ISSUES AND POLICY OPTIONS FOR GROUNDWATER RESOURCES IN GUJARAT

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Abstract.

Central Water Commission, Central Ground water Resources Board and Gujarat Ground water supplies and Sewerage Board have seriously examined techno-economic aspects of ground water resources management in India and Gujarat. It is pertaining to geographical area wise classification and use of groundwater resources, quality of the water for public health. The present paper analyses district wise situation of ground water quality in Gujarat state. The paper has highlighted to have a link with surface water resources with ground water resources not only in Gujarat but also in all states of India. The Eleventh finance Commission has considered investment in water resources under state subject. Still, however, the commission has not provided a code of conduct for devolution of resources between the states and the Centre under the central pool so as to have resources for water investment by the states. This so as local self- government solely depends upon the states Governments and the states on the Centre Government as local bodies are running heavy financial deficits. And hence deployment of financial resources in Infrastructure in general and water resources in particular by the states has become a crucial issue.

The aim of this paper is to review existing latest literature grown in the recent past so as to sort out issues of research/ debate in ground water resources management India vis-à-vis Gujarat. An attempt is made in this paper to know water geography in terms of nature of water so as to have more private investment in the sector to development water market in Gujarat for more economic use of water. District-wise ground water extraction and inter-district variations are examined along with quality of ground water resources in different districts of Gujarat state. Ground water quality is examined so as to have more efficient use of the water for irrigation and drinking purposes. At the end of this paper, policy options are offered so as to have efficient ground water resources management in 21st Century in Gujarat of India with economies of scale for extraction of the water.

INTRODUCTION:

As per UNESCO estimates (1992), over half of the World's population depends upon ground water for their survival, whereas, in the case of India, 85% of rural and over 50% of urban water supplies depend upon ground water for meeting drinking & domestic water needs. It is most necessary for the developed state like Gujarat in India to tap potential sources of ground water for sustainable growth.

As per estimates of Central Water commission Report (1999), 90% of country's drinking water supply in India comes from groundwater resources. Drinking water requirements of urban areas where groundwater sources are not utilized are met from the reservoirs of irrigation and multipurpose projects. Therefore, Geologists and hydraulic engineers pleaded for immediate completion of Narmada Sardar Sarovar project in Gujarat so as to raise the levels of ground water relatively in scarcity affected drought areas. North-Gujarat and Saurashtra regions in Gujarat state of India are scarcity affected drought area in general and districts like Kuchchha, Banaskantha, Mehsana, Jamnagar, Junagadh and Rajkot in particular. Ahmedabad – Vapi Industrial Belt on west coast of India in general and Gujarat in particular is famous for highly industrialized and urbanized geographical areas. Groundwater is used for drinking, agriculture

and industrial purposes in the region as it can be developed at low cost. However, advent of green revolution with high yields varieties of crop, demands extraction of ground water in excess of recharge leading to depletion of water table, vis-à-vis degradation of water quality, heavy application of fertilizers, pesticides, relocate of industrial effluent and domestic sewage and its infiltration to aquifers aggravated the problem. Since groundwater quality is deteriorated, it is very expensive to restore, monitor and protect for sustainable period of time.

The present paper is divided into four parts the first one reviews existing body of literature grown in the recent past so as to sort out issues of debate in area of ground water resource management in India Vis-à-vis Gujarat. The second one shows present scenario of ground water resources and their quality in Indian and Gujarat. The third one analyses district wise nature of ground water resources in Gujarat, whereas, the fourth one expresses policy options to be followed for better ground water resources management in Gujarat.

I. RETROSPECT:

The state government publications reveals (1997)1 that there are over-exploited talukas having less than 100% Ground Water Development (GWD), dark talukas for exploitation between 90% to 100% GWD and gray talukas for exploitation have between 70% to 90%. Gujarat state has 183 talukas out of which 31 fall in overexploitation category, 8 talukas between 90% to 100% GWD, whereas, 42 talukas 70 to 90% of GWD. As against this, Rajkot district does not have first two categories of **talukas** but 7 talukas having GWD between 70% to 90%. Gujarat Pollution Control Board study holds the view that quality of groundwater is not identical in these seven talukas of the district considering analysis of water components. There is a case for the researchers to identify villages in the talukas in each districts of Gujarat state having poor level of groundwater and deteriorating quality of the water.

The National Water Policy (1987)2 and the New water policy (2002)3 provided guidelines for optimum use of water with priority to drinking, irrigation, hydropower, navigation, industrial and other purposes respectively. The policies reveal that such priorities can be modified with reference to area specific considerations. Ground water resources constitute 45% of irrigation in India, whereas, 52% in the case of Gujarat. Groundwater development is financed through institutions within 50 Meter depth and it is necessary to see feasibility of taping ground water resources in through various means of water storage like means of groundwater recharge and water harvesting for economic use of water. Therefore World Commission on Dams was constituted in 1998 for assessment of need of large dams to cater to raising levels of groundwater in different geographical areas in general and scarcity affected areas in particular. The same is applicable to Saurashtra and North-Gujarat regions of Gujarat state

Dr Sharma (2000)4 Attempted to explain ground water resourced management at all India level. He has explained major aquifer types in India, groundwater productivity and groundwater quality resources assessment from hydraulic engineering point of view with different groundwater Models. However, the present attempt is to highlight economic policy pertaining to ground water resources in Gujarat state. As against this, Dr. Purohit studied different parameters affecting ground water quality and provided guideline for planning about preventive majors before punching the underground aquifers in Gujarat state in India

Gujarat Infrastructure Development Board (1998)5 published Gujarat Infrastructure Agenda: Vision 2010 which reveals that demand supply of water assuming no capacity addition the gap will widened from 334.91 (MLD) in 1998 to 986.43 in 2010 in the case of five big cities of Gujarat named Ahmedabad, Vadodara, Surat, Jamnagar, Rajkot and Bhavnagar. For this, cumulative investment will be required from Rs. 376.43 crore to Rs. 779.28 crore at the end of 2010. The report has posed a challenge for these six cities having Municipal Corporation to finance their water need in 2010 and their prime source is ground water resources tapping .The report has advocated for Municipal reforms in financing in Urban Infrastructure in general and

water resources in particular through bond finance by public –private partnership in water market.

Pillai(1992)6 attempted to explain water Management and planning with reference to different methods to tap ground water, cost of lift irrigation in watershed area and use of ground water resources for planning irrigation schemes. The techno-economic study revealed technique to measure cost-benefit for agriculture sector ground water use in arid zone of Rajasthan. There is a gap between costing of ground water and price of ground water for different use in fast developing state like Gujarat.

Tushaar Shah (1999)7 attempted to highlight a model for ground water resources utlization in rural economy of Gujarat so as to express water markets in rural area of some the districts in Gujarat. The main theme of the paper show policy options for public private participation in rural water markets. In another study(1993)8 (1988)9, Shah attempted to analyzed nature and working of ground water markets, political economy of irrigation development in command area. In the case of Gujarat he has found oligopolistic market structure with competitive performance. It is to his credit that common property resource Water Extraction Model (WEM) for ground water resources focused on external economy realized by the private owners. He has seriously explained water markets for electric power pricing, power supply by showing example of Andhra Pradesh, U.P. and Gujarat in his study so as to show optimal price Model of electricity for agriculture.

Ashok Keshari(2002)10 provided an excellent account of groundwater modeling in India to measure quantity and quality of ground water resources in different states of India. He viewed that with growing ground water quality problems and effective management of resources, it is necessary to identify and make use of modeling technique for comprehensive evaluation of ground water system on scientific basis. The main features of the various numerical models are :

1. the solution is sought for the numerical values of the state variables only at specified points in the space of time domains defined for the problem,

2. the partial differential equations the represents the physical process occurring within the system under investigation are placed by a set of algebraic equations written in terms of the sought discrete values of the state variables at different time, space and point.

3. the solution is obtained for a specific set of numerical values of the various model coefficients, and

4. Since a very large number of equations are involved and need to be solved simultaneously, a computer code has to be developed in order tom obtain a solution using digital computer.

It has been observed from professional journals that many ground water models are developed to deal with real-life problems over the globe and many of them are well documented.(Segol,1994, Anderson and Woessner,1992 Bear and Verruijt, 1987)

Syed Zair(1995)11,(2000)12 attempted to show conflicts emerging amongst ground water users in the context of declining water tables during the dry season. The author highlighted that despite seemingly abundant water, increasing use of deep water table exacting technologies for irrigation takes water from shallow hand-pumps used for domestic water supply in Bangladesh. Seasonal crisis affected adversely excessive use of hand pump operators largely due to unclearly defined ground water rights. Non-irrigation household depend upon shallow hand-pumps for domestic water are deprived by water as well as endowed farmers excessively drawing groundwater through tube wells. On reviewing this case, it appears that there is a case for Gujarat to examine such a phenomenon in scarcity affected drought areas. Similarly, financing

system is discussed for financing for private participants in Bangladesh. The allocation system must take into account all type of users, particularly, the Poors.

Gurjar and Shukla (2000)13 studied ground water and surface water resources in Rajasthan so as to know geohydrology of the state with regard to water resources, quality of ground water, area-wise ground water situation in different districts of the state and funding by NABARD. The work is full of base line profiles for water management techniques in urban and rural areas.

Yagnik, Kavalanikar and Gandhi (2003)14 attempted to know groundwater impact assessment of Mahi river in peripheral effects in Anand and Vadodara districts of Gujarat state so as to know water quality in different locations geological sub-surface and groundwater cross-sections in Vadodara, Padara and Borasad taluka due to tidal and industrial pollution . According to them out of the total area of 10130 hectares, 559 in Vadodara taluka, 9153 hectares in Padara taluka and 390.56 hectares in Borasad taluka affected by tidal and industrial waste water pollution.

Moreover, Patel (2001) examined palaeochannels for ground water resources in Saurashtra Peninsula, Peninsula of Kuchchh, Easter rock highland and alluvial plains development in Gujarat so as to express geo-hydrology grounds water resources in the state. The author has examined total watersheds, surface water potential, ground water potential as well palaeochannels aquifer storage in the said geo-hydrological regions in Gujarat state. He has shown comparative picture of ground water and surface water details with cost of development. According to his, shallow version 22 billion M3 of surface water need to be linked with 3 billion M3 ground water resources of Gujarat for better water management. If 50% of these portions are linked up, which may create a dependable water source equivalent to Narmada in Gujarat. Very recently, C.W.C(1990)13 and Sinha and Jain(2000)14 studied ground water resources development in different geographical regions of Gujarat so as to show engineering plan so as to up date ground water resources against rising demand of water by different segments of our society.

1.1 Issues Drawing Attention of Researchers:

Experts of different disciplines can enlist areas of research, the present researcher being an economists, he poses following areas of research on the basis of the said inter-disciplinary literature grown in the recent past with considering techno-economic aspects of ground water economics in Gujarat state.

1. The Government of India has not directly invested in Water management efforts at state level. However, whatever the efforts are made are only by the state governments in India. The issues of investment in water resources development require involvement of the center, the state and local self-government so as to repose confidence of private participants interested to invest in water resources at state and local level.

2. Ground water is over excessively extracted and is uncontrollable with respect to annual recharge of rainwater. Here question arises what Government should do and what people should do looking to alternative economic uses of ground water resources in Gujarat ?

3. For this, no correct assessment is made for demand for and supply of ground water resources as a common property in various districts of Gujarat from techno-economic point of view.

4. What course of action required for local self-governments in Gujarat for high distribution loss of water ? What is the price and the cost to local-self-governments for ground water supplies to the people ?

5. Which kind of alternative Models used by the local self-governments in Gujarat based on replenishment and recharge of surface and groundwater resources ?

6. How water geography and commercial geography of Gujarat are correlated, in other words, how regional imbalances of different districts are related with geographical factors for balanced extraction of ground water resources ?

7. What should be cost and price of ground water resources in different districts of Gujarat to tap the resources optimally in economic way ? Is it a wiser step by the Government of Gujarat to equally invest in all districts to exploit ground water resources? Sometimes, cost component may not allow to do so ?

8. It has been observed by Geo-hydraulic engineers that retention of rainwater is very less in hilly areas of Gujarat and surface water is facing turbid containing silica salt. There are 1200 villages in Gujarat having Nitrogen losses to the surface environment of water and land use. What is a way out of the situation ?

9. Is there a case to link up ground water resources with surface water resources in Gujarat through palaeochannels for scientific development and management of water resources in Gujarat? If so Why the Government of Gujarat has not sought advice of geo-hydrologists in for the development of both the sources of water ?

10. Why the Government of Gujarat has not framed water rights for the extraction of ground water resources in the state? It is a fact that the rich is exploiting more at the cost the Poors and other middle class people of Gujarat?

11. What is a relationship between quality of water and economic value of water for alternative uses of ground water resources in Gujarat ? Whether cost component allows to full utilized ground water resources in all district of Gujarat in a balanced way ?

12. Is it true that Public health and occupational health are highly affected by polluted or low quality of water ? How Economics of health is related with economics of ground water resources in Gujarat ?

he present paper addresses a few of the said issues.

II Five-year plans and Growth of Groundwater Resources :

Table No.1 provides growth of irrigation potential created and potential utilized. India had potential created and utilized are fully 100% from the first five-year plan to Annual plans period 1978-80A careful observation of the table reveals that potential created has increased notable during the eighth and the Ninth five-year plan period in India. As against this, up to the period of the first five-year plans in India 100% potential utilized then it has declined notably. There is a gap between potential created and potential utilized due to technical and financial reasons. Out of total estimated fund in urban development of Rs. 51284.20 crore under the ninth five-year plan, the fund requirement for urban water supply only would be Rs.26301 crore. It is expressed in the plan that private sector participation will be encouraged, as budgetary resources are inadequate to meet total financial requirement of the sector. The Planning Commission expressed the gap between potential created and potential utilized water resources will be widened during the Xth five-year plan due to lack of resources to tap potential. The central government of India has never directly invested water resources development at state level in India. Therefore, there is a case for private-public participation in ground water resources development, as it requires sizeable investment not only in India but at all state levels too. All

state governments should prepare **Master Plan** for better utilization of ground water resources for possible investment by the public and private investments.

Gujarat's annual renewable per capita availability of water is 1137 M3. According to Falkemark's indicator of water scarcity, the state is **"water stressed ".** As against this, water availability is only 474 M3 per capita per annum in North-Gujarat in contrast to 1937 M3 in South-Gujarat, where nearly 70% of total state's fresh water resources are concentrated. International Water Management Institute projected for 2025,availability of 700 M3 per capita per annum making a Gujarat a **"Crisis State".** It is estimated that during the drought year 2000,25 million people in 9500 villages, 4 metros and 79 towns were hit by drinking water scarcity. Moreover, 2400 villages had to be supplied drinking water by tankers and agriculture loss about Rs.4000 crore. Well-off section of community had to buy water at high cost, drilling deeper access to groundwater. Presently, industrial wastewater pollution to groundwater resources is a big challenge in the state. Inequalities of also exist in access to public water system in urban areas of the state as urban water supplies are heavily subsidized, and users pay only flat tariff for water irrespective of the quality of water used. Households with private tap are at an advantage of greater convenience. NGOs like Aga khan Rural Support Services(AKRSP) played a vital role for Jal Kranti (Water Revolution) movement in which the ownership of water harvesting within the village has shifted decisively from the state from the state/ NGOs to the village community. This has led AKRSP to low cost quickly executed structure of water harvesting. Thus. The organization marked a paradigm shift from implementation role to facilitative role.

Table No. 2 shows groundwater structure and growth trends at all India level. During the period 1951-97, the number of dug wells increased from 3.86 million to 10.12 million, that of shallow tube wells from 3000 to 5.38 million and public tune wells from negligible to 68,000 as mentioned in the table. The central water commission observes that electric pump sets have increased from negligible to 9.34 million and diesel pumps sets from 66000 to 4.59 million. During the eighth five-year plan period 1.16 million dug wells, 1.14 million shallow tube wells and one-lack deep tube wells are added up to March 1997. Similarly, during 1951-97 the ground water based irrigation potential steadily increased from 6.5 million hectares per annum (mha) in 1951 to 41.99 million hectares (nearly six times).

1.2 Water and Land Geography of Gujarat:

It is necessary to glance through water and land geography India vis-à-vis Gujarat to identify ground water resources problem in different districts of Gujarat. Table No.3 provides different districts and their percentages of 0ver-exploited area located in different states of India.. It can be observed from the table that Punjab and Haryana are leading with 52.54% and 41.67 % share respectively in over exploited Talukas/Blocks. However, Tamilnadu has 11.20%, Haryana 7.61% of total in India, whereas, Maharashtra has highest 34 dark Talukas/Blocks. Compared to this, Gujarat has 184 total talukas of which 12 are over exploited and 14 are dark talukas in the state. As per estimate by the Central Ground Water Board, 37% of total available ground water resources have so far been developed at all India level. Gujarat has total 1,95,894 Sq. Km geographical area and 24300 Sq. Km area is saline ground water area. It has been observed by the document of the IX five year plan (Vol. II P. 272) that rapid development in ground water based irrigation in many states has caused water depletion, resulting in reduction in the life of the drinking water sources. A number of steps need to be taken up to manage ground water in a more scientific manner especially in dark and gray zones and the state should bring in a legislation to control over-exploitation of ground water on the lines of the Model Bill brought out by the Central Ministry of water resources. Users group needs to manage ground water as a common property resources rather than allowing it to be over-exploited as an open access resources.

Gujarat has total geographical area of 1.95,894 Sq. Km (100%). Out of these, 109899 Sq. Km (56.7%) are rocky areas, 35463 Sq. Km.(18.09%) area is suitable alluvial area, whereas, 34962 Sq. Km (17.83%) is saline and arid area. As against this, Gujarat has 1550 Sq. Km. (0.80%) Limestone saline area and semi-arid area. Moreover, 14025 Sq. Km (7.15%) area has sand stone draw attention of researchers of different disciplines for possible solution of water crisis in the different geographical areas.

Table No.4. Provides district-wise break up of the geographical area of Gujarat state. A careful perusal of table expresses that kachchh and Banaskantha districts are occupying highest geographical area of salinity in sq.Km.10422 and 2936 respectively. As against this, Surendranagar district alone occupy 10443 Sq. Km geographical areas among which 4609 Sq Km areas are saline. So far as hard rocks areas are concerned, Rajkot district is leading with 8975 sq. Km area followed by Panchmahal 8722, Junagadh 8502, and Jamnagar 7460 Sq. Km area. Looking to Alluvium & sedimentary area, Kuchchh is leading with 10111 Sq. Km. areas followed by Banaskantha, Mehsana and Surendranagar. This provides us a clue that water and land geography are correlated for acute water problem in Gujarat state.

Similarly, fresh water area is highest in Rajkot district in Gujarat having 9840 Sq. Km area followed by Junagadh 9231 Sq. Km. These districts draw attention of Geo-hydrologists in Gujarat and India to tap potential sources of fresh water. It appears that it would be a wiser step if such scientists can draw master plan showing economic viability and technical feasibility to extract the water for other areas of Saurashtra and Gujarat comparatively at low cost than other sources to provide water by the Government. Even private participants can exploit the resources through new investment, which may enable to develop new water markets in Saurashtra region of the state.

Table No.5 provides details about district –wise recharge of ground water, surface recharging and draft in 1997. The aim of this table is to sort out districts with a view to know ground water balance and development in percentages in its levels in different districts of Gujarat. Gujarat has total 16060.35 Metric Cubic Meter (MCM) water resources per year. Out of these, 3212.07 MCM/Year provision for domestic and industrial uses, 12848.28 MCM/year utilizable ground water resources, whereas, 9708.35 MCM/year as gross draft and balance MCM/year is 3139.43. This means level of ground water development in Gujarat state is 75% falling in category Grey of ground water. However, there are inter-district variations in this recharge table. We have Gandhinagar, Banaskantha and Mehsana districts having water development above 100% falling in category OE. As against this, Ahmedabad, Banaskantha, Gandhinagar Kutch and Mehsana districts leading to state level average in ground water development. There are districts having ground water development is below the state average. These include Surat, Surendranagar, Valsad and Bharuch. These calculations and classification of the districts are pertaining to phreatic aquifer.

Looking to the table, Banaskantha, Mehsana and Gandhinagar have minus balance in the case of water resourced utilized. However, North-Gujarat and Saurashtra areas are deficit in water largely due to over extraction of ground water. There is a need for clear **Water Rights** in a fast developing state like Gujarat.

III. WATER QUALITY IN GROUND WATER RESOURCES IN GUJARAT:

It is necessary here to know about water quality of ground water resources in different districts of Gujarat for more economic and hygienic alternative use of the resources. Moreover, this may help public and private investors for better utilization. For this, data is collected from Gujarat

water supplies and sewerage Board Gandhinagar from their sample analysis done in the recent past. It is a published one. Chemical analysis is necessary before investment for ground water resources.

Gujarat water supply & sewerage Board published survey results of ground water survey undertaken by the Board. Total Sample of 27812 were drawn out of which 6334 were from non-potable sample study of different districts of Gujarat to know quality of ground water resources. It is necessary to compare results of the survey with norms laid down by Gujarat Pollution control Board for drinking purpose. For this, table No.6 provides Chemical norms for normal drinking water, outdoor bathing norms, Propagation of wild life as well as for irrigation and industrial cooling and controlled waste. If quality of water is found below the norms, the state will have to invest for purification of water with scientific calculation of such blow standard water. Table No.7 provides details about water quality of ground water resources in different districts of Gujarat from the survey. If one can compare the norms with water analysis of different districts of Gujarat, it is visualized that Chemical parameters are different as per geological difference in the land of the districts. The table also expresses that groundwater quality in Gujarat is highly affected by rainfall, industrial pollution, type of soil and nature of aquifers. The water quality at any location is determined as the one, which is, satisfied at least 80% of time by all the criteria parameters. To further elucidate on this, as if at a location of 80% of time DO, pH, were in the range for specified for class A, BOD for class B and total califorms for class C, then the existing status is determined as C. Sometimes, decline in water levels in different districts of Gujarat high drawl also cased deteriorating in the quality of water. However, water pollution in India comes from three sources: domestic sewage, industrial effluents and run off from activities such as agriculture. Major industrial source of pollution in India include the fertilizer plants, metal plating, leather tanneries, pulp and paper mills and refineries. Economics of ground water resources in Gujarat is necessary to study considering these aspects, as water is not free good. It has both cost of conservation and price for sustainable use being a scarce valuable natural resource.

Table No.8 provides details about pollution of groundwater and deteriorating quality of the water in villages of different districts of Gujarat. It appears from the table that in the case of Bharuch, Banaskantha, Sabarkantha and Surat districts, their villages are highly got polluted due to contamination of water quality in aggregates. Perhaps, it may be a result of open disposal of wastewater by chemical industry in on Golden corridor districts of Gujarat. However, if one can observe from aggregate level, there are fluoride affected villages in sizeable number of 2798, salinity affected villages are 1031 and 748 villages are affected by Nitrate. It appears that pipeline of wastewater disposal projects need to be introduced in the districts where chemical industry pollution if visualized. There are inter-district and intra-district variations in water quality. Table shows that so far **as salinity affected villages in Gujarat** are concerned Kheda district is leading with 149 villages followed by, Mehsana 112, Bharuch 100 and Ahmedabad 88. This has happened largely due to spreading salinity in groundwater by coastal water in the case of kheda and Bharuch districts, whereas, in the case of Ahmedabad and Mehsana districts due to over extraction level of water gone very deep. Such water quality is deteriorated due to minerals and surface salinity of land has also affected fresh water into saline one. This means that land geography has substantially adversely affected the quality of groundwater in Gujarat If detailed study pertaining to taluka-wise and district-wise in Gujarat conducted, inter–taluka and intra taluka-disparitiers of salinity of ground water may be visualized by the researchers. Similarly, in the case of **Nitrate affected villages in Gujarat,** Sabarkantha district is leading with 142 villages followed by Kheda 85 and Amreli 64, Panchmahals 111, Bhavnagar 106 Kheda 85 and Amreli 64. This means that detail chemical analysis is required of water quality of these villages constantly so as to monitor quality of Nitrate for the programme and policy in effective way in rural areas of Gujarat.

IV ECONOMICS POLICY OPTIONS :

1. The Government of Gujarat should give due weightage to techno-economic aspects of groundwater extraction considering quality of water, category of the water and size of investment district-wise and area wise. Rehabilitating traditional water systems may require levels of investment both by public private partnership in investment process in Gujarat. Considering different geological conditions, different techniques of water recharge must be used.

2. There is a growing need of linking surface water of perennial rivers like Tapi, Mahi and Narmada with ground water resources relatively in districts of Saurashtra and North Gujarat for permanent solution of water resources. For this, the center and the state government will have to work for outlay and layout of such big investment project as such agriculture, industry and drinking water scarcity is there.

3. North-Gujarat and Saurashtra are regions, where salinity has dominated in groundwater resources of water. The cost components of desalination are very high in the present situation. It is most necessary to invent and make use of such technology as disposal of treated water has pollution groundwater quality in all areas. As compared to 1984, there is substantial rise in groundwater resourced polluted by coastal tide and other pollutants disposed by the industries.

4. It is most necessary to allow private player in water market development in Gujarat state so as to boost link between surface water and ground water resources by through scientific approach to wards palaeochannels for better management, investment by participants. This is so as water resources development requires sizeable investment, which is beyond the rich of the government in era of rising budget deficits of both the Centre and the states.

5. Water is used as free commodity and used liberally by over extraction. Use of Price Policy and subsidy instrument is needed to conserve water resources in Gujarat. It is most necessary to include the price of water, which may reflect scarcity value and environmental cost in order to conserve, protect and to preserve water resources in Gujarat.

6. For further research in areas of water resources development, an inter-disciplinary-team consisting of geo-hydrologists, economists, management experts and cost accountants is required for research possible in order to prepare **Master Plan** for investment in water sector and different alternatives to tap ground water resources in Gujarat

   Such inter-disciplinary team will surely help to exploit water resources by economies of scale with reasonable period of time particularly in earthquake-affected areas in Gujarat.

7. Gujarat Infrastructure Development Board should continuously carry out training Programmes for infrastructure development in Gujarat as well as for professional engineers to execute economically viable and technically feasible projects with efficiently with low cost alternatives so as to develop cost consciousness in execution of the project.

8. To stimulate ground water irrigation access to small landholders with tube well concessional finance should be given by the nationalized and private sector banks as a term loan. The Government should stop subsidy in water area so as to have reasonable extraction to the genuine farmers.

9. In order to raise level of ground water resources in Gujarat, **National Water Grid system** need to executed so as to link rivers of Saurashtra and North-Gujarat with perennial rivers of rest of India

10. Even for the development of **Power Sector** in Gujarat, it is most necessary to develop ground water resources in Gujarat. Hydal thermal power depends solely on ground water resources development in Gujarat. For this, foreign direct investment should be encouraged in ground water development as well as for the development of captive private power projects,

11. As a policy, one can safely recommend framing of an institution in Gujarat to frame action plan to cover ecological, economic social and institutional issues such as economic valuation of water indifferent districts of Gujarat, High-power committee of Water Management in Gujarat, setting up of State Water Management fund and transparency in the system.

CONCLUSION :

One can safely conclude that the Government of Gujarat should be very vigilant on water issue being the prime infrastructure of Gujarat economy for fast economic development of the state compared with other states in India. It is most necessary to tape surface water resources with ground water resources in each state of India in general and all districts of Gujarat in particular as economical as possible with cost consciousness following suitable policy for investment for the development of groundwater resources. Indian states require public-private partnership for the development of groundwater resources. For this, global finance is required to develop such partnerships. Moreover, researchers of the relevant discipline need to undertake research in the area in the wider interest of the community and economic growth of Gujarat. Political economy of growth in Gujarat should made special provisions in the Xth five-year for water resource development with clear **Water Rights** as such it is community development issue. It is necessary to regulate use of groundwater resources but for long term planning government should have suitable layout and outlay strategy.

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Table No. 1. Plan-wise position of irrigation potential created and utilized for Ground water (All India Level)

Plan	**Potential created**	**Potential utilized**
Pre- Plan up to 1951	6.50	6.50
I Plan 1951-56	7.63	7.63
II Plan 1956-61	8.30	8.30
III Plan 1961-66	10.52	10.52
Annual Plans 1966-69	12.50	12.50
IV Plan 1969-74	16.50	16.50
V Plan 1974-78	19.80	19.80
Annual Plan 1978-80	22.00	22.00
VI Plan 1980-85	27.82	26.24
Vii Plan 1985-90	35.62	33.15
Annual Plan 1990-92	38.89	36.25
End of VIII Plan (1992---- 97	45.73	41.99
IX Plan(1997-2002)	51.24	47.02

Source : Plan Documents, Planning commission, Govt. of India, New Delhi.

Table No. 2. Ground Water Extraction structure & Growth Trends – All India

Year	Dug wells	Shallow Tube wells	Deep public Tube wells	Total
1987	8893216	3987163	103552	12983931
1988	9072610	4137624	121433	13331666
1989	9234737	4303315	142214	13680267
1990	9386285	4490196	165338	14041819
1991	9535908	4692168	190803	14418879
1992	9683996	4942968	218611	1484575
1993	9834409	5243900	248761	15327070
1994	9989551	5618682	281252	15889485
1995	10152972	5993464	316086	16462521
1996	10327204	6368246	353262	17048711
1997	10501436	6743028	390438	17634902
1998	10675669	7117809	427613	18221092

Source Central Ground Water Board, New Delhi.

Table No.3 CATEGORIZATION OF BLOCKS/MANDALS / TALUKAS /WATERSHEDS AS OVEREXPLOITED AND DARK ON ALL INDIA BASIS

Sr Nº	**Name of state**	**Total Nº. of Dist.s**	**Total No. of Talukas/ Blocks**	**OVEREXPLOITE No.**	**%**	**DARK No.**	**%**
1.	Andhra Pradesh	23	1104	6	0.54	24	2.17
2	Arunachal Pradesh	8	48	-	-	-	-
3	.Assam	23	134	-	-	-	-
4	.Bihar	42	585	-	-	1	0.17
5.	Goa	3	12	-	-	-	-
6.	Gujarat	19	184	12	6.62	14	7.61
7.	Haryana	16	108	45	41.67	6	5.58
8.	Himachal Pradesh	12	69	-	-	-	-
9.	Jammu & Kashmir	14	123	-	-	-	-
10	Karnataka	19	175	6	3.43	12	6.86
11	.Kerala	14	154	-	-	1	0.65
12	Madhya pradesh	45	459	-	-	3	0.65
13	Maharashtra	30	1053	-	-	34	2.26
14	Manipur	6	26	-	-	-	-
15	Meghalaya		29	-	-	-	-
16	Mizoram	3	30	-	-	-	-
17	Nagaland	7	21	-	-	-	-
18	Orissa	27	314	-	-	-	-
19	Punjab	12	118	62	52.54	8	8,78
20	Rajasthan	30	236	85	36.02	11	4.66
21	Sikkim	4	4	-	-	-	-
22.	Tamil Nadu	21	384	54	14.06	43	11.20
23	Tripura	3	17	-	-	-	-
24.	Uttar Pradesh	63	895	19	2.12	22	2.46
25	West Bengal	16	341	-	-	-	-
No. of Blocks (Except) Guja &Maharashtra			**4272**	**231**		**107**	
No. of Mandals (A.P.)			**1104**	**6**		**24**	
No. of Talukas (Gujarat)			**184**	**12**		**14**	
No. of Water sheds (Maharashtra)			**1503**	**-**		**34**	
Andhra Pradesh			**1104Mandals**	**6 Blocks**		**24**	
Gujarat			**184 Dist.**	**12 Talukas**		**14**	
Maharashtra			**1503 Watersheds**	**231 Talukas 366 Blocks**			

Source: Central Ground Water Board, New Delhi, 2001.

Table No. 4 District wise Breakup of Geographical areas in Gujarat state

District.	Total area sq.KM	Hard Rock Area in Sq. Km	Alluvium & sedimentary Area in sq.KM	Fresh water Area in sq.Km	Saline area in Sq. Km
1. Amreli	6711	5840	872	5834	877
2. Ahmedabad	8566	952	7614	5956	2610
3. Banaskantha	12404	2600	9804	9468	2936
4. Bharuch	7806	3186	4620	5509	2300
5. Bhavnagar	9786	7211	2575	7799	1987
6. Kachchh	19476	5364	10111	9055	10422
7. Gandhinagar	964	0	964	964	0
8. Dangs	1983	1683	0	1683	0
9. Jamnagar	10143	7466	2677	8246	1897
10. Junagadh	10540	8502	2138	9231	1308
11. Kheda and Anand	6888	1573	5315	5334	1554
12. Mehsana	9011	135	8817	7266	1765
13. Panchmahal and Dahod	8850	8722	128	8850	0
14. Rajkot	11152	8975	2177	7266	1765
15. Sabarkantha	7273	5784	1487	7274	0
16. Surat	6688	4356	2332	5849	860
17. Surendranagar	10443	1947	8496	5835	4609
18.Vadodara and Narma	7769	4487	3282	7495	275
19. Valsad and Navasari	5144	4256	888	4925	219

Source: Government of Gujarat, Gandhinagar.

Table No. 5 GROUND WATER POTENTIAL OF GUJARAT

(Based on Norms of Ground Water Estimation Committee). calculations pertain only to Phreatic aquifer, District – wise Summary of recharge and draft 1997

Sr. No.	Name of District	Total Ground Water Resour (MCM/Yr)	Provision for Domestic & Industrial uses (MCM/Yr)	Utilizable Gro Water Resources (MCM?Yr)	Gross Draft (MCM/yr)	Balance	Level of Ground Water deve-Lopm %	category
1.	Ahmedabad	946.94	189.39	757.55	701.71	55.85	92.63	Dark
2.	Amreli	849. 56	169.71	679.65	483.73	196.92	71.03	Grey
3.	Banaskantha	994.80	198.96	795.84	887.29	-91.45	111.49	OE
4.	Baroda	965.94	193.19	772.75	493.76	278.99	63.90	White
5.	Bhavnagar	938.34	187.67	750.67	472.74	277.93	62.98	White
6.	Bharuch	499.34	99.87	399.47	238.14	161.33	59.61	White
7.	Valsad	899.93	179.99	719.94	327.23	392.71	45.45	White
8.	Dang	90.92	18.02	72.07	0.74	71.33	1.03	White
9.	Gandhinagar	111.57	22.31	89.26	130.35	-41.09	146.04	OE
10.	Jamnagar	815.96	163.19	652.77	374.96	277.81	57.44	White
11.	Junagadh	121.29	242.46	969.83	752,45	217.38	77.59	Grey
12.	Kheda	1160.26	232.05	928.21	675.73	252.48	72.80	Grey
13.	Kutch	627.00	125.40	501.60	431.19	70.41	85.96	Grey
14.	Panchmahal	661.66	132.33	529.33	242.69	286.64	45.85	white
15	Rajkot	1230.24	246.05	984.19	684.73	299.46	69.57	White
16.	Sabarkantha	961.83	192.37	769.46	682.92	86.54	88.75	Grey
17.	Surat	1389.14	277.83	1111.34	355.65	755.69	32.00	white
18.	Surendranagar	627.65	125.53	502.12	354.21	147.91	70.54	Grey
19	Mehsana	1077.78	215.56	862.22	1419.64	-557.42	164.65	OE
	Total Gujara	**160660.35**	**3212.07**	**12848.28**	**9708.35**	**3139.43**	**75.57**	**Grey**

Source: Government of Gujarat Gandhinagar

Table No. 6. Primary Water Quality Criteria

Designated Best Use	Class of water	Criteria
Drinking Water without Conventional Treatment	**A**	**1.Total Coliforms Organism MPN/100ml Shall be less than 50 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 6mg/1 or more 4.Biochemical Oxygen Demand 5 days 20 Degree 2mg/1 or less**
Outdoor Bathing	**B**	**1. Total Coliforms Organism MPN/100ml Shall be less than 500 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 6mg/1 or more 4.Biochemical Oxygen Demand 5 days 20 5.Bio-chemical Oxygen Demand 5days 20 degree C 3mg/1 or less**
Drinking water Source	**C**	**1.Total Coliforms Organism MPN/100ml Shall be less than 5000 or less 2. pH between 6.0 and 9.0 3. Dissolved Oxygen 4mg/1 or more 4.Biochemical Oxygen Demand 5 days 20 Degree C 3mg/1 or less**
Propogation of Wild life	D	**1. pH between 6.0 and 9.0 2.Dissolved Oxygen 4mg/1 or more 1. Free Ammonia (as N) 1.2mg/1 or less**
Irrigation, Industrial Cooling, Controlled Waste	E	**1. pH between 6.0 to 8.5 2. Electrical conductivity at 25 degree C Micro mhos/cm Max 2250 3.Sodium absorption Ratio, Max 26 4. Boron, Max 2mg/1**

Source : Water Quality – status & Statistics (1993 & 1994), Central Pollution Control Board

Table No. 7 Present Status of Ground Water quality in different Districts in Gujarat (1997)

Sr. No.	District	Total Of Sample:	Total Nº of No-pot A Sample	F	NO3	TDS	Hardness	Alkality	CI	SO4
1.	Amreli	972	233	48	11	127	91	139	58	24
2.	Ahmedabad									
3.	Banaskantha	6540	400	206	93	115	40	1	92	0
4.	Bharuch	691	164	32	22	765	88	29	36	1
5.	Bhavnagar	1212	257	115	11	110	111	86	74	17
6.	Kutch	1362	286	13	0	164	217	31	87	18
7.	Gandhinagar									
8.	Dangs	110	0	0	0	0	0	0	0	0
9.	Jamnagar	869	207	29	13	149	152	0	100	30
10.	Junagadh	982	198	60	0	96	130	5	56	2
11.	Kheda and Anand	2945	894	344	142	180	178	240	60	10
12.	Mehsana	3051	1388	942	27	397	191	34	201	37
13.	Panchmahal and Dahod	1594	379	257	76	45	78	29	21	1
14.	Rajkot	2567	670	118	20	440	548	2	331	26
15.	Sabarkantha									
16	Surat	758	178	20	20	69	106	10	28	1
17.	Surendeanagar									
18.	Vadodara and Narmada	3066	888	452	107	219	190	47	74	41
19	Valsad and Navsari	1099	192	45	0	102	41	1	0	0

Source : Gujarat Water & Sewerage Board, Geri Campus, Vadodara and published in Water Asia 2001 Volume, New Delhi

Table No.8 STATUS OF GROUND WATER POLLUTION IN GUJARAT

Sr. No.	District	Total No. of villages	Fluoride affected villages	Nitrate Affected villages	Salinity Affected villages
1.	2 Amreli	576	80	64	9
2.	3 Ahmedabad	662	196	12	88
3.	4 Banaskantha	1374	407	58	74
4.	5 Bharuch	1178	32	41	100
5.	6 Bhavnagar	875	109	106	28
6.	7 Kachhch	949	14	5	44
7.	8 Gandhinagar	73	21	0	0
8.	9 Dangs	309	0	1	0
9.	10 Jamnagar	754	25	9	47
10.	11 Junagadh	1157	77	11	50
11.	12 Kheda and 13 Anand	973	220	85	149
12.	14 Mehsana	1103	522	23	112
13.	15 Panchmahal and Dahod	1908	331	112	53
14.	16 Rajkot	856	38	7	30
15.	17 Sabarkantha	1387	336	142	52
16.	18 Surat	1781	27	22	42
17.	Surendranagar	651	62	1	47
18.	19 Vadodara and Narmada	1653	287	50	65
19.	20 Valsad and 21 Navsari	830	14	6	41
	22 Total	**18569**	**2798**	**748**	**1031**

Source: Gujarat Water Supply & sewerage Board, Vadodara (1998)