

WATER AND INFRASTRUCTURE DEVELOPMENT WATER RESOURCES FOR RURAL DEVELOPMENT-SALINITY INGRESS & CONTROL MEASURES THROUGH INFRASTRUCTURE DEVELOPMENT-A CASE STUDY SAURASHTRA COASTAL REGION-GUJARAT.

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ABSTRACT:-

Salinity affects approximately 20% of irrigated land worldwide. Controlling salinity and reclaiming saline land is an urgent priority in order to increase productivity of existing land, make better use of irrigation and demonstrate that new irrigation areas can be managed in a sustainable manner. The State of Gujarat has longest coastline of 1600 km, out of this the major part is covered (about 765 km) by Saurashtra region. Salinity Ingress in the coast of Saurashtra has created many problems in the vicinity of the coastal area, particularly for the irrigation land, ground water quality, surface water including drinking water etc. The main reasons for salinity ingress in the region are less and irregular rain fall, porous geographical formation, less natural water filling and weak land management. The problem of salinity ingress has aggravated over the years due to heavy withdrawal and non scientific exploitation of ground water. All these led to Salinity ingress in Coastal belt and economic life of people was seriously affected, Migration of people started.

The problem was brought to the notice of the Government. Considering the situation, importance of combating salinity in the saurashtra region, Government formed two high level committees in the year '76 and '78 respectively to investigate the problem of salinity ingress and to give suggestions for its remedial measures. Solutions suggested by them were construction of Tidal Regulators, Bandharas, Checkdams, Spreading channels, afforestation and some management techniques which include regulation of lifting of underground water and change of crop pattern and coastal land Reclamation bunds. As per the suggestions given by the committees, various infrastructure development plan had taken place through constructions of Bandharas, Tidal regulators, Recharge reservoirs, recharge tanks, check dams and spreading channels in the Districts of the Saurashtra region by the Government of Gujarat in last 30 years & as such benefits have been obtained, which includes, increase in irrigation potential for land and the increase in the quantity of benefited areas of cultivable land. The lines of 2000 TDS have been moved towards the coastal region from the non-coastal region. Migration of the population has been arrested and in majority of the cases the migrated people have returned and restored to their respective villages and professions. The prices of agriculture land have also improved considerably. This has direct bearing on the improvement of economic prosperity of the region. After successful implementation of salinity control program an overall improvement in environmental and socio-economic conditions of the area has been recorded.

The efforts made by the Government of Gujarat have changed the scenario of rural people, who were suffering from the problem of salinity for a long time. Now they witnessed the development. The future is bright in the coming years. We have to save every drop of water, and have to use water as per requirement, adopt proper water harvesting technology and rain water harvesting must be promoted. Let us work together for combating the deteriorated ground water and help the mankind.

1. INTRODUCTION:-

The Prosperity of mankind is always governed by the environment. The natural conditions on earth are not uniform throughout, and it has placed the man in different conditions of habitation. With the progress of civilization mankind tried to utilize the surface and ground water resources where and when available. Since time immemorial man has been trying to device more and more infallible methods for locating ground water.

Exploitation of ground water by adopting esoteric method is carried where necessity is felt and resources compromised.

An overlook over the supply and demand agreement creates unhappy sign due to the excessive withdrawal of ground water in this vulnerable coastal tract of Saurashtra. More than 10 million people who are living in the coastal area of Gujarat in about 1500 villages are facing serious problem of growing salinity.

2-DETAILS OF WATER RESOURCES OF GUJARAT:-

Water is a vital resources for agriculture, domestic use and industries. Productivity of agricultural sectors, economy of rural and urban and changes in environment depends upon the development and management of water resources. Management of water resources in coastal area is most valuable task due to coastal salinity ingress and inherent salinity of groundwater. Management of ground water resources is not a daunting task but a challenge in the areas due to varied factors, like social, political and technical reasons.

The main source of water for Gujarat is surface water. The state has 185 river basins and the available quota of water in state is 50100 MCM, out of which, 38100 MCM is surface water. Moreover, the available quota of surface water is not distributed properly. The underground water is resources of state are 12000 MCM. The details of availability of surface and ground water can be seen from the tables as below.

TABLE-1

Details showing the available Water Resources of Gujarat state

Area	Total Water Quota MCM	Surface Water MCM	Ground Water MCM	Storage Capacity at present (Except Sardar Sarovar) MCM	% of Water Resources
Central & South Gujarat	35700	31750	3950	10400	71
North Gujarat	5400	2100	3300	2100	11
Saurashtra Region	7900	3600	4300	2250	16
Kutch	1100	650	450	250	02
Total	50100	38100	12000	15000	100

It can be seen from the above table that the Saurashtra region is having only 4300 MCM of ground water resources and 3600 MCM of surface water. Water resources of saurashtra region is only 16 % of the total water resources of Gujarat. Due the scanty of rain, the available water is very less as compared to the other regions of Gujarat as a whole. This kind of situation need special attention to develop new techniques to have more availability of water at any cost.

3. SALINIZATION OF LAND, MAGNITUDE OF SALINITY :-

Saline soils occur for the most part in regions of arid or semiarid climate. Leaching is usually local in nature, and soluble salts may not be transported far away from parent soil, which tend to concentrate the salts in soils and in surface waters. Restricted drainage is a factor that usually contributes to the salinization of soils and may involve the presence of a high ground water table or low permeability of the soil.

The drainage of salt-bearing waters away from the higher lands, may cause upward movement of saline ground water or evaporation of surface water results in the formation of saline soil. The extent of saline areas, thus formed may vary from a few acres to hundreds of square miles. Saline soil usually occurs in areas that receive salts from water, ocean as marine deposits, from transportation of spray by winds. Due to the steadily increasing

pressure on water resources there is an emergent need to develop techniques that optimize exploitable water resources while protecting it from contamination and preventing Over-Use.

Most of the Southern and Western Coast of Saurashtra comprises of Lime stones which is cavernous in nature. Due to cavernous nature of the geological formation near the coast and excessive withdrawal of ground water by farmers for irrigation the intrusion of saline water in the ground water aquifers took place, which ultimately resulted into the salinity ingress. Natural replenishment of ground water into aquifers is a slow process and is often unable to keep pace with the excessive withdrawal of ground water in this vulnerable coastal tract of Saurashtra. About 700120 hac. of coastal land of Saurashtra region lost its fertility. Due to salinity ingress the quality and yield of agriculture produce is affected and prices of agricultural land fall considerably. This in turn affected its economy. In the saurashtra region there are 6 Districts wick are affected due the salinity. The table below shows the details.

TABLE NO.-2

Details of Salinity affected areas of the Saurashtra Coastal Region

Sr. No.	District	Talukas	Affected Talukas
1	Bhavnagar	10	3
2	Amreli	11	2
3	Junagadh	13	5
4	Porbandar	03	3
5	Jamnagar	10	7
6	Rajkot	13	2
	Total	60	22

The problem of salinity ingress was first evinced and detected in late sixties and early seventies due to large scale induction of oil engines and electric motors by the farmers in the coastal area to draw water from greater depth and in large quantity for intensive Irrigation & other purposes. The heavy withdrawal or non scientific exploitation of ground water has disturbed the delicate groundwater balance of the sensitive coastal region and ground water levels started to fall noticeably and well water quality turned brackish and saline up to considerable distances inland. The problem was brought to the notice of the Government by villagers' and peoples' representatives, from these areas.

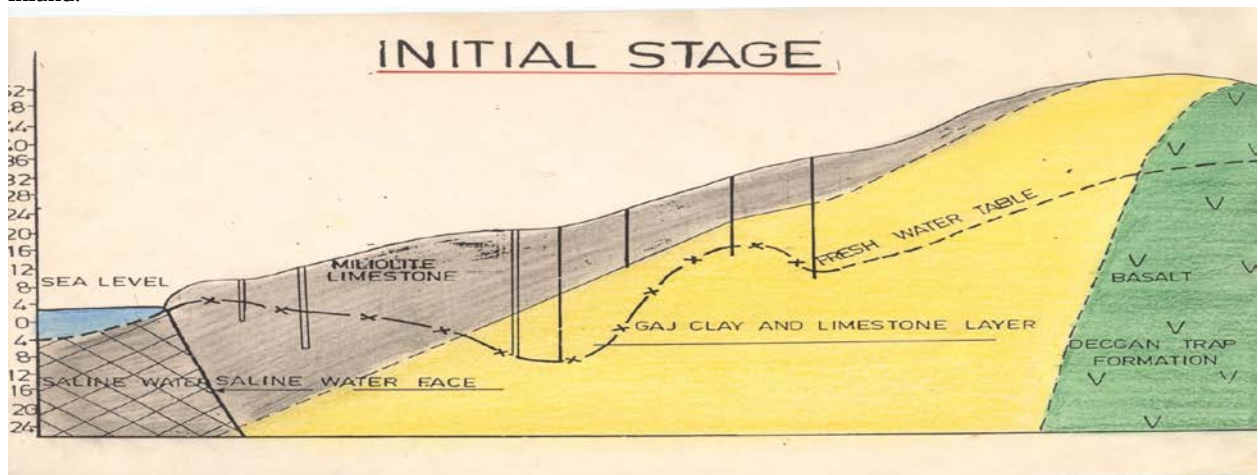
4. MAIN CAUSES OF SALINITY INGRESS IN SAURASHTRA REGION:-

Geological formation, No perennial river, Scarce and uneven rainfall, Large scale pumping of ground water by farmers in the Coastal Region, Imbalance between water recharge and water withdrawal, Unawareness/ carelessness in usage of precious water, all these led to Salinity ingress in Coastal belt.

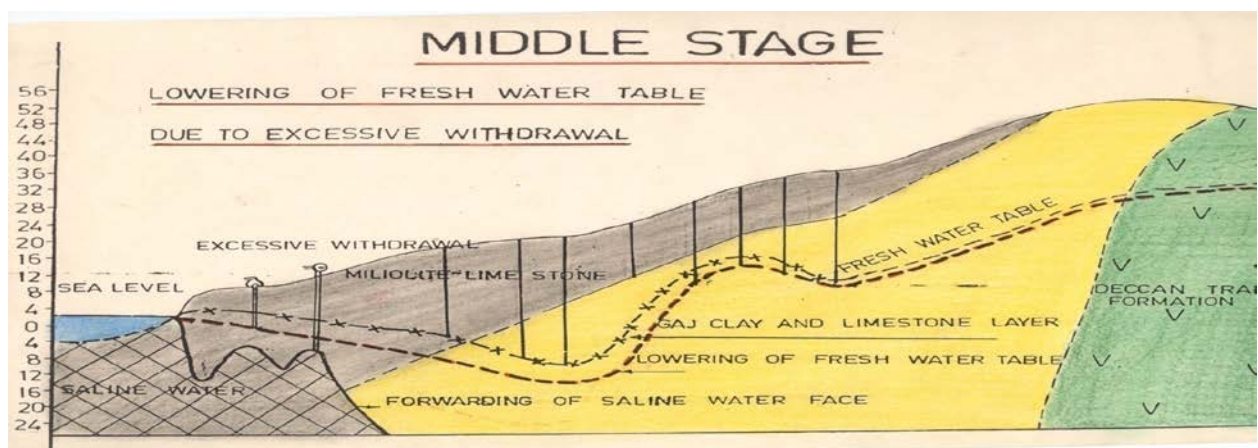
5. HOW SALINITY INGRESS IN INLAND:-

5.1 Intial Stage:- In the initial stage the interface of sweet and saline water is observed near to the sea coast. The miliolite limestone formation which is cavernous in nature is found expose near the coast line which is followed by lower formation of Guj, limestone and clay and the Deccan trap basalt exposure are found quiet inland from the sea coast. The position of ground water which is fresh in nature was found at higher levels in the

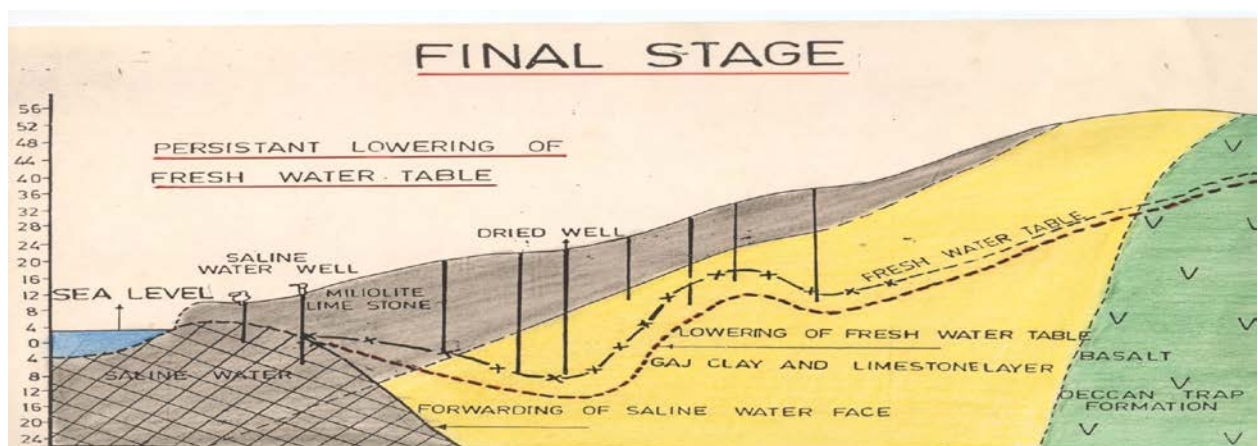
nearby wells to the sea coast. It is ideal situation. The sketch below shows the initial stage of Salinity Ingress in inland.



5.2 Middle Stage:- After the introduction of oil engines and electrical motors the extraction rate of pumping the ground water head increased for irrigation and domestic purpose. As result the ground water table was declined and the intrusion of saline water towards inland started. Due to imbalance of recharge rate and pumping rate. This resulted in to the overdraft of ground water and this sweet water cushion over the saline water was decreased. The sketch below shows the middle stage of Salinity Ingress in inland.



5.3 Final Stage:- At last the over withdrawal of ground water or mining of water created a large scale for heavy ingress of saline water far inland from the sea and the area near the sea coast was highly affected by the sea water intrusion. The sketch below shows the final stage of Salinity Ingress in inland.



5.4- Effect of salinity ingress:-

1. Quality of ground water deteriorated,
2. Deterioration to Fertile Land
3. Reduction of crop yield
4. Shortage of irrigation and drinking water
5. Health hazards for men and cattle
6. Economic life of people seriously affected
7. Migration of people
8. Disturbance in social life

6. FORMATION OF HIGH LEVEL COMMITTEES:-

Looking to the magnitude and gravity of the Salinity problem, the Government of Gujarat appointed two High Level Committees (HLC-I & II) to study the Salinity Ingress Problem and suggest solutions. HLC-I was headed by the then Chief Secretary Shri. H.K.L. Kapoor in 1976 and HLC-II by the then Chief Secretary Shri.K.Shivrajan in 1978.

The committee visited the affected areas of saurashtra region. The outcome of their visit and findings are tabulated as under in Table-2.

TABLE-2
Details of study carried out by the HLC-I & II for the salinity ingress for the region

Name of the Committe	Reach Covered	Lenth in kms.	Dist Covered	Area of Study Hac.	Affected Area in Hac.	Population affected	Villages Affected	Wells Affected
HLC-I	Una-Madhavpur	160 Kms.	3	227000	100000	280160	120	12562
HLC-II	Una-Bhavnagar	180 Kms.	4	250000	140000	220000	166	8800
HLC-II	Madhavpur-Malia	425 Kms.	4	615340	460120	579373	248	11338
Total		765 Kms.	7	1092340	700120	1079733	534	32700

6.1 SUGGESTED SOLUTIONS BY HLC-I & II:-

The committee studied the problem in coastal belt of saurashtra and kutch and recommended the salinity prevention works amounting to Rs.64.00 crores (revised Rs.100.24 crores) in Una-Madhavpur reach. Rs. 168.70 crores (revised Rs.802.54 crores) in Una-Bhavnagar reach and Rs.370.42 crores (revised Rs.1427.30 crores) in Madhavpur-Malia reach. Following are the main schemes/techniques which were suggested to be constructed to combat salinity ingress in the saurashtra coastal region.

6.1.1 Salinity Control Techniques:- (1) Tidal Regulators and Bandharas at river mouth/creek (2) Fresh Water barriers (3) Extraction barriers (4) Static barriers .

6.1.2 Recharge Techniques :-(1) Check dam (2) Recharge Tanks (3) Recharge Reservoir (4) Recharge Wells at suitable locations (5) Spreading Channel (6) A forestation & Nala plugging

6.1.3 Management Techniques :-(1) Change in cropping pattern (2) Regulation of ground water extraction

6.1.4 In addition to above all HLC-I recommended Coastal Land Reclamation.

7. DETAILS OF WORKS COMPLETED SALINITY SCHEMES

Salinity Ingress Prevention Circle, Rajkot, which is under the Narmada, Water Resources, Water Supply and Kalpsar Department, Government of Gujarat has carried out various salinity ingress prevention and Control works which includes, 12 Nos. of Tidal Regulators, 27 Nos. of Bandharas, 13 Nos. of Recharge Reservoir, 19 Nos. of Recharge Tanks, 649 Nos. of Check dams and @125 kms. length of Spreading Channels at the cost of Rs.440 crores at present. The total storage capacity of all these projects are @425 MCM and @ 65850 hac. of land is benefitted and irrigation potential of about 40,000 hac.is achieved by the completed schemes. In addition to these projects the coastal Reclamation Bunds are also constructed in many districts of saurashtra region. These Completed works are beneficial to more than 900 villages.

TABLE NO-3
Status of salinity control works recommended by HLC I & II & completed works.

Sr. No.	Name of Structure	HLC-I Area Recommended	HLC-II Area Recommended	Total: HLC-I & II Area	
				Recommended	Completed
1	Tidal Regulators	7	31	38	12
2	Bandharas	10	77	87	27
3	Recharge Reservoirs	4	43	47	13
4	Checkdam	75	760	835	649
5	Recharge Tanks	7	90	97	19
6	Spreading (km)	60	300	360	125

8- SPREADING CHANNELS:-

Spreading channels form a useful recharge device when recharge is desired along a narrow but long area. Miliolite limestone and Gaj limestone occur in belt parallel to the sea coast. If the artificial recharge is attempted near the junction of Miliolite limestone and Gaj limestone, the induced recharge will result in ground water movement towards the sea. It will help to control movement of saline water from sea side, in addition to providing additional ground water. The Spreading channel will also feed surplus floodwater from one reservoir basin to another where rainfall is scanty.

A channel of considerable length would definitely be advantageous but, the dimensions would have to be restricted depending upon availability of quantum of fresh water. The channel should be constructed in small length at different locations in the reach- area depending upon availability of water from proposed recharge reservoir. It is extremely important that both recharge and salinity control works are taken up intensively in a particular reach, basin wise, in the shortest possible time so that the results are as per expectation. To avail maximum benefit of available storage of water of all schemes which are under construction and schemes which are in pipeline may be planned as follow:-

A- The water of the reservoirs of schemes which are in progress at present in the area can be considered as available for first 5 years for the work of salinity prevention as canal distribution system may only develop fully after 5 years from completion of the canal system.

B- In order to get maximum recharge benefit, the reservoir of Medium and Minor capacities may be constructed on all big and small rivers depending upon condition and feasibility of sites.

9 - BENEFITS OF SPREADING CHANNELS:-

At present @17200 Ha. land is getting direct & indirect benefit from 125 kms. of completed length of Spreading Channel. Storage of sweet water is available for recharge into lower aquifers resulting in raising of ground water table and improvement of quality of water.

By connecting two reservoirs excess water from one reservoir can be diverted to another, this helps in times of unequal and less rainfall. Water stored in spreading channels can be utilized by farmers of nearby area for irrigation purpose which results in improved yield of crops. Due to increased output in farming, agricultural income is enhanced which reduces migration from this area. Spreading channels are unlined canals which are connecting two nearby reservoir and facilitating availability of water to nearby areas.

These channels are not meant for flow water for irrigation, but water stored in this facilitates lift irrigation for surrounding areas, thus raising agricultural production and improving ground water quality. Construction of spreading channels is very easy as it involves excavation and C.D. works only, which can be taken up faster as compared to lined canals. These channels allow water to percolate into deep grounds, thus raising ground water table and improving ground water quality also.

10 - BENEFITS ACCRUED FROM SALINITY SCHEMES:-

The office of the Superintending Engineer, Salinity Ingress Prevention Circle-Rajkot had carried out many salinity ingress prevention and control schemes in saurashtra coastal region which includes the districts, namely Jamnagar, Rajkot, Porbador, Bhavnagar, Junagadh, Amreli districts. Many fruitful results arises by the projects carried out by this office, which is under the department of Narmada, Water Resources, Water Supply & Kalpsar, Government of Gujarat.

More and more people are getting benefits of all these schemes. Many more projects of salinity control as suggested by the HLC-I & II are under progress in this region and many are under consideration. By completing the projects which are at present at hand will give more benefits to the people residing in the vicinity of the project areas and their life will become more happy and progressive than today. Government of Gujarat is going to take more beneficial projects to combat the salinity ingress problem in the region, however, much more is to be carried out for the betterment of the people because the problem of salinity in this area is not yet completely overcome.

10.1 Various salinity control and recharge works under the salinity control and recharge techniques are taken up by the Govt. according to the recommendations of the HLC-I & II. Due to completion of different salinity prevention works in HLC-I & II reaches, much more irrigation potential is created. In addition to this beneficiaries (local farmers/villagers) have lifted water for irrigation from radial canals through their own means.

10.2 The quality and yield of the agriculture produce has improved marginally particularly in the area suggested by HLC-1 area where most of the works are completed. Good amount of recharge from structures is created.

10.3 Additional recharge generated due to completed structures in HLC-I area is more than 35.756 Mcum. Recharge factor is affected by the timing, magnitude and intensity of precipitation. Average rise in water level of 2.07 to 4.70 m is observed in HLC-I area as compared to base year of 1988.

10.4 The prices of agriculture land have also improved considerably in the areas where salinity control or recharge works have been effectively taken up. An increase in the yield of wheat, groundnut, Bajra and in Coconut produce has been observed. This has direct bearing on the improvement of economic prosperity of the region. In most of the areas where migration has taken place due to effects of salinity the migrated families have returned after constructions of salinity control schemes.

10.5 Due to arrest of salinity ingress the quality of water in the area has improved which resulted in substantial improvement in quality and yield of agriculture produce of the area. After successful implementation of salinity control program. An overall improvement in environmental and socio-economic conditions of the area has been recorded. Substantial increase in the market prices of land to tune of 300 to 1000% and more are observed in these areas. This has given a commercial and economic boost to the people's welfare and the region.

11. SOCIO-ECONOMIC IMPACT OF SALINITY CONTROL SCHEMES:-

The socio economic assessment study of salinity prevention schemes shows a good sign of the development of coastal area of saurashtra region.

11.1 Livelihood- As the main occupation of the villagers is agriculture and animal husbandry, the benefit of various salinity schemes occurred as availability of water increases for agricultural purpose and also for drinking water. This helped for the betterment of their livelihood and lifestyle changed.

11.2- Gender sensitization-As the availability of drinking water increased the women of villages gets more time to spend in other social activities, like child carrying, to take part in agricultural activities of their own family and to attend gramsabhas. Some women who are keen in stitching work and embroidery work, they also gets more time and started such works for earning purpose for their family.

11.3-Animal Husbandry- More fodders is available for animals and thus milk production increased, which helps villagers to earn more. Also as the marketing opportunities increased due to the development of dairies in nearby town, more and more villagers go for this another beneficial business and gets good earning.

11.4- Health- As the people gets pure drinkable water, the health status of villagers increased. Also many water born diseases reduced due to availability of fresh and good quality water. Ultimately good health helps the people in doing their day to day work with more energy and strength.

11.5-Migration- In early days villagers have very little choice for their earning, but due to the availability of good water resources in every village, the opportunities of job increases and they gets jobs in village itself for their earning and the migration of villagers for earning reduces.

12. CONCLUSION:-

All the painstaking efforts are made by the Govt. of Gujarat, Narmada Water Resources, Water Supply & Kalpsar Department to mitigate or lessen this acute problem, harassing human beings residing on coastal belt of Saurashtra. Awareness among the stakeholders has motivated to take up and are being taken up the more work by Government to satiate the need of soil, earth and people in particular.

The problem of Salinity Ingress, is indeed a widespread problem throughout India, and especially in Saurashtra coastal region. The efforts taken by the Government are really commendable, as they have managed to control the salinity from reaching deeper within the land and thus help the farmers of Gujarat. Today these steps played a major role in making Gujarat a leading agrarian state in India.

The people of the coastal area are really blessed by these efforts and the future efforts will help more and more number of people and improve the quality of soil for farming. Along with these efforts, a lot of projects dealing to combat salinity ingress and Coastal Sea erosion are being carried out by the Government of Gujarat, particularly in the region of Saurashtra. This is how the Water resources development has taken place in Saurashtra's coastal region, with Salinity Ingress control schemes playing a key role. Jai-Hind.

RECOMMENDATIONS:-

- 1) Coastal sea erosion policy needs to be framed.
- 2) There is a need for critical survey of all the coastal areas, to find out the ingress of salinity and as such development of policies for combating the same and more funds should be provided.
- 3) More useful and suitable technology to minimize the salinity in the coastal region must be developed and implemented.
- 4) Public awareness creation programmes should be implemented to avoid injudicious use of scarce water resources.
- 5) Technology transfer needs to be done, to learn from other countries and apply it in India's context.
- 6) Setup of more organisations is needed in the coastal areas to combat salinity ingress.
- 7) More awareness creation should be done for the use of geo-synthetic materials for the construction of irrigation structures in this region.

BRIEF PROFILE OF THE AUTHORS

Er. Kirit B. Trivedi, 54, graduated in Mechanical Engineering Branch from the L.D. College of Engineering of Gujarat University, Ahmedabad. He joined as an Assistant Engineer (Mech.) in the Government of Gujarat after he was selected for the post of Assistant Engineer (Mech.) by the GPSC in the year 1981 & carried out various tasks as a Mechanical Engineer during his tenure of 29 years. He was then promoted as a Deputy Executive Engineer (Mech.) in the year-2010 and posted in the Narmada, Water Resources, Water Supply & Kalpsar Department at Gandhinagar. He has done Master of Business Administration-(MBA) in Marketing and a Post Graduate Diploma in Disaster Management from IGNOU-New Delhi. He has presented Technical Papers at the Vigyan Bhavan- New Delhi during the “International Conference on Habitat” in the year-1997 & “World Congress on Natural Disaster Mitigation” in the year -2004, both conferences were organized by the Institution of Engineers-India & WFEO. He was also invited to deliver talks on various subjects by All India Radio-Rajkot. He also presented papers on Disaster Management at various conferences. He is life member in Mechanical Division of the Institution of Engineers-India and also worked as an Executive committee member at its Saurashtra Local Branch-Rajkot for 14 years. He is a **Fellow** of the Institution of Valuers-New Delhi also. At present he is working as a Deputy Executive Engineer (Mech.) at Gandhinagar-Gujarat.

REFERENCES

The website : www.gswan.gov.in and my learning and observations during the service at the Salinity Ingress Prevention Circle, Rajkot, Gujarat.