CHAPTER-1

INTRODUCTION

1.1 Irrigation Potential - Issues and Challenges

Looking to present scenario of withdrawals of surface water and ground water, the futuristic demand of water resources for irrigation will be highly critical. The scarce surface water resources cause decrease in annual intensity of irrigation and thereby cause loss in economy due to insufficient agricultural production. It is observed that excessive pumping of ground water for irrigation will cause decline in water table and results in decrease of ground water storage. If such trend continues, then it will cause undesirable mining of ground water, which is considered to be against the conservation standpoint.

According to World Watch Institute, New York, the year 2025 will be most critical in satisfying the increasing water demand for irrigation Agriculture consumes nearly 85% of the available water resources and the requirement of water in the agricultural sector is expected to rise. The domestic and industrial sectors are also expected to experience a 3-fold and 2-fold increase respectively in water demand by 2025 With the current rate of food production, irrigated area and water availability increase every year in India, it is very difficult to achieve the planned irrigation potential in 2025 from presently available resources.

The current land use pattern considering India's total geographical area of 328 mha is shown in Table 1 1.

Table 1.1 Current Land Use Pattern

Classification	Area (mha)
I. Geographical area	328.73
II. Reporting Area for land utilization statistics (1 to 5)	304.88
1. Forests	68.75
2. Not available for cultivation (a+b)	41.54
(a) Non Agricultural Uses	22.45
(b) Barren and unculturable land	19.09
3. Other uncultivated land (excluding fallow land (a+b+c)	28.55
(a) Permanent Pastures and other grazing land	11.04
(b) Land under Miscellaneous tree crops and groves not included in net area sown	3 57
(c) Culturable Wasteland	13.94
4. Fallow Land (a+b)	23.27
(a) Fallow land other than current Fallow lands	9.89
(b) Current Fallow lands	13.33
5. Net area sown (6-7)	142.82
6. Gross cropped area	189.54
7 Area sown more than once	46 72
8. Cropping intensity	131.71
III. Net irrigated area	55.14
IV. Gross irrigated area	73.28

(Source: Department of Agriculture & Cooperation, Ministry of Agriculture, 2001)

The statewise reassessed Ultimate Irrigation Potential (UIP) is shown in Table 1.2.

Table 1.2 Statewise Reassessed Ultimate Irrigation Potential (UIP)

(In thousand hectares)

Sr. No	State Name	Ultimate Irrigation Potential				
		Major & Medium Irrigation	Minor Irrigation			Total UIP
			Surface Water	Ground Water	Total	
1.	Andhra Pradesh	5000	2300	3960	6260	11260
2.	Arunachal Pradesh	0	150	18	168	168
3.	Assam	970	1000	900	1900	2870
4	Bihar	6500	1900	4947	6847	13347
5.	Goa	62	25	29	54	116
6.	Gujarat	3000	347	2756	3103	6103
7.	Haryana	3000	50	4462	1512	4512
8.	Himachal Pradesh	50	235	68	303	353
9.	Jammu & Kashmir	250	400	708	1108	1358
10	Karnataka	2500	900	2574	3474	5974
11	Kerala	1000	800	879	1679	2679
12.	Madhya Pradesh	6000	2200	9732	11932	17932
13.	Maharashtra	4100	1200	3652	4852	8952
14	Manipur	135	100	369	469	604
15.	Meghalaya	20	85	63	148	168
16.	Mizoram	0	70	-	70	70
17.	Nagaland	10	75	-	75	85
18	Orissa	3600	1000	4203	5203	8803
19	Punjab	3000	50	2917	2967	5967
20.	Rajasthan	2750	600	1778	2378	5128
21.	Sikkim	20	50	-	50	70

22.	Tamil Nadu	1500	1200	2832	4032	5532
23.	Tripura	100	100	81	181	281
24.	Uttar Pradesh	12500	1200	16799	17999	30499
25.	West Bengal	2300	1300	3318	4618	6918
Total States		**58367**	**17337**	**64045**	**81382**	**139749**
Total Uts		98	41	5	46	144
Grand Total		**58465**	**17378**	**64050**	**81428**	**139893**

(Source: National commission for integrated water resources development plan, Ministry of water resources, 1999)

The statewise details of lag in Net Irrigated Area (NIA) Vis-À-Vis Net Sown Area (NSA) are shown in Table 1.3.

Table 1.3 Statewise Details of Lag in Net Irrigated Area (NIA) Vis-À-Vis Net Sown Area (NSA)

(In thousand hectares)

Sr. No.	State	Net Sown Area (NSA)	Net Irrigated Area (NIA)	% of NIA to NSA
1.	Andhra Pradesh	10637	4123	38.76
2.	Arunachal Pradesh	185	36	19.46
3.	Assam	2780	572	20 57
4.	Bihar	7321	3680	50.27
5.	Goa	139	23	16.55
6.	Gujarat	9609	3002	31.24
7.	Haryana	3586	2761	76.99
8.	Himachal Pradesh	568	101	17.78
9.	Jammu & Kashmir	734	386	52.59
10	Karnataka	10420	2302	22.09
11.	Kerala	2265	342	15.10
12.	Madhya Pradesh	19752	5928	30.01

13.	Maharashtra	17911	2567	14.33
14	Manipur	140	65	46.43
15.	Meghalaya	206	45	21.84
16.	Mizoram	109	7	6.42
17.	Nagaland	211	62	29.38
18.	Orissa	6210	2090	33.65
19.	Punjab	4139	3847	92.94
20	Rajasthan	16575	5232	31.56
21.	Sikkim	95	16	16.84
22.	Tamil Nadu	5342	2625	49.14
23.	Tripura	277	35	12.64
24.	Uttar Pradesh	17399	11675	67.10
25.	West Bengal	5462	1911	34.99
Total – States		**142072**	**53433**	**37.61**
Total - UT		**143**	**75**	**52.45**
Grand Total		**142215**	**53508**	**37.62**

(Source: National commission for integrated water resources development plan, Ministry of water resources, 1999)

The regionwise UIP as % of cultivated area and created potential as % of UIP are given in Table 1.4

Table 1.4 Regionwise UIP as % of Cultivated Area and Created Potential as % of UIP

Sr. No.	Region	States	UIP as % of cultivated area	Created potential as % of UIP
1	Eastern	Bihar, Orissa, Sikkim & West Bengal	116.60	053.24
2	Northern Eastern	Arunachal, Pradesh, Assam Manipur, Megalaya, Mizoram, Nagaland & Tripura	066 97	028.65
3	Northern	Harayana, HP, J&K, Punjab, Rajasthan and UP	084.81	095.32
4	Southern	AP, Karnataka & Kerala	064.37	054.59
5	Western	Goa, Gujarat, MP & Maharashtra	058.58	039.95

(Source: National commission for integrated water resources development plan, Ministry of water resources, 1999)

The Registrar General and Census Commissioner of India has made population projections as shown in Table 1.5. The corresponding food grain demand is also worked out in the same table considering consumption rate of 600 gms/capita/day. The future water demand projection is worked out as shown in Table 1.6 and 1.7.

Table1.5 Population Projections and Food Grain Demand

Year	Population (million)	Food grain demand (Million tonnes)
1991	0846	179
2001	1000	212
2011	1200	263
2021	1300	285
2025	1400	307

(Source. Mohile A D , Bathe T S. and Jodi V. K , 1996)

Table 1.6 Future Water Demand Projection

Population Projection	Water demand in Billion Cubic Metre (BCM)	
	2010	2025
Low	489	619
Medium	536	688
High	556	734

(Source· Mohile A D , Bathe T S. and Jodi V K ,1996)

Table 1.7 Water Demand of Various Sectors

Purpose	Demand (Cubic Kilometre)		
	1900	2000	2025
Domestic Use	25	33	52
Irrigation	460	630	770
Energy	19	27	71
Industrial use	15	30	120
Others	33	30	37
Total	**552**	**750**	**1050**
Surface Water	362	500	700
Ground Water	190	250	350

(Source: Theme Paper on Water Conservation, CWC, 1991)

The figures in the above table should be compared with total average utilizable Water resources of 1086 BCM per annum From a per capita annual average of 5,177 cubic metres in 1951, fresh water availability in India dropped to 1,820 cubic metres in 2001. In fact, it is predicted that by 2025, per capita annual average fresh water availability will be 1,340 cubic metres approximately.

Already, the potential of most river basins is being exploited beyond 50 per cent and several basins are considered to be water scarce Over 80 per cent of the domestic water supply in India is dependent on groundwater. However, groundwater is fast depleting Water tables have fallen significantly in most areas and there is a significant pollution of groundwater from natural as well as manmade sources

According to the World Bank, the water demand for industrial uses and energy production will grow at a rate of 4 2 per cent per year, rising from 67 billion cubic meter in 1999 to 228 billion cubic meter by 2025. With a view to meet food grain demand of 350 million tonnes (inclusive of 43 mha of food grain for export) in 2025, it is required to ensure irrigation potential accordingly. Considering the present normal average productivity of 2.2 t/ha for irrigated area and 0.75 t/ha for unirrigated area, a plausible overall national scenario for 2025 would be about 148 mha. It is crucial task to achieve irrigation potential of 148 mha in 2025, which is higher than recently upgraded Ultimate Irrigatión Potential of 139.9 mha.

1.2 Use of Treated Sewage Water for Irrigation

Ultimate Irrigation Potential of 139 9 mha is difficult to be achieved looking to available water resources but not impossible and can be achieved through giving serious thoughts to ensure required rise in irrigation potential. In such crucial situations, it is required to investigate alternate source of water for irrigation i e, treated sewage water with a view to conserve surface water and ground water resources It is observed that problems related to disposal of municipal sewage increase with increase in population of city. This leads to rise in pollution load on natural water bodies Table 1.8 represents status of polluted river stretches

Under above circumstances, the use of municipal sewage for irrigation also paves way for efficient disposal of sewage (domestic wastewater), which in turn has become bane for many municipalities and local bodies. As per the latest status report of Central Pollution Control Board (CPCB) under Control of Urban Pollution Series (CUPS), the following facts are revealed so far as wastewater generation and treatment for class-I and class-II cities of India are concerned.

1.2.1 Class – I Cities with population above one lakh

The total population of 299 class-I cities according to 1991 census (including 23 metro cities) is 13,99,66,369. The state Maharashtra and the Ganga river basin have the highest number and population of class-I cities.

The total quantity of water supplied to 299 class-I cities is 20,607.24 MLD and the wastewater generated is 16,622 56 MLD

According to 1991 census, the percentage of population covered by organised water supply is 88% and the average per capita water supply in class-I cities is 183 lpcd, which is an improvement of about 22% over the 1988 water supply values.

The percentage population covered by sewerage facility is 70% in class-I cities and the volume of wastewater collected is 11,938.2MLD.

Table 1.8 Details of Polluted River Stretches

Sr. No.	River	Polluted Stretches	Desired Class	Existing Class	Critical Parameters	Possible sources of pollution
1.	Sabarmati	(i) Immediate upstream of Ahmedabad upto Sabarmati Asharm	B	E	DO, BOD, Coliforms	Domestic and Industrial waste from Ahmedabad.
		(ii) Sabarmati Ashram at Vautha	D	E	DO, BOD, Coliforms	
2.	Subernarekha	Hatia Dam to Baharagora	C	Partly D and Partly E	DO, Coliforms, BOD	Domestic and Industrial waste from Rachi and Jamshedpur
3.	Godavari	(i) D/S of Nasik to Nanded	C	Partly D and Partly E	BOD	Waste from Sugar and Distillery Industries
		(ii) City limits of Nasik and Nanded	B	Partly D and Partly E	BOD	
4	Krishna	Karad to Sangli	C	Partly D and Partly E	BOD	Waste from Sugar and Distillery Industries
5.	Indus (Tributaries Sutlej)	D/S of Ludhiana to Harike	C	Partly D and Partly E	DO, BOD	Industrial waste from Hosieries, Tanneries, Electroplating and Engg Industries and domestic waste from Ludhiana and Jullundur
		D/S of Nangal to Anandpur	C	E	Ammonia	Waste of Fertilizers, Chlor Alkali and paper mills from Nangal

6.	Ganga (Tributaries) (i) Yamuna	(i) Delhi to Confluence with Chambal	C	Partly D and Partly E	DO, BOD, Coliforms	Domestic and Industrial waste from Delhi, Mathura and Agra
		(ii) In the city limits of Delhi, Mathura & Agra	B	Partly D and coliforms Partly E	DO, BOD, Coliforms	
	Hindon	Sharanpur to Confluence with Yamuna	D	E	DO, BOD, Toxic	Industrial and domestic waste from Sharanpur and Ghaziabad
	Chambal	D/S of Nagda and D/S of Kota (approx. 15 kms at both the places)	C	Partly D and Partly E	BOD, DO	Domestic and Industrial waste from Nagda and Kota respectively
	(ii) Damodar	D/S of Dhanbad upto Haldia	C	Partly D and Partly E	BOD, Toxic	Industrial waste from Dhanbad, Durgapur, Asansol, Haldia and Burnpur
	(iii) Gomti	Lucknow to Confluence with Ganga	C	Partly D and Partly E	DO, BOD, Coliforms	Industrial waste from Distilleries and domestic waste from Lucknow
	(iv)Kali	D/S Modinagar to Confluence with Ganga	C	Partly D and Partly E	BOD, Coliforms	Industrial and domestic waste from Modinagar

(Source: Barua A K., 2001)

Total available wastewater treatment capacity is 4,037.2 MLD, which works out to be 32% of wastewater collected and about 24% of the wastewater generated. Out of the total of 299 class-I cities, Sewage Treatment Plants (STPs) either primary or secondary level of treatment, exist for 76 cities only.

1.2.2 Class- II towns with population between 50000 and one lakh

According to 1991 census there are 345 class-II towns with a population of 2,36,45,614.

The overall population density in class-II towns works out to 3,695 persons per sq.km

The total quantity of water supplied to 345 class-II towns is 2030 9 MLD and wastewater generated is 1649 MLD The projected generation of sewage for the year 1999 is 1897 MLD

The percentage of population covered by organised water supply is 88% and the average per capita water supply in class-II towns is 103 lpcd, which is an improvement of about 22% over the 1988 water supply values

The percentage population covered by sewerage facility is 66, in class-II towns and the volume of sewage collected is 1090 MLD

Total available wastewater treatment capacity is 61.5 MLD, which works out to be 6% of sewage collected and about 4% of the sewage generated Out of 345 class-II towns, sewage treatment plants exist in 17 towns only

The generation of such large quantum of untreated municipal wastewater favours sewage farming practice in a big way looking to high nutritive value of sewage. There may be multi purpose usage of land application of sewage water viz. agricultural, disposal, treatment, nutrient recycling and ground water recharge. Hence, such applications become important issue for pollution prevention and sustainable development.

Growing population and industrialization coupled with the introduction of modern intensive agricultural techniques involving irrigation are causing increasingly heavy demands on water resources The re-use of municipal and industrial wastewater has thus become an attractive option for increasing water reserves in such areas Re-use of wastewater for agricultural purposes may be particularly attractive, since this may allow for the expansion of intensive agriculture while preserving limited resources of good quality drinking water for the rapid urban development that is taking place in most regions of the world In addition to the amounts of water provided by wastewater re-use in agriculture, many agronomists see the advantage of using such water, since it is rich in organic content and can be expected in many cases to supply part or even all of the nitrogen required to fertilize the fields as well as some of the other essential nutrients. The direct agricultural application of human excreta ('nightsoil') has been widely practiced in many areas of the world primarily for its fertilizer value

However, in planning wastewater re-use high priority must be given to the public health considerations since wastewater carries a potentially dangerous load of pathogenic micro-organisms that can be infectious to man. Health criteria must be established in the early planning stages of any wastewater re-use programme so as to ensure that the benefits gained by additional water resources are not negated by unreasonable public health risks to agricultural workers and the public at large.

The worldwide projects / experiments are being conducted in connection with perspective of reuse of wastewater in agriculture. During the last two decades, efforts to evaluate safety and feasibility of wastewater irrigation worldwide, millions of rupees have been spent to study the impact of human wastes (particularly wastewater) as important resource in many parts of the world.
Sewerage coverage and wastewater treatment by world region are represented in Table 1.9.

Table 1.9 Sewerage Coverage and Wastewater Treatment by World Region

Region	Population (%) in large cities having sewers	Sewage wastewater (%) that is treated to secondary level
Africa	18	00
Asia	45	35
Latin America Caribbean (LAC)	35	14
Oceania	15	Not reported
North America	96	90
Europe	92	66

(Source: Global Water Supply and Sanitation Assessment 2000 Report, WHO and UNICEF, 2000)

With water scarcity, land pressure, and little feasible budgetary alternative for effectively treating the growing wastewater volumes, the burgeoning of wastewater irrigation in urban areas of developing countries is already taking place. Figure 1.1 indicates growth in urban water supply coverage by world region.

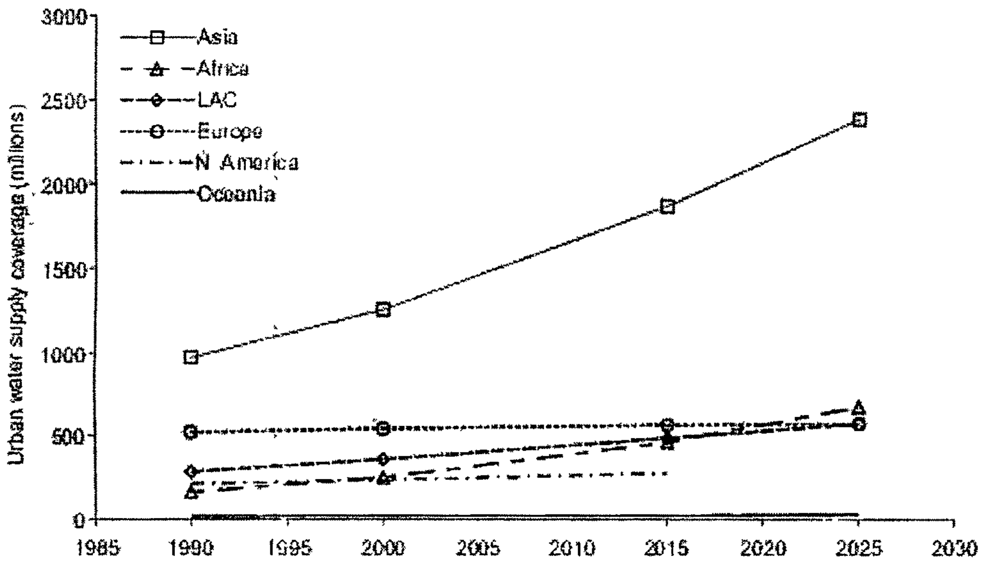

Fig 1.1 Growth in Urban Water Supply Coverage by World Region

The challenges of wastewater management in the urban to peri-urban corridors will unavoidably be more complex.

1.3 Research Objectives

Numerous case studies on the dynamics of urban agriculture show that wastewater irrigation supports countless livelihoods of both marginal and better established, or even commercial farmers and the labourers they employ, all of whom occupy production and marketing niches These social and economic processes driving wastewater irrigation may often be overlooked from the regulatory perspective of urban, public health or environmental authorities who view the protection of public health and environmental quality as their primary objectives, despite the fact that regulators may be aware that urban farming using wastewater is a prevalent phenomenon.

The following objectives are considered in this research work.

1.3.1 Study of environmental and socioeconomic impacts

The research work is aimed at studying environmental & socioeconomic impacts of irrigation by blending sewage water with ground water & surface water with special reference to semi arid regions. Main emphasis is also laid on the quality of yield to be human friendly

1.3.2 Utilization of sewage water as alternate source for irrigation to minimize water scarcity

Water scarcity for irrigation has been regular feature in Gujarat. If we have to improve agricultural production, we have to have more water to irrigate more lands. Since surface and subsurface water is not enough to meet this tremendous demand, we have to find out an alternate source. One such source is the treated sewage effluent which our municipalities have in abundance. Thus, the research work using such source for irrigation is carried out, the results of which will help result in reduction of use of good quality of water which then can be beneficial to other needy sectors

1.3.3 Assessment of nutrient value of sewage water

Mere application of sewage water does not save the situation. We have to ensure that it is not causing any health hazard. We also have to see whether it provide nutrients to the plant We also have to see whether it reduces intake of fertilizers. This approach is more environment friendly.

1.3.4 Judicious use of available water resources (as per relevance to State priorities)

The proposed research work is aimed at providing inter-disciplinary approach to problems related to effective utilization and conservation of scarce water resources as well as safe disposal of sewage water. As Gujarat is facing severe water crisis, the priority is being given to judicious use of available water resources In this context, the research work undertaken here is a step in the right direction.

1.3.5 Reuse of wastewater (as per directives of Ministry of Environment and Forests, Government of India)

As per Ministry of Environment & Forests Order (New Delhi, 29th May, 2001) in connection with Water Quality Assessment Authority, one of the important functions to be focused is "to promote recycling / reuse of treated sewage/ trade effluent for irrigation in development of agriculture". In this context, the research work is focused on Reuse of wastewater for irrigation as per the given directive.