Program. This organization has been working in west coastal Saurashtra[4] region in State India region for almost 25 years. Its intervention span across multiple domains. Water, sanitation and hygiene, sustainable agriculture, and skill development for rural youth are few among many intervention areas.

Cases discussed in the paper have been taken from villages in three districts namely Dwarka, Junagadh and Porbandar. The entire region comprising of three districts receive an average annual rainfall of 732 mm (Government of Gujarat 2016). The region is underlain mainly by coastal alluvial soil. Some part also comprises of medium black and shallow black soil. These are suitable for cotton cultivation. Groundnut, cotton, pear-millet, and pulses are the major crops grown here. Agriculture in this region relies largely on rainfall. However, since last decade there have been acute freshwater crises. Proximity to sea and excessive groundwater withdrawals by large farmers have drastically depleted the regional groundwater table. As a result, there has been saline intrusion into groundwater. This has led to both drinking water and irrigation crises. Salt water has drastically affected health of local residents. Kidney stone, liver failure and diarrhea are reported on large scale. Drinking water crises have much larger implications for women and children. In the studied villages as will be discussed, women and children used to long as 8 km to fetch water. Physical stress and opportunity cost involved were large in this case (Rajnarayan Indu 2011). Individual and collective measures were then devised to mitigate the crises. These included roof rainwater harvesting structures, farm ponds, farm bunds, and precise irrigation methods such as micro irrigation systems. These are further discussed in detail in the preceding sections.

a. Roof Rainwater harvesting structures (RWHS)

This structure comprises of a storage tank, collection pipes and a roof where the rain water will be collected. Usually 5000-7000 liters capacity tank is installed. This is enough to support domestic needs for family of 4-5 members. Nearly 42 roof rainwater harvesting structures were made in the three villages in last financial year. Groundwater in these villages is saline due to sea water ingress. The roof rainwater collected over the monsoon season reduced the miles of the water for the family members. The entire intervention cost around Rs. 30,000-40,000. Initially 50 percentage subsidy was given by the organization. But now a model of zero percent interest loan is introduced to augment the scale. Similar convincing results have been observed in primary and secondary schools of these villages. Roof Harvesting structures in schools have made substantial differences. Now the model is proposed to be replicated in secondary and higher secondary schools. One of the major limitation of this intervention is its seasonal functioning. As such in majority of the months, residents and particularly women have to struggle. Another limitation is the cost incurred. Many domestic households do not have the financial capacity even to avail the interest free loan.

b. Micro irrigation systems (MIS)

The organization, has undertaken many interventions like construction of check dams, bore recharge etc. for storing water and reviving ground water levels. However, increasing population and anthropogenic activities are continuously leading to more water consumption. It is in this way that supply could never match demand. Given the climatic regime and salinity problem of Saurashtra, the organization decided to focus on irrigation. The objective was to enhance water use efficiency in irrigation. Traditionally, farmers were using flood irrigation method. This had detrimental effect on both groundwater and soil. Farmers were therefore encouraged to collectively construct water harvesting structures. In addition to this, alternative irrigation methods such as furrow irrigation, raised bed cultivation and micro-irrigation systems – drip and sprinkler were encouraged to follow. Initially, these methods sounded alien to the local farmers. Also, micro irrigation method is a costly affair. In addition to this, there were limitations of human resource and finance on part of organization. To tackle these stated problems, the organization devised an entrepreneur based extension model in 2001. Under this model, the organization supports a willing local person to set up an enterprise. Financial help is provided to set up a shop, seed capital, and maintenance of the micro-irrigation system. Technical knowledge of the system is also provided to the individual. This helps in building a local value chain which can approach different manufacturing companies and make the farmer to choose as per the requirement and budget. The local entrepreneur also ensures in providing maintenance service of these irrigation systems. Such two promoted enterprises now have an average annual turnover of Rs. 4 crore ($ 0.6 million) (primary data). These enterprises have provided services to almost 10,000 farmers. This has resulted in an outreach of over 14,000 hectares. Large farmers benefitted with this irrigation system are now able to save up to 40 percentage of water in relation to traditional flood irrigation.

c. **Farm Ponds**

Farm pond is a small water harvesting structure. It can be constructed by an individual farmer even in a small portion of land. The location of the farm pond is identified in accordance with the terrain. That is the natural slope or constructed slope should fall in the catchment area of the pond. This will ensure water storage during rain. Mean annual evaporation rates in Saurashtra varies from 250-300 cm. However, in the post monsoon season it is generally of the order of 30-40 cm. Though this is high but constructed farm ponds prove to be an insurance. Farm ponds in the region have been constructed with government schemes and farmer's own contribution. It has been observed that 65 percentage (nearly 13 farmers) have been greatly benefitted. With more available water, these farmers have been able to change their cropping pattern. This includes shift from less water intensive crops like pearl-millets or sorghum to cotton and groundnut. In addition to this, there has also been an increase in the productivity by 24-40 percentage in these crops. Farm pond structures are also cost effective. Depending on the size, the cost generally varies between Rs. 10,000 to Rs. 50,000 ($150 to $750 approximately).

d. **Bore recharge**

Bore recharge is a low depth bore. It is generally done on a low lying area. The installed bore is surrounded by a filer chamber. This aids in cleaning rain water. The filtered water then runs into the ground through the shaft. This is a low cost intervention. It costs generally around140$ per unit. This includes cost of drilling and making a filter chamber. Bore recharge does not have any direct implication on farmer's income. However, this intervention has helped in reducing soil salinity and groundwater level. Nearly 80 percentage of sample farmers (nearly 16 farmers) have done bore recharge in their fields. The results are widely acclaimed when they are done in the large scale. All the rain water which falls on the ground in the farmer's field flows to a low lying area and later enters the ground water through these filtered bores. It therefore aids in groundwater recharge. Moreover, the quality of groundwater increases. Primary data reveals that majority of farmers have seen reduction in Total Dissolved Solids.

e. **Conservation Agriculture**

Tillage[5] has always been seen as an integral component in agriculture. Generation after generation farmers have tilled land to sow seed and harvest. Conservation Agriculture (CA) on the other hand stands like a way out of the tillage follies. CA farming reduces the soil disturbance. Much of the residues of the previous crop are left in the field. This ensures better soil health. One can also manage diversified crops leading to a socio-economically and environmentally viable field. CA promises a win-win situation for a farmer. It cuts down the cost of production for a farmer and increases the productivity. This technique is still in the experimental stage in the study area. But it has shown good results in terms of yield. A test plot of CA was tested in village Kalej, in Junagadh district of coastal Gujarat. Groundnut – wheat rotation crop was followed. The farmer experienced a reduction of 19% cost of production majorly in tillage done and irrigation given. The CA plot which the farmer had adopted had also seen reduction of one support irrigation which was induced by the mulch cover on the soil. Overall there was an increment of 6.52 percentage in the yield. Soil testing analysis also revealed an increase in the organic carbon content from 0.5 percentage to as high as 0.75 percentage (Primary Data). This test was performed after the completion of one crop cycle. It is to be noted that the increase in organic carbon content increases the water holding capacity of the soil.

f. Water management societies

A number of models have been devised in the study region to ensure water justice to each and every individual. Also, attempts have been made to encourage power players to change the copping pattern. However, there have been only 3-4 success stories in the latter case. In the study area, a large number of medium and small farmers were facing difficulties to irrigate. This was primarily due to inequitable distribution of water from river and canal source. Large and politically established farmers in the head part used to grow water intensive crops. As a result a large amount of water was consumed and less water was made available to the tail end lands. This uneven consumption necessitated alternative measures. Lift Irrigation Society, Participatory Irrigation Management and "Gram Pani Samitis" or Village Water Management Committee (VWMC) were established. These models proved successful in bringing a sense of equity and created social pressure on large farmers for a just use of water. VWMCs are the organized body at each and every village which have representation from all segments of society – caste, class, farming category, politics and is a collective which ensure the water use is scrupulously managed. They also charge some token amount from the community members on the different interventions promoted through government. The committee also manages a Reverse Osmosis (RO) plant for drinking water purpose. This model completely runs on a social enterprise model. The RO plant operates in 3 villages covering over 1000 households. The plant is run by the committee on no profit loss basis. It supplies water to the community members at a

[5] Tillage is a practice of cutting, lifting and pulverizing soil, in order to prepare a fine and loose bed for further sowing or transplanting of crop planting material.

low affordable price of Rs. 150/100 liters ($2.3/ 100 liter). The plant was initially supported by a donor organization while the maintenance is now borne by the revenue generated from plant.

g. Lift irrigation (LI) societies

Lift irrigation uses pumping technology to lift water from nearby surface water reserves. This can be done through a combination of electric, diesel, solar and air mechanisms. The objective is to create pressure to lift water and transport it to a main delivery chamber. This chamber is usually positioned at an elevation in the command area. Gravity based lanes can be constructed to transfer the water in smaller tanks in each of the farm. Such a model is being practiced on river Meghal in the study area. The LI model developed on the river has around 80 beneficiaries. This has a mix of different categories of farmers and it covers a command area of around 96 hectares. The model has been constructed with a society formation. This has disbursed the total cost of Rs. 25 to 40 lakhs ($38,000 to $60,000) among the beneficiaries. In addition to this, drip and sprinkler for a more efficient use. Though the organization is trying to encourage farmers to irrigate less water intensive crops, the facility is also used for water intensive crops like sugarcane and groundnut. A large number of small and medium farmers cannot afford to invest. They have been relying mostly on lift irrigation with animals. For this, Meghal river society also supports zero percentage interest loan for installing the LI facility. All the village level VWMCs, LI societies collectively have formed an umbrella organization named *Mahasangh* or Federation, by democratic representation. The federation has been doing advocacy work in the region in order to influence the policies of the government in regards to the judicial management of water as well as designing mitigation strategies. The federation has been able to mobilize a government grant of Rs. 9,10,000 ($15000 approximately) for repairing and construction of the spreading canal.

4. State Adaptive Measures

Realizing the gravity of freshwater crises, there have been many interventions initiated by Central and State governments. This section will discuss two such interventions – Jal Yukt Shivar (Inclusive Water Campaign) in Maharashtra and Spreading Canal Project in Gujarat. Jal Yukt Shivar is an Integrated Water Management Programme launched by Government of Maharashtra in 2014. The objective is to make water stressed areas relatively empowered. As such a large number of interventions have been initiated under this wide flagship programme. This involves deepening and widening of river streams, construction of check and stop dams, construction of farm ponds, de-siltation of existing water bodies. A total of $ 3840 Million has been allocated for these works over a period of four years. A large State level data is available over the progress of these programmes. However, this paper will only address details with respect to Osmanabad district of the state. Both authors have been visiting the district and have been monitoring the intervention.

Osmanabad is located in the drought prone Marathwada region of Maharashtra. The district receives a normal annual rainfall ranging from 600-850 mm (District Collector Office 2015). All the eight blocks of the district are highly prone to drought. Also, there have been increasing fluoride contamination in deeper aquifers of Tuljapur, Omerga and Osmanabad blocks. Responding to the condition, the district collector initiated the Jal Yukt Shivar in 217 villages of the district. In fact Osmanabad district laid the foundation of the entire programme. A unique feature of this programme is the convergence of different departments. Agriculture, irrigation, water, public works, social forestry, gram panchayat and village residents were brought to work in co-ordination and consultation in one another. This was a difficult and complex task that was achieved with months of consultation and campaigns. A number of works were there initiated. A summary of these have been listed in Table I. In addition to this, river rejuvenation and de-siltation works have also been undertaken. A total of 18.1 million silt has been removed since 2013-2015. This converted nearly 6000 hectare of barren land into cultivable land. Also, the water storage capacity was increased by 18.29 million cubic feet. This will further increase the irrigated area by 5000 hectares (District Collector Office Osmanabad, 2016).

Table I: Summary of Work Undertaken in Jal Yukt Shivar, 2015.

Sr. No	Type of Work	Work Stated in no. of villages	Total no. of Works	Total no. of Completed Works	Total no. of Ongoing works	Expenditure (Rs. in Lakhs)
1	Desilting through Govt Machinary	18	83	43	40	474.97
2	Desilting through Public Participation.	77	612	536	76	2504.56
3	Compartment Bunding	88	4335	2949	1386	3885.11
4	Loose Bolder Strcture	8	44	8	36	2.60
5	Farmpond	27	1378	134	1244	79.43
6	Perculation Tank Repair	7	12	2	10	66.00
7	Cement Nala Bund	44	289	42	247	94.00
8	Cement Nala Bund Repair	30	320	158	162	119.93
9	Earthen nala Bund	6	115	11	104	29.37
10	Earthen nala Bund Repair	17	57	3	54	23.00
11	Tree Plantation	15	120	7	113	9.41
12	Well Recharge	46	9757	396	5361	23.11
13	Nala training and Deepening	71	1104	645	459	844.07
14	Deep CCT/CCT	4	231	27	204	37.3
17	Recharge shaft	2	504	96	408	35.00
18	Drip and Sprinkler	195	8092	7913	179	1703.73
19	Canal Repair	22	0	0	0	0
20	Other	17	3211	157	3054	220.88
TOTAL		217	30333	13127	17206	10152.47

Source - District Collector Office 2015

Another state adaptive measure that is under consideration is spreading canal. Spreading canal is an elongated canal of 10 meter deep and 8-10 meter wide excavated along the coast line. It diverts freshwater from rivers at estuaries. This in turn helps in recharging the groundwater, reduce salinity and act as a source of irrigation. Government of Gujarat has constructed such a spreading canal in Saurastra coastal region. A study was undertaken in 8 villages of Mangrol block through which canal passes. There are nearly 2058 farmers in these villages. The undertaken study followed simple random sampling. A total of 92 samples across were interviewed to gain insights about the advantage of the facility. Decrement in total dissolved solids up to 500 points was reported as the main benefit. Also, with the canal water the cropping intensity has increased by almost 400 percentage. Farmers earlier could grow only one crop as groundwater was saline. With available canal water farmers are now opting multi-cropping. Wheat, mungbean, pearmille and groundnut are the main crops grown. Decrement in salinity has increased the yield by nearly 35 percentage in case of groundnut. This helped in generating an additional average income of Rs. 15, 775 per hectare (nearly $242.75) in a cropping season. Village level societies have been constituted to maintain the canal and approach the government for timely funds.

5. Conclusion

Freshwater crises are increasing day by day. Increasing physical and economic scarcity are now common. This has larger implication in multiple life domains. In midst of this, mitigation mechanisms now seem necessary. These mechanisms can fulfill individual needs but one has to take into account the implications for resource sustainability. This was seen with the undertaken study in urban and rural areas. But the larger argument, the study brings in is the dynamics and working conservation models. Not to mention, but nature of geography and anthropogenic activities plays a very important role in determining the type of mitigating mechanisms. Small and collective efforts can create a substantial difference in balancing the use and recharge of freshwater resources. However, a large gap is still exists in amalgamating the traditional and technological innovations at an affordable cost. With increasing urbanization and unsustainable practices, it becomes necessary to adopt and innovate further. In an increasing market society, the objective should not only be of an enhanced capital (s) circulation but a sustainable natural resource management. The latter would be difficult to achieve as that can be seen with contemporary practices. However, the discussed micro and macro efforts do make us to make serious efforts for a better water resource management, both at the individual and collective level.

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