Chapter 1: Introduction

1.1 General

Water the unique gift of nature and as a natural factor it has an important role in human civilization. Over the progress of human civilization demand for water resources had been increased due the multidimensional uses of these precious resources. For the sustainable socio-economic development and for maintaining sustainable ecological balance water is truly an indispensable factor and is necessary for all the living elements of this universe. This resource is used in any field of production i.e. in primary, secondary and tertiary sectors. Due to its non-substitutability as a factor of production present world is very much concerned about the efficient utilization of this resource. This concern generates because purification of water is very costlier and difficult and it is expensive to transport from one place to other. Still water is one of the most controllable and manageable resources that can be stored for future use. It should be noted in this context that, being a natural resources water cannot be treated as pure public good, sometimes it acts as private good as it is available at private cost.(Gatto and Lanzafame,2005)

As population grows over the time there is an increase in demand for water which requires more allocation of water resources both surface and ground water for the use in domestic, agricultural and industrial activities. This ultimately creates an upward pressure as the uses of water leads to a crisis, conflicts and disagreement among the users. Moreover, it generates excessive, unexpected and unhealthy pressure on ecology and environment which ultimately leads to environmental degradation (UN Water Report, 2007).

Earth's 97% water is salty and only 3% water is fresh in nature. Of this fresh water, only 15% water is available as ground water or surface water. It means that rest of this water is locked in glacier or in deep aquifers which is not accessible for the use of domestic purposes, agriculture and industrial sector. World Summit on Sustainable Development (WSSD) has identified water resources as an important factor of human development and scarcity of water resources got worldwide concern for the sustainable development.

Water scarcity is in general, generates impact on all the users when demand for quality water by the different sectors of production can't be fulfilled given the present institutional arrangements. Scarcity of water may arise at any point of demand and supply. Water scarcity may vary due to the differences in the causes. Variation in the climate condition, rate of growth of population, and level of economic development or growth causes variation in the degree of scarcity of water. Imbalance in water availability and demand, the degradation of ground water and surface water quality, intersectoral competition and interregional and international conflicts, all are the burning issues in water scarcity [UN water Report – 2007].

Most of the countries of this universe are giving unwanted pressure on water. The way global population is increasing at a faster rate; there will be 40% deficiencies between demand and supply of water by 2030. Agricultural production should be increased by 60% to feed 9 billion people by 2050 which requires an increase in the consumption of water resources by 70% and withdrawals of water resources by 15%. If demand for the utilization of water resources is increasing at this rapid rate then about 1.8 billion people of this globe will reside in water scarce country by 2025 (World Bank 2017).

Climate change plays a negative role in the problem of water crisis and it creates unpredictable situation. Nearly 500 million people resides in deltas and 1 billion people use to live in the monsoonal basin are in a dangerous zone of increasing intensity of natural calamities like drought and flood and 120 billion people of this globe may be affected by the unpredicted drought and flood. A total of 148 countries of the World are sharing 276 trans boundaries which is source of global fresh water. Nearly 2 billion people depend on 300 transboundaries aquifers system for ground water requirements for livelihood, domestic use, and agriculture and for industrial uses. This complex sharing of global water resources among different countries becomes more complex due to the problems of climate change and a global warming [World Bank 2018].

In this context of impact of global warming, IPCC report, 2018 is important to mention. Global warming of 1.5^0c will affect to raise sea level which in turn damage the balance of eco system of low line coastal areas, intrusion of salt water in the arable land, flooding and causesin damage social and economic infrastructure. It also creates a high level of loss of coastal resources and reduces productivity of fisheries. IPCC reports revealed that climate change i.e. global warming may create high risk to health, livelihood, food security, water supply, human security and economic growth [IPCC, 2018].

India gets 4000 sq.km as annual precipitation, of which monsoon rain contributes 3000 sq.km. It is noteworthy to mention that rainfall is not homogenously distributed throughout the country. In most of the places of India rain occurs due to south west monsoon in the month of June and September. Whereas in some parts of the country rain occurs due to north-east monsoon in the month of October and December. In India average rainfall is almost 1215 mm with a spatial variation ranging from less than 100 mm in western Rajasthan and more than 2500 mm in the north-eastern part of our country. Among this available water resources, India is able to explore only 20% i.e. 761 sq.km. Of which a part of it is unsustainable ground water. Out of the surface water and ground water resources India utilizes 688 sq.km. for irrigation, 56 sq.km for Municipal demand and for drinking purposes. Only 17 sq.km are being utilized for the Industrial use (CWC report, 2011).

World's 4% fresh water resource owned by India which enables India in the same bench of top ten water rich countries despite this factthat IPCC bracketed India in the group of water stressed region because per capita utilizable fresh water is 1122 cubic meter (CuM) per year, which is low compared to international standard of 1700 cum. According to Census Report 2011, India's population is 1320 million. Due to this high rate of growth of population, demand for fresh water increases by lips and bound. If per capita availability of fresh water falls to 1000 cubic meter per year, then India will be declared as water scarce region (Das. Binayak , 2009).

World's population's 17% lives in India with the availability of 4% of world's fresh water. India is the 2nd largest country in the world with respect to the production of agriculture and allied sector output. Agriculture is the lifeline of Indian economy. 54.6% of the total work force is still engaged in primary sector for their livelihood and primary sector contributes 17.4% of country's GDP. Out of 328.7 million hectors of geographical area, net sown area is 140.1 million hectares where gross cropped area is 198.4 million hectares. Net sown area is only 43% of geographical area. Net Irrigated Area is only 68.4 million hectares. Out of total irrigated area 55.68% is irrigated through well irrigation, canal irrigation systems contribute 32.04% of total irrigated area. Tank irrigation systems contribute only 5.8% of total irrigated area and 6.47% of total irrigated area is irrigated by other sources (World water development report, 2018).

Irrigation is the most important factor behind the success of agriculture in Indian economy because of the geomorphological differences in the different regions of the country. Moreover, temporal and spatial variation of the rainfall in the country calls for a scientific and environmentally sustainable irrigation management in the country with a long term perspective. With the introduction of mechanized system of irrigation techniques, India relied much on ground water lifting for irrigation purpose, since independence. But with the threat of global warming, environmental degradation and ground water depletion, tank water irrigation through rain water harvesting can play a significant role for agricultural economy of India, which had not been optimally utilized.

Although tank irrigation has strong historical background in the state of Tamil Nadu, Odisha, Andhra Pradesh, Kerala, Karnataka and West Bengal, traditionally tanks were utilized in India for the purpose of agricultural activities in a limited scale and tanks served as moderators of flood at the time of rainy seasons. They act as a top-up of ground water which had been taken to meet the need for the demand of drinking water. Moreover, tanks were treated as insurance against the drought situation at the time of summer. Basically these small water bodies perform as storage of runoff from its catchment for the future use. From the ancient time all these tanks were owned and controlled by the local rulers and they allow the tenants to use the tank water for the agricultural activities in exchange of small part of crops as price.

Basic problems of this irrigation tank are the poor and insufficient maintenance and management of this commonly used water bodies from time immemorial. Due to this negligence, siltation, reduction in storage capacity, encroachment, high degree of seepage in the delivery system are commonly seen in the tank irrigation system which is an obstacle in way of utilizing tank irrigation in a sustainable manner. Therefore, there is an urgent need of strong, effective and rational management system for socially, economically, environmentally sustainable use of this tankirrigation system for the better present and future use(Arivoli and Ambujam, 2016).

1.2 Origin of tank in India

Tank as source of irrigation had been utilised for domestic and agricultural purposes in India from time immemorial. In the text of the Purans, the Ramayana, and the Mahabharata and in various Vedic texts, strong evidences of tank irrigation were traced by historians. In fact in Indus Valley Civilisation (3000-1500 B.C.), we found evidence of water harvesting through tank irrigation in the North-Western part of India. Brick-made water reservoirs had been excavated by the archaeologists, which were used for rain water harvesting to meet the domestic and other needs of the people.

In the Mauryan Empire (321-297 B.C.) we get extensive descriptions of dams and bunds which were constructed for the purpose of agricultural activities in

"Kautilya's Arthasastra". Dams and bunds were constructed under the ownership of King and were permitted to use by the people by following a well framed strict rules and regulations. Water tax was levied at various rates depending on the extent and methods of drawing water. Provisions of punishments were introduced for the violations of rules and regulations framed by the rulers.

In between 1^{st} century B.C. to 2^{nd} century A.D., in the Satvahana period wells made of bricks were constructed to store water to meet various purposes. In between 1^{st} to 3^{rd} century A.D., during Pandya, Chera, Chola dynasties large wells were constructed for the purpose of irrigation. Concept of cascade tanks wasintroduced in Andhra Pradesh and Karnataka during the period of Vijayanagara Kingdom (1336-1546 A.D.).Moreover, the concept of interconnected tanks is chain system tanks was also witnessed in the same period which was an example of advancement of irrigation technology at that time. In northern India, during Rajput dynasty (1000-1200A.D.) under the regime of king Bhoja 647 Sq.km.Bhopal Lake was constructed for development of irrigation activities to enhance agricultural production at that time. During 760 to 1100 A.D. Pal kings ruled Bengal and in Pal dynasty a number of tanks were constructed for the purposes of irrigation to feed water in agriculture. In Orissa during Gond kingdom, in 9^{th} century many tanks were constructed for the domestic purposes and to promote supply of water to the field to cultivate lands. In 12^{th} century, in Kashmir many tanks were built for the agricultural development. During the medieval era, rain water harvesting through tank irrigation was encouraged by Mohammad Bin Tughlaq (1325-1351 A.D.).Western Yamuna canal was built to feed water for dry zones for agriculture during the time of Feroz Shah Tuglaq (1336-1546

A.D.). In southern part of India, during the rule of Vijayanagar Empire (1336-1546 A.D.) several tanks were constructed. Among them, Anantraj Sagar tank, Snekere tank, Kaveri delta project, famous Korangal dam are noteworthy to mention. During Bahahamani empire irrigation through canals were given priority. Many canals had been built for agricultural activities through rain water harvesting. Traditionally, tank irrigation was the main source of irrigation in India since Independence. During British rule, due to negligence, system of tank irrigation was declined significantly. After the independence, policy makers had given much importance for development of construction of dam, deep and shallow tube wells, neglecting the century old tank irrigation system for primary sector activities in India.

1.3 *Water Scenario in India*

Water is a crucial renewable natural factor which is very much essential for the livehood, agriculture, industry and energy sectors. Sustainable economic growth, creation of human welfare and ecological balance basically rest upon the availability, proper utilisation, conservation, and protection of these precious natural resources. India is the home of 17.5% of world's total population while only 4% of world's fresh water is available in India. Excessive pressure of rapid population growth, increasing trend of erratic urbanisation had pushed India, unfortunately in the bench of water stressed country. Moreover worse impact of climate change and effects global warming had made this water crisis, even more complex and multidimensional. India's present scenario of water resources is depicted in the following Table 1.

Table 1: Water Resources in India

Sl No	Items	Quantity
1	Average annual Rainfall	4000BCM
2	Annual Rainfall(2016)	3560 BCM
3	Mean Annual Natural Run-off	1869 BCM
4	Estimated Utilizable Surface Water Resources	690 BCM
5	Total replenishable Ground Water Resources	433 BCM
6	Ground Water Resources Available for Irrigation	369 BCM
7	Ground Water Potential Available for Domestic, Industrial And Other Purposes	71 BCM (approx...)
8	Ultimate Irrigation Potential From Surface Water From Ground Water	140 Mha 76 Mha 64 Mha
9	Storage Available Due to Completed Major & Medium Projects (Including live Capacity less than 10 M.Cum)	253 BCM
10	Estimated Additional Likely Live Storage Available due to Projects Under Construction/Consideration	155 BCM

Source: CWC, Report 2016-17.

BCM: Billion Cubic Meters, CuM: Cubic Meter

It is observed from the table that annual average water availability in India is 1869 BCM. Total annual utilizable water resources are 1123 BCM, among which 690 BCM from surface water and 433 BCM from ground water (central ground water Board, 2017). It signifies that India is relied on surface water for irrigation purposes; heavy dependency on ground water is still prevalent. This excessive use of ground water causes serious depletion of natural aquifers and ultimately hampers the possibility of future use. Presently ground water available for agriculture purposes in India is 369 BCM which is alarming. Over the years, in the planning periods, demand for water not only increased for primary sector activities, but demand for water in the other sectors of the economy had also been increased rapidly which should be considered to understand the water and irrigation issues in India. Projected water demand for various sectors of the economy is listed in the following Table 2.

Table 2: Water demand in India

Projected Water Demand in India(By Different Use)						
Sector	Water Demand in BCM(Billion Cubic Meter)					
	Standing Sub-Committee of MOWR			NCIWRD		
	2010	2025	2050	2010	2025	2050

				Low	High	Low	High	Low	High
Irrigation	688	910	1072	543	557	561	611	628	807
Drinking Water	56	73	102	42	43	55	62	90	111
Industry	12	23	63	37	37	67	67	81	81
Energy	5	15	130	18	19	31	33	63	70
Other	52	72	80	54	54	70	70	111	111
Total	813	1093	1447	694	710	784	843	973	1180

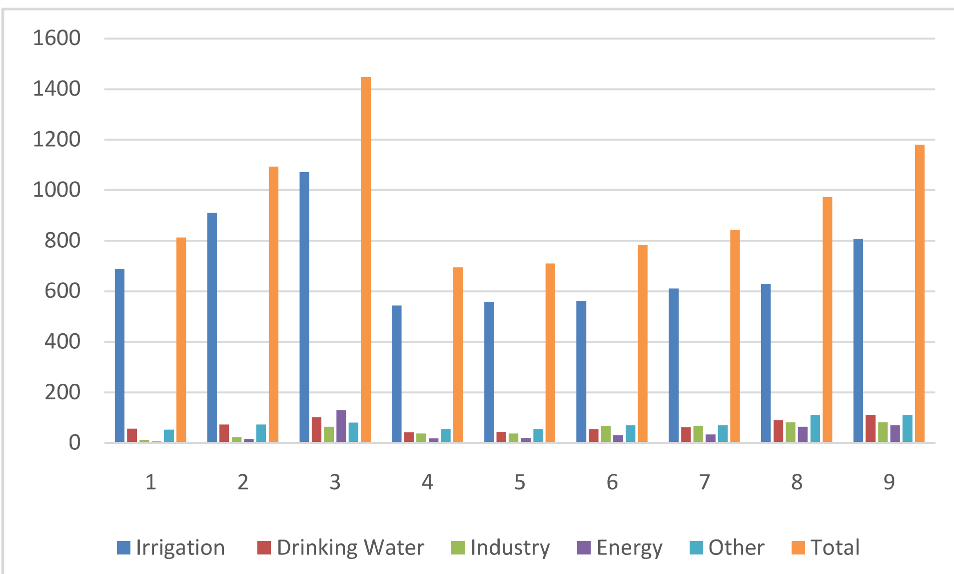

Figure 1: Water Demand in India

Among these sectoral activities, availability of safe drinking water and power generation are majorly linked with the higher water demand and demand for water for these sectors are increasing rapidly over the time. More than 2 lakhs people had to breath last due unavailability of safe drinking water in India. Because with the disproportionate distribution and allocation of these essential natural resources, it is not possible to supply water to fulfil the water need. Availability of water in India is depicted in Table 3.

Table 3: Water Availability in India

Sl No	Item	Quantity
1	Per capita water Availability(2001) in cubic meters	1816 Cu. M
2	Per Capita Water Availability(2010) in cubic meter	1588 Cu.M
3	Per Capita Water Availability(2015) in cubic meter	1720.29 Cu.M

Source: Central Water Commission, 2015

Cu M: Cubic Meter

Per capita availability of water resources is gradually declining over the time due to various reasons. Replenishment of ground water in India is basically indebted to monsoon. Monsoon failure, climate change, global warming, lack of proper maintenance of surface water bodies, mainly the river basins, negligence towards the century old eco-friendly rain water harvesting through tank irrigation system are responsible for declining water availability in India.

India is lagging behind the other countries with respect to per capita availability of water which is depicted in Table 4.

Table 4: Per capita availability of water in Different Countries

Sl No	Nameofthe Country	Quantity
1	Australia	3223 m^3
2	Brazil	2632 m^3
3	China	416 m^3
4	U.S.A	2193 m^3

Source: Ministry of water resources, 2012

Rapid population growth is a hindrance in the way of socio-economic development of any country. In developing country like India, this population explosion is the mother of all economic crises. Specifically, problems of crisis of water are manifold over the years, with this high rate of population and per capita availability of water is steeply falling over the years is being depicted in Table 5.

Table 5: Per capita water availability in India:

Year	Population(Million)	Per Capita WaterAvailability(M^3 /Year)	Remarks
1951	361	5178	
1955	395	4732	
1991	846	2210	

2001	1027	1820	
2011	1211	1651	Water stressed
2015	1326	1508	Water stressed
2021	1345	1486	Water stressed
2031	1463	1367	Water stressed
2041	1560	1282	Water stressed
2051	1628	1228	Water stressed

Source: Government of India, 2009(NCIWRD report, 1999), projected from 2011 Census

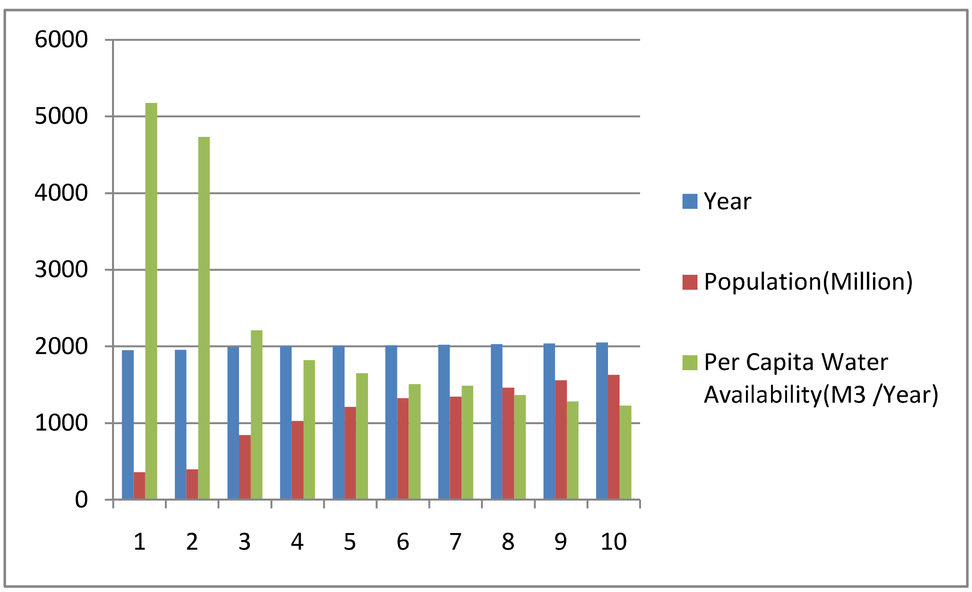

Figure 2: Per capita water availability in India

Water demand is expected to increase over the coming years due to increased agricultural need, expansion of energy sector, municipal demand for water due to rapid urbanisation and sanitation facilities to the people. As a result, if supply of water is not increased up to the expected level, naturally per capita availability of water per year will fall and hence the country has to face water stressed situation. The way the problem of water crisis is aggravating, country is going to face the serious threat of huge deficit in the gross supply of water.

1.4 *Irrigation Potential in India*

Irrigation plays a pivotal role for agrarian development and ensuring food security to the rapid growing population in India. Different modes of irrigation had been utilised from the ancient times to meet up different needs. In views of this role of irrigation different agencies had tried to conduct studies to estimate irrigation potential of the country so that demand for irrigation water can be justified. Some of these irrigation potential estimated before and after independence is listed in Table 6.

Table 6: Estimated Irrigation Potential in India

Sl No.	Year	Authority/Method of Estimation	Quantity(BCM)
1	1901-03	Fast irrigation commission /using coefficients of run off	1443.2
2	1949	Khosla's empirical formula	1673

3	1960	CW& PC/Statistical analysis of flow data wherever available and rainfall-run off relationship wherever data were meager	1881
4	1988	CWC/General water balance approach	1880
5	1993	CWC	1869
6	1999	National Commission for Integrated Water Resources Development(NCIWRD)	1953

Source: Planning commission, Govt. of India

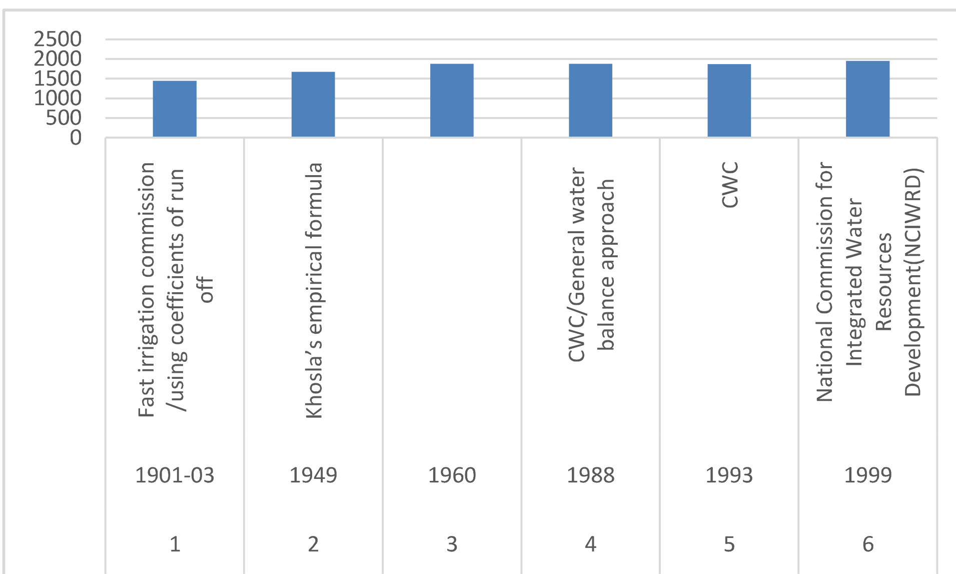

Figure 3: Irrigation Potential in India

Due to the differences in the methodology used by different agencies or institutions different results of irrigation potential had been achieved. But it is seen that irrigation potential created over the time since independence is on rise. Optimum utilisation of water resources depend on various factors. Unless irrigation potential created is matched with the irrigation potential utilised, the country cannot have sustainable water resource development and that may harm the future supply of water resources. Greater the deviation of irrigation potential utilised from the irrigation potential created, greater will be the loss of water resources. Irrigation potential created and irrigation potential utilised in different plan periods is shown in Table 7.

Table 7: IPC and IPU in India

Sl No.	Plan Periods	Potential Created(MH)	PotentialUtilized(Mh)
1	Pre Plan Period	22.60	22.60
2	First Plan(1951-56)	22.26	25.04
3	Second Plan(56-61)	29.08	22.80
4	Third Plan(1961-66)	33.57	32.17
5	Annual Plan(1966-69)	37.10	35.75

6	Fourth Plan(1969-74)	44.20	42.19
7	Fifth Plan(1974-78)	52.20	48.46
8	Sixth Plan(1980-85)	65.22	58.82
9	Seventh Plan(1985-90)	76.53	68.59
10	Annual Plans(1990-1992)	81.09	72.86
11	Eighth Plan(1992-97)	86.26	77.24
12	Ninth Plan(1997-2002)	93.95	80.06
13	Tenth Plan(2002-2007)	102.77	87.23

Source: Different reports of Planning Commission Report, Govt. of India

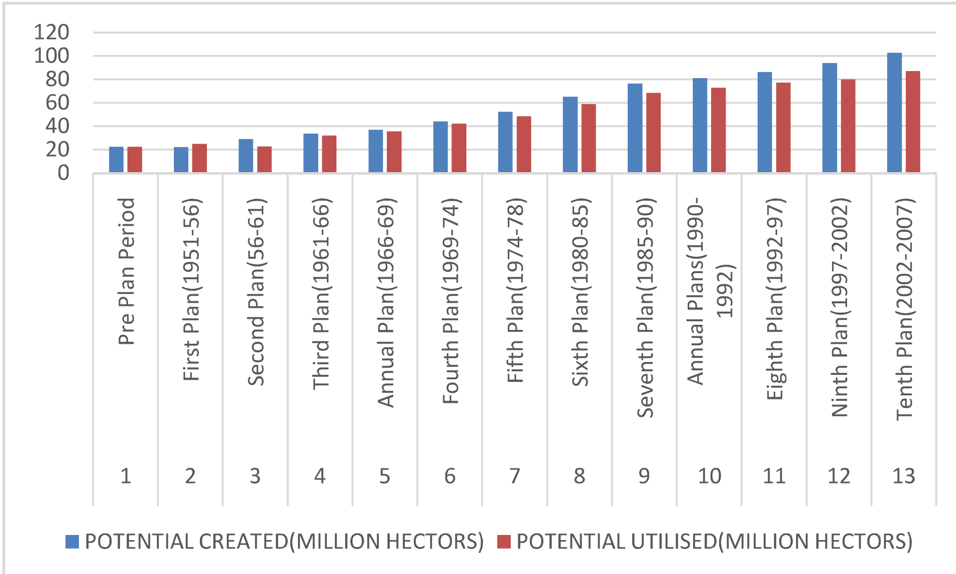

Figure 4: Irrigation Potential in Different Plan Periods

Before independence during British Rule, condition of irrigation was not favourable for the agrarian development of the country. Because, British Govt. had not given much importance for the development of irrigation facilities. They had not taken any endeavour for the maintenance and management of the century old tank irrigation based on rain water harvesting. Whatever initiative they have taken that was for the development of ground water irrigation which was not sufficient to meet the irrigation demand. After the independence, up to early sixties, irrigation potential created is lagging behind the irrigation potential utilised. After mid-sixties, Govt. of India had adopted new technology in the field of agriculture, known as green revolution; as a result demand for irrigation water had been increased at rapid rate. Adoption of new technology in the field of irrigation, based basically on ground water lifting and cannel water, ultimately able to cope with the problem. During the period of green revolution Govt. of India gave tremendous emphasis on the well irrigation and canal irrigation. As a result irrigation potential created had been increased over time. Post green revolution period experienced a steady growth of irrigation potential creation. In fact, potential utilisation of irrigation water fall behind the potential created in irrigation indicated excess capacity creation.

1.5 *Sources of irrigation water in India*

Sources of irrigation water of India comprises of rivers, canals, reservoirs, tanks, ponds, lakes, and ground water. These sources of water play a very significant role in the supply of irrigation water and water requirements of different other sectors. Water availability of different sources is shown in Figure 5.

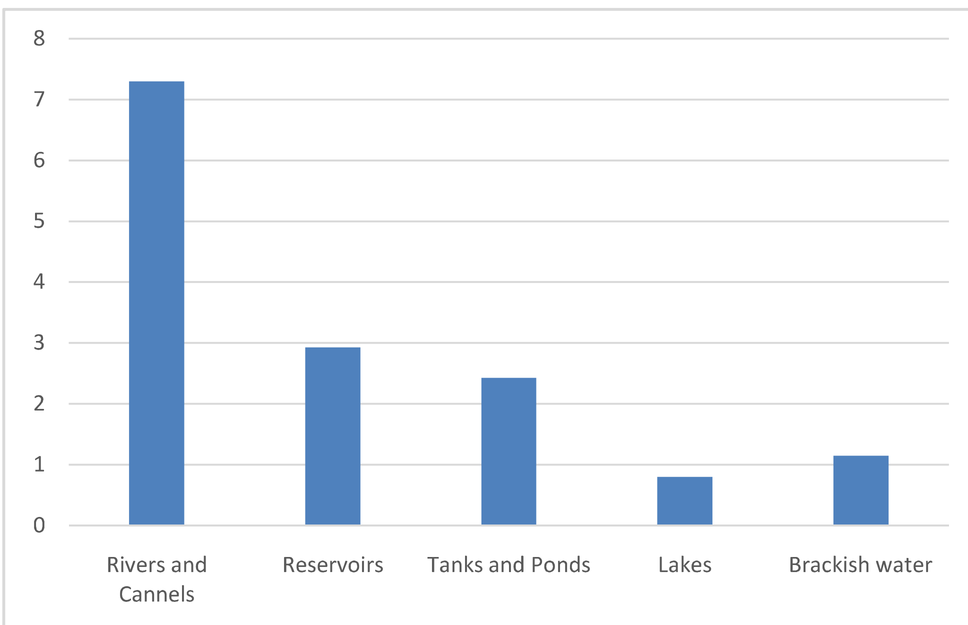

Figure 5: Water Sources in India

Inland water resources of different states in India:

Distribution of different sources of water is not evenly distributed throughout the country. Significant variations in the water availability are seen in different states because of the differences in the sources of water resources, which are depicted in Figure 6.

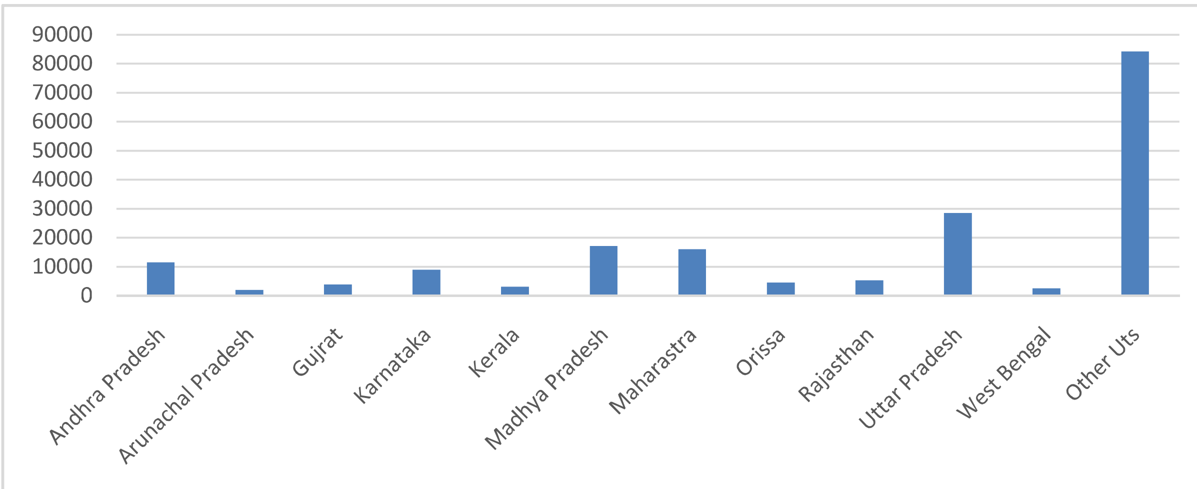

Figure 6: River and Canals (Length in kms)

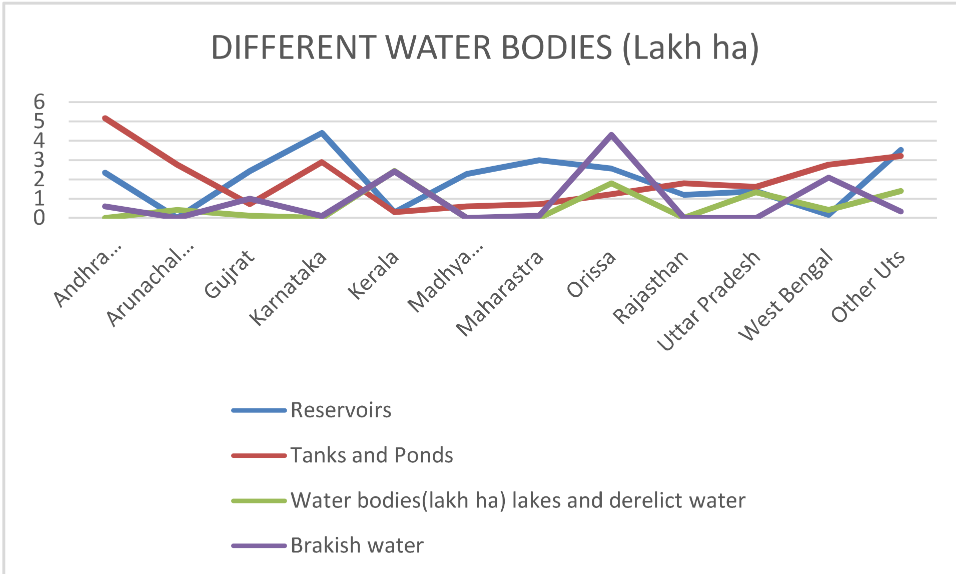

Figure 7: Different Water Bodies (lakh ha)

Rainfall in India:

The annual rain fall precipitation is the major source of water in India. The calculated amount of rain fall per year in India is 4000 BCM. It should be mentioned that there is geo-spatial variation in the rainfall of the country. A summary of rainfall is listed in Table 8.

Table 8: Rainfall in India

ANNUAL RAINFALL(BCM) IN INDIA											
YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
TOTAL RAINFALL(mm)	1234	1086	1215	1161	1181	1117	954	1213	1116	1024	1243
TOTAL VOLUMN OF RAINFALL	4057	3570	3996	3819	3882	3674	3136	3989	3669	3467	4085

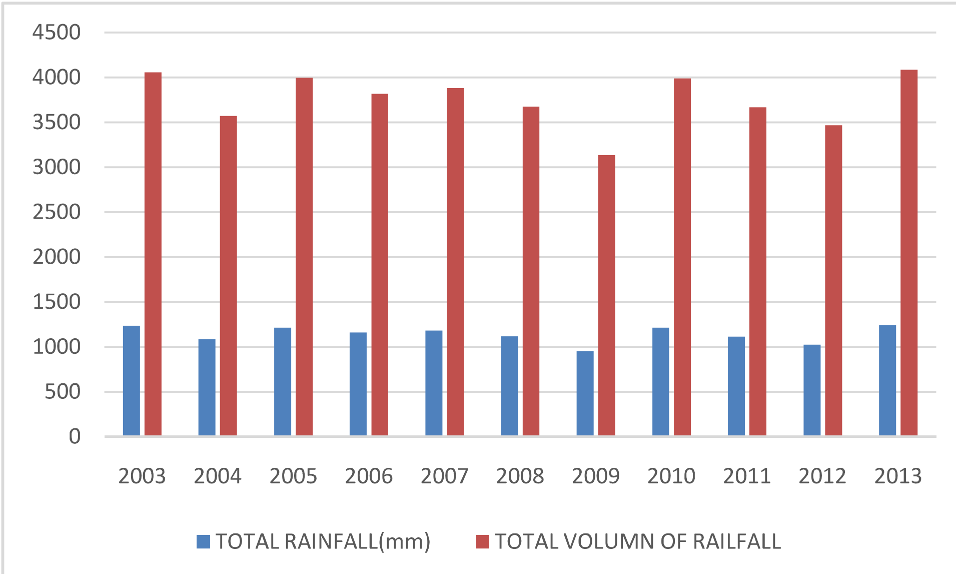

Figure 8: Annual Rainfall in India

Total volume of rainfall recorded in 2013 was 4085 BCM which is much more than previous two years. It comes due to the increasing total rainfall during 2011 and 2012.

Water resources of major river basin:

River basin plays an important role in the surface water irrigation as well as ground water recharge of any country. India is no exception of that. India is blessed with as many as two hundred big and small rivers and tributaries. Indian River basin system is generally divided into 20 large river basins. These river basins continue to ensuring the supply of water in India. Although there is temporal and spatial variation regarding the storage capacity and availability of water in different water basins, still these basins are the life line of Indian economy. These river basins almost cover major states of India from north to south. Availability of water resources in major Indian River basins are listed in Table 9.

Table 9: Water Resources in Major River Basin in India

SL NO.	BASINS	CATCHMENT AREA(Sq.Km.)	AVERAGE WATER RESOURCES POTENTIAL(BCM)	UTILISABLE SURFACE WATER RESOURCES(BCM)
1	Indus(with in India)	321289	73.31	46.0
2	Ganga-Brahmaputra-Meghan a) Ganga b) Brahmaputra c) Barak and others	861452 194413 41723	525.02 537.24 48.36	250.0 24.0 86.67
3	Godavari	312812	110.54	76.3
4	Krishna	258948	78.12	58.0
5	Cauvery	81155	21.36	19.0
6	Subarnarekha	29196	12.37	6.8
7	Brahamani and	51822	28.48	18.3

	Baitarani			
8	Mahanadi	141589	66.88	50.0
9	Pennar	55213	6.32	6.9
10	Mahi	34842	11.02	3.1
11	Sabarmati	21674	3.81	1.9
12	Narmada	98796	45.64	34.5
13	Tapi	65145	14.88	14.5
14	West Flowing Rivers from Tapi to Tadri	55940	87.41	11.9
15	West Flowing Rivers from Tadri to KanyaKumari	56177	113.53	24.3
16	East Flowing Rivers Between Mahanadi and Pennar	86643	22.52	13.1
17	East Flowing River between Pennar And KanyaKumari	100139	16.46	16.5
18	West flowing Rivers between Kutch and Saurashtra including Luni	321851	15.10	15.0

19	Area of Inland drainage's in Rajasthan desert	144835	Negl	Negl
20	Minor River Draining into Myanmar and Bangladesh	36302	31.00	26.56
	Total		1869.37	690.1

Total catchment area of 20 river basins in India is 3271953 sq.km, average rainfall is 4000 BCM and average water resources availability is 1869.37 BCM. These river basins are the main sources of the water for irrigation, industry, power generation and domestic purposes of the country. Top ten river basins from the point of view of water resources availability are Brahmaputra (537.24 BCM), Ganga (525.02 BCM), Godavari (110.54 BCM), West flowing River from Tadri to KanyaKumari (113.53 BCM), Krishna (78.12 BCM), Indus (73.31 BCM), Mahanadi (66.88 BCM), Narmada (45.64 BCM). It should be no worthy to mention here, that Ganga – Brahmaputra – Megna Basin contributes nearly 60% of India's total available water resources. Ganga Basin is the longest river basin on the basis of catchment area (8, 38,803 sq.km.). Pennar river basin is the smallest river basin in India whose resource availability is 11.02 BCM. During 19th century, irrigation was heavily relied on tank irrigation. But with the advancement of irrigation technology, major river basins like Ganga-Yamuna-Godavari-Krishna and Kaveri had been utilised for surface irrigation through the construction reservoirs and dams. Many large and medium size irrigation projects had been undertaken for the purpose of irrigation development of the country.

The contribution of different river basins of India is different due to many constraints like topographical differences and temporal and spatial differences. Resource potential of different major river basins is shown in Figure 9.

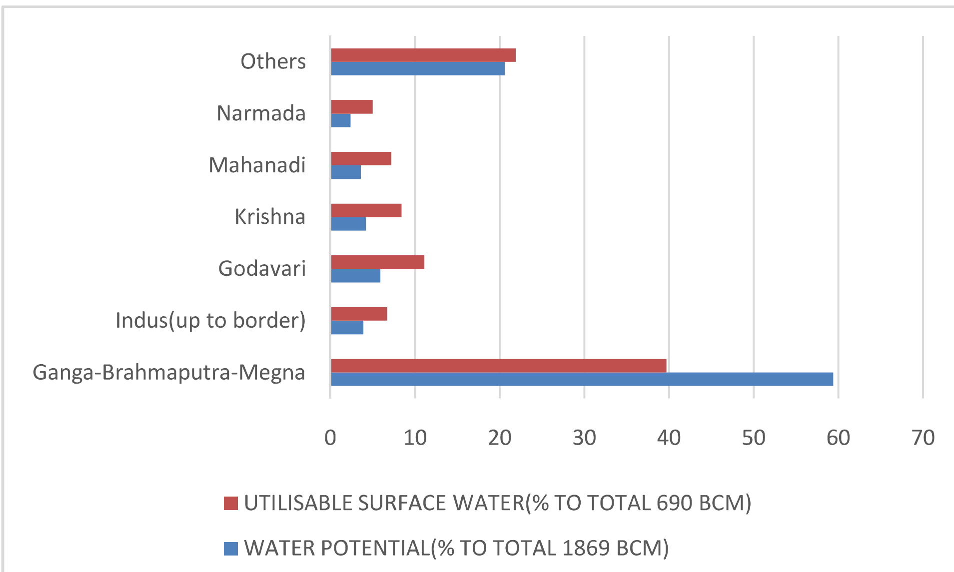

Figure 9: Water Potential in Major River Basins

Source: water and water related statistics of CWC, April 2015

Ground Water Resources:

Ground water is one of the main pillars of supply of water for irrigated agriculture, domestic and industrial purpose. Estimated annual replenishable ground water in India is 433 BCM. Ground water resources of different major states of the country are shown in Figure 10.

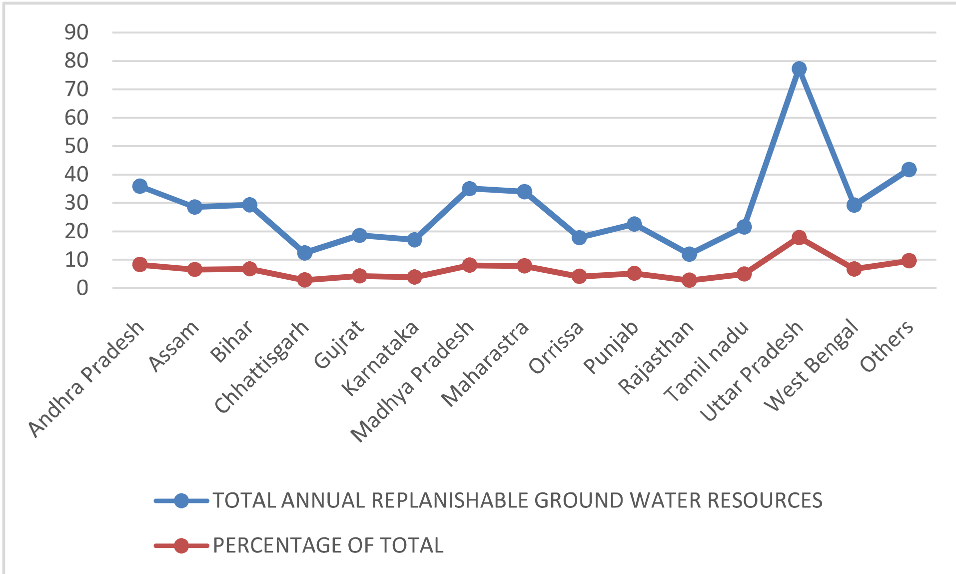

Figure 10: Annual Replenishable Ground Water Potential

Source: water and water related statistics of CWC, April 2015

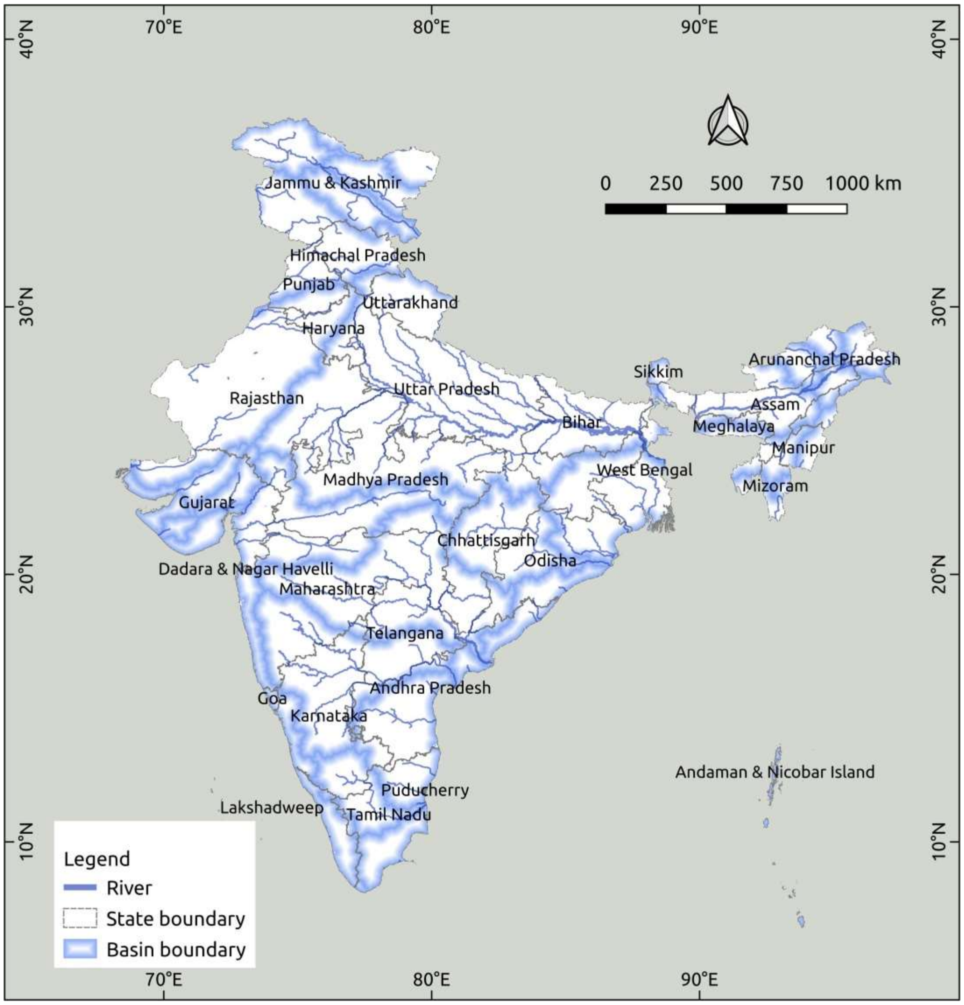

Figure 11: Major River Basin in India

Source: Generated from GIS Mapping

1.6 *Minor Irrigation in India*

Any irrigation scheme either by using surface water or by using ground water, with less than 2000 hectares Cultivable Commend Area is defined as

Minor Irrigation Schemes (MI) in India. Minor Irrigation Schemes include dug wells, shallow tube wells, medium tube wells, deep tube wells surface flow schemes, surface lift schemes(depends on surface water). The comparative study of number of MI schemes between 4th and 5th irrigation Census is shown in Table 10.

Table 10: Minor Irrigation Schemes (4th and 5th Census) in India

Category	4TH MI Census	Percentage	5TH MI Census	Percentage	Growth (%)
Dug well	92	44	87.8	40.4	-4.51
Shallow tube well	91.0	43	91.1	92	0.14
Deep tube well	14.4	7	26.1	12.1	80.24
Ground water	197.6	94	205.2	94.5	3.87
Surface flow	6.0	3	5.9	2.7	-1.49
Surface lift	6.5	3	6.0	2.8	-7.36
Surface water	12.5	6	11.9	5.5	-4.53
Total	210.1	100	217.1	100	3.37

Source: 5th Census of MI schemes, MoWR, Govt. of India, Nov, 2017

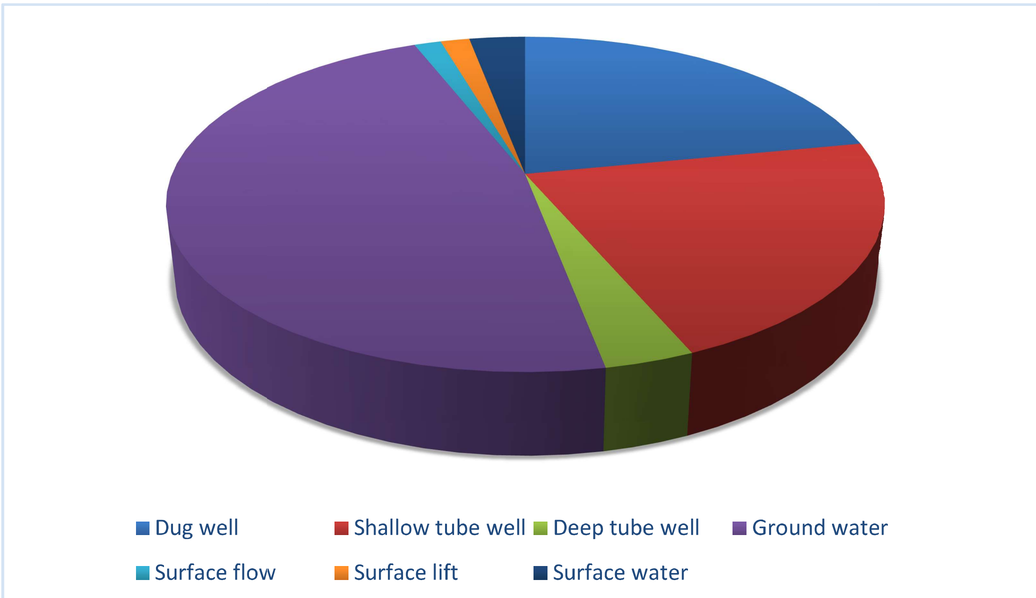

Figure 12: Components of Minor Irrigation in India (4th MI census)

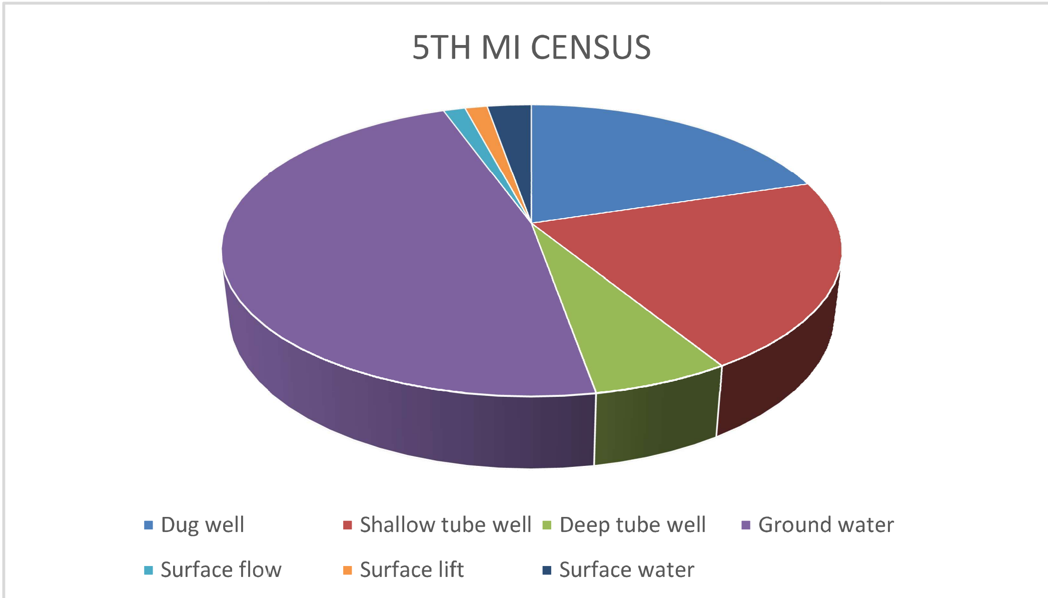

Figure 13: Components of Minor Irrigation in India (5th MI Census)

Table 10 and Figures 12 and 13 show the dependency on ground water in MI schemes. This dependency had increased (3.87%) from 4th to 5th minor irrigation Census. Share of dug well had declined, but share of small tube well and share of shallow tube well had been increased. It is quiet astonishing that role of deep tube well in MI schemes had a growth of 80.24%. Surface water use in MI scheme was reduced by 4.53% between 4th and 5th MI Census.

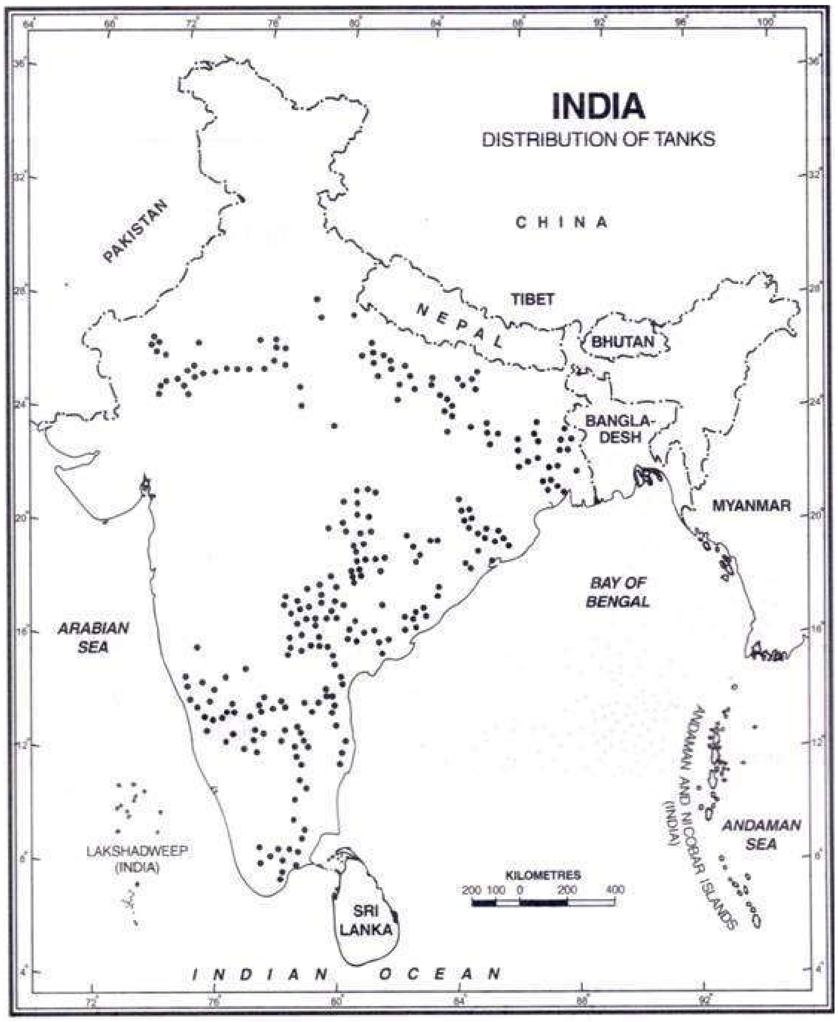

Figure 14: Distribution of tank irrigation in India

1.7 Irrigation potential of minor irrigation schemes

Irrigation potential created (IPC) in 5th minor irrigation Census had been increased by 6.5% as compared to 4th irrigation Census. IPC was changed from 84.03 mh to 89.52 mh from 4th MI Census to 5th MI Census. In the same way, irrigation potential utilised had been enhanced nearly 12.3% from 4th to

5th minor irrigation Census. According to 5th MI Census report 80.3% IPC in GW had been used while 77.8% IPU had been utilised. A comparative study of IPC and IPU in 4th and 5th MI Census is given in Table 11(a).

Table 11(a): IPC and IPU in 4th and 5th MI Census in India

Census	IPC(mh)	IPU(mh)
4th Census	80.03	63.5
5th Census	89.5	71.3

Sources: 4th and 5th MI Census Report, MoWR, Govt. of India

Scheme wise ratio of IPU to IPC in 5th MI Census (in mh) is given in the following table to understand the degree of utilisation of minor irrigation potential in India:

Table 11(b): Ratio of IPU to IPC

CATEGORY	IPC	IPU	RATIO OF IPU/IPC
Dug well	20.7	16.8	0.82
Shallow well	28.5	22.2	0.78
Medium tube well	14.3	11.6	0.81
Deep tube well	15.3	12.7	0.82
Surface flow	6.9	4.9	0.71
Surface lift	3.7	3.0	0.82

Source: 5th MI Census, MoWR, Govt. of India, 2017

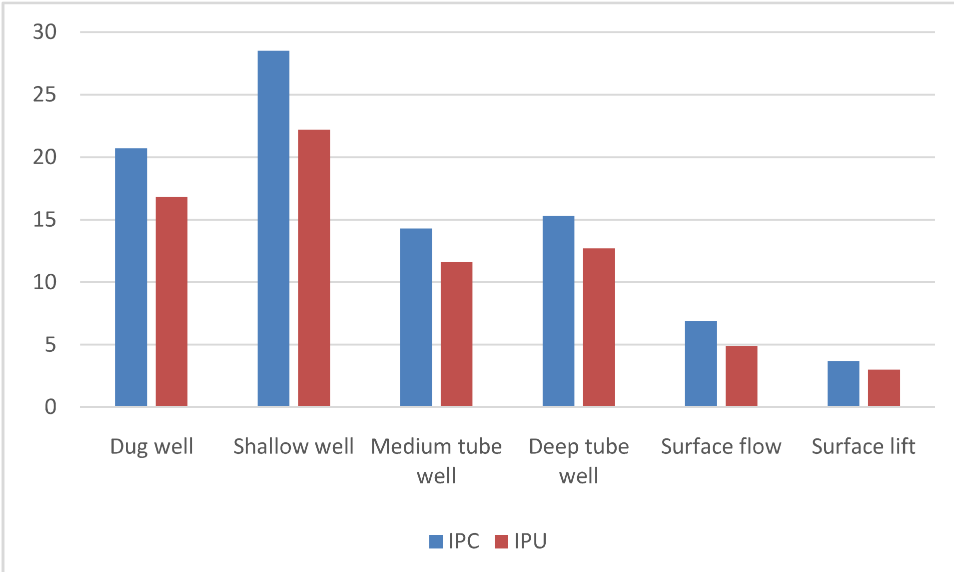

Figure 15: IPC and IPU in 5th MI Census

1.8 *Irrigation Development in India*

Irrigation activities use maximum quantity of water resources for the agricultural sector. With the growing population, India needs to produce more agricultural products for the supply of food grains and other related products to achieve food security. For this reason, irrigation development in an area where, strategic policy should be taken, so that expected target of agricultural product can be achieved. Irrigation development of India is depicted in Table 12.

Table 12: Irrigation Development in India

Land Use AndIrrigation in India				('000 hectares)			
YEAR	GEOGRAPHICAL AREA	FOREST AREA	NET SHOWN	TOTAL CULTIVABLE	GROSS SHOWN	GROSS IRRIGATED	NET IRRIGATED

			AREA	AREA	AREA	AREA	AREA
2000-01	328726	69843	141336	183455	185340	76187	55205
2001-02	328726	69720	140734	183552	188014	78371	56936
2002-03	328726	69821	131943	183450	173889	73055	53897
2003-04	328726	69968	140708	183132	189661	78042	57057
2004-05	328726	69960	140642	182946	191103	81078	59229
2005-06	328726	69994	141162	182686	192737	84280	60837
2006-07	328726	70025	139823	182476	192381	86753	62744
2007-08	328726	69965	141016	182438	195223	88058	63189
2008-09	328726	69978	141899	182459	195314	88896	63638
2009-10	328726	69990	139173	182179	188992	85085	61936
2010-11	328726	70009	141559	182018	197323	88630	63598
2011-12	328726	70015	140801	181983	195246	91530	65263

Source: CWC, Report 2015

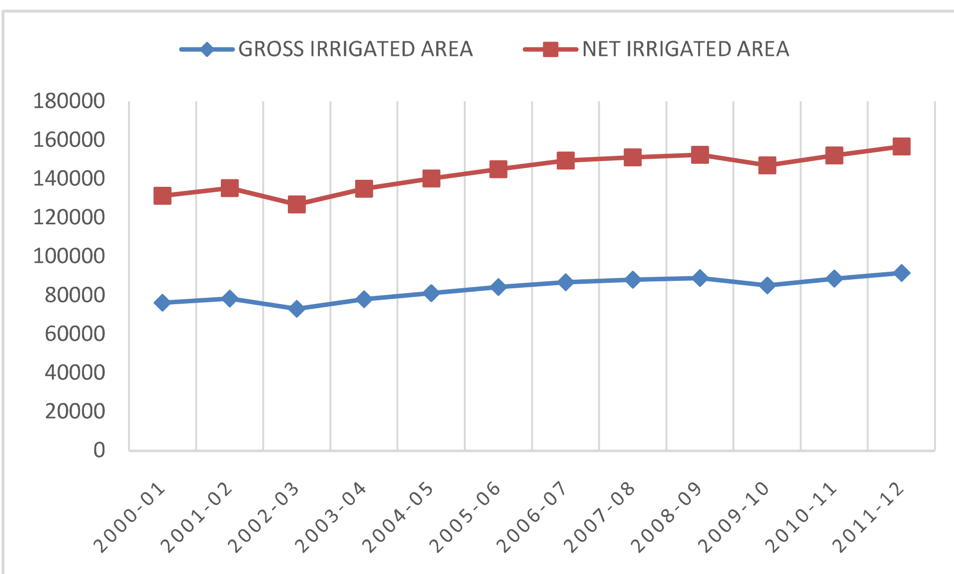

Figure 16: GIA and NIA in India

Figure 16 shows that during the period 2000-01 to 2011-12 GIA and NIA had been increasing at a very slow rate, as a result almost 44% of the cropped area of India is under the sphere of irrigation facilities while almost 56% of the cropped or shown area is not irrigated in India.

1.9 *Source wise irrigation in India*

In India, canal, tanks or ponds, wells and tube wells are the main means of irrigation in India. Source wise Net Irrigated Area in India between 2000-01 to 2011-12 is listed in Table 13.

Table 13: Source Wise Net Irrigated Area in India

NIA(Source Wise) in India					('000 hectares)
Year	Canal	Tank	Wells	Others Source	Total(All Source)
2000-01	16012	2466	33818	2909	55205
2001-02	15202	2196	35197	4342	56937
2002-03	14073	1811	34354	3658	53896
2003-04	14458	1996	36284	4299	57057
2004-05	14766	1734	35191	7538	59229
2005-06	16718	2083	36070	5966	60837
2006-07	17027	2078	37640	5999	62744
2007-08	16748	1973	38361	6107	63189

2008-09	16881	1981	38756	6020	63638
2009-10	14978	1587	36363	7008	61936
2010-11	15667	2004	39061	6887	63619
2011-12	16017	1937	40187	7123	65264

Source: CWC, Report 2015

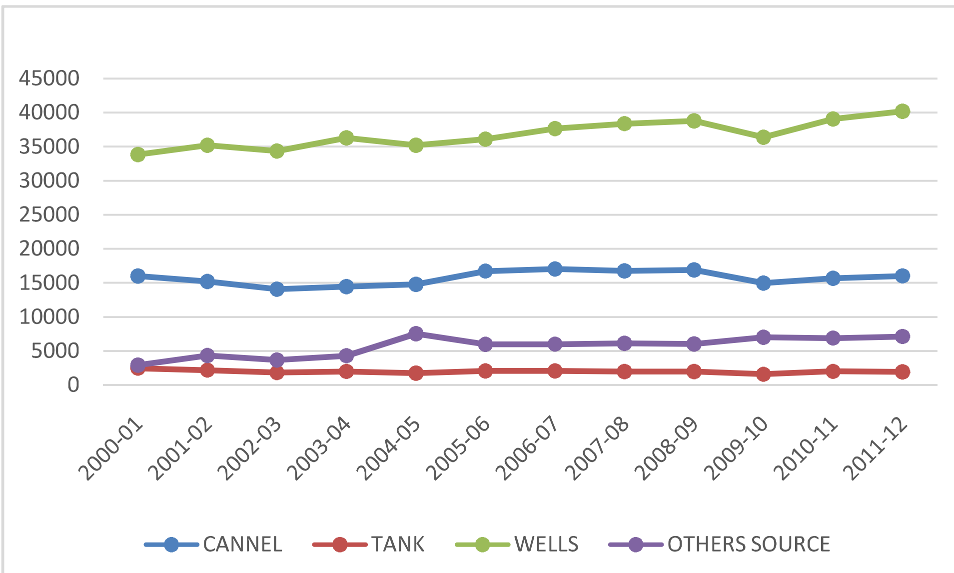

Figure 17: Source Wise NIA in India

Table 13 and Figure 17 show that, canal and well irrigation had been increased, but tank irrigation declined sharply during the period 2000-01 to 2011-12.Development of irrigation can be understood by analysing IPC and IPU over the time. IPC and IPU in different plan period are listed in Table 14.

Table 14: IPC and IPU in different Plan Periods in India

IPC and IPU for Major Medium Irrigation						('000 hectares)
States	UIP	IPC up to 10th Plan	IPC up to 11thPlan	PotentialUtilizedup to 10th Plan	% of IPC(of11thPlan) to UIP	% of IPU to IPC (10th Plan)
Andhra Pradesh	5000	3600.2	4803.7	3244,6	96	90.1
Haryana	3000	2193.7	2206.3	1893.3	74	86.3
Jammu & Kashmir	250	187.3	138.3	174.6	130	93.2
Karnataka	2500	2637.7	328.1	2119.7	119	80.4
Orissa	3600	1974.4	2147.4	1878.7	60	95.2
Punjab	3000	2574.7	2684.4	2510.5	89	97.5
Rajasthan	2750	2861.6	3167.1	2526.1	115	88.3
Tamil Nadu	1500	1562.6	1528.3	1556.9	105	99.6
West Bengal	2300	1754.8	1901.4	1573.6	83	89.7
All India	58465	41637.9	4972.4	33739.6	82	81.0

Source: CWC, Report, 2015.

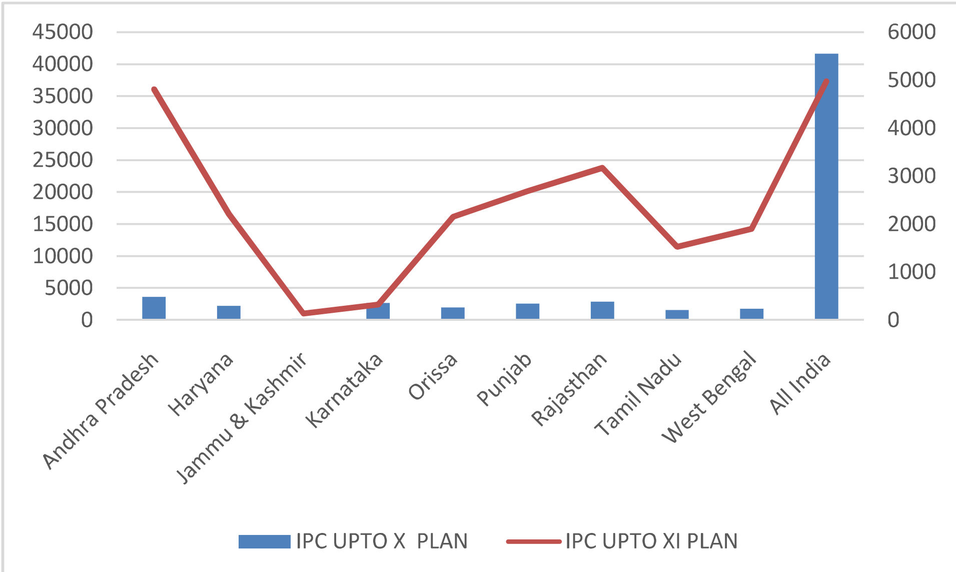

Figure 18: IPC and IPU in 10th and11th plans

1.10 Tank Irrigation in India

Tank irrigation is one of the oldest forms of irrigation which had been practiced in India from the ancient time. But with the advent of modern technique of irrigation, this oldest eco-friendly rain water harvesting form of irrigation had declined rapidly in India. In the following diagram falling tendency of tank irrigation during the periods 1950-51 to 2010-11 is shown in Figure 19.

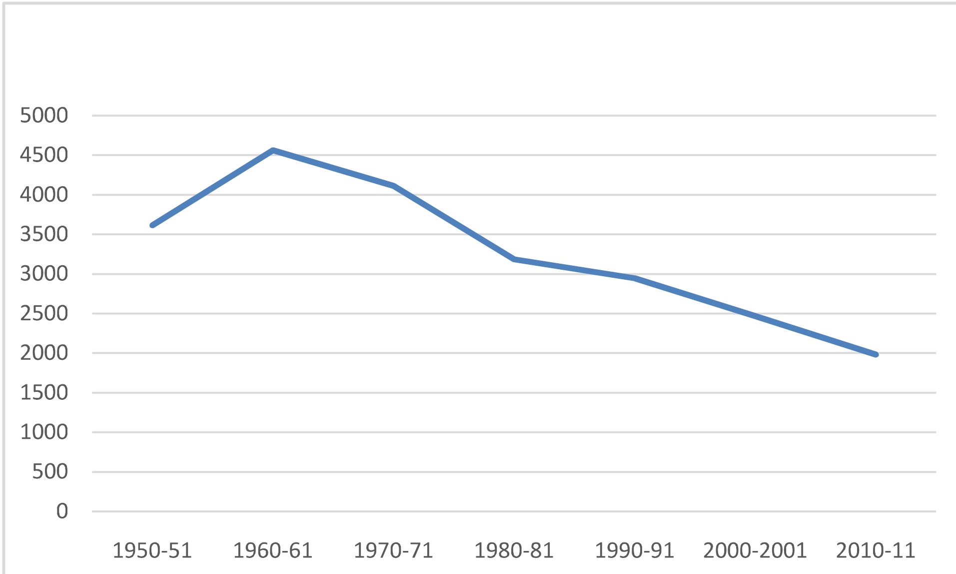

Figure 19: Area Under Tank Irrigation ('000 hectares)

Source: MOSPI, Govt. of India.

Over the years net tank irrigated area in India had been increasing slowly but the gross irrigated area had shown a very slow rate of growth during the periods 1950-51 to 1980-81. But it had shown a slight better rate of growth during the periods 1990-91 to 2010-11. In Figure 20 the decadal growth (1000 hectares) of tank irrigation is shown.

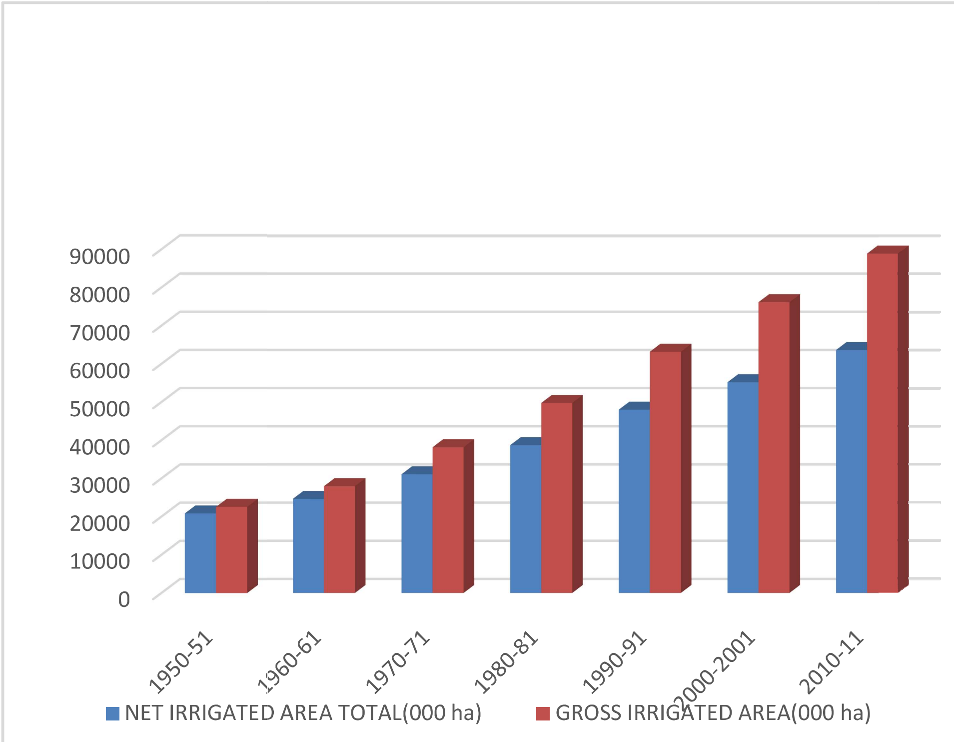

Figure 20: Decadal Growth of Tank Irrigation in India

Source: MOSPI, Govt. of India.

In the year 1950-51 percentage of tank irrigated area over net irrigated area was almost same. But during the period 1960-61 to 1990-91 percentage of tank irrigated area over net irrigated area had been increased at a very insignificant manner, but percentage of gross irrigated area over gross cropped area had been declining at a very rapid rate but in the year 1990-91 to 2010-11 percentage of tank irrigated area over net irrigated area had been reduce sharply, but in that period percentage of gross irrigated area was over gross cropped area had been increasing, which is shown in Figure 21.

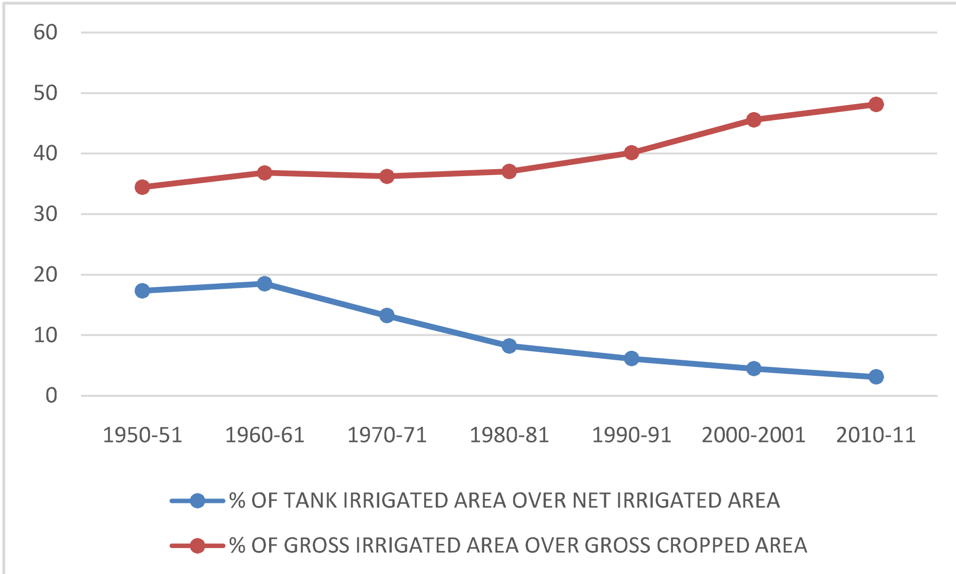

Figure 21: Decadal Growth of Percentage change of Tank Irrigation

Source: MOSPI, Govt. of India.

1.11 Tank irrigation in West Bengal

West Bengal is located in the river basin of the Ganga. Being an agrarian state of India, West Bengal had been using different source of irrigation for the agricultural activities. Irrigation activities comprises of canal, well (both deep and shallow) and tank irrigation in West Bengal area irrigated by different source of irrigation in West Bengal during the periods 2001-02 to 2012-13 is listed in Table 15.

Table 15: Sources of Irrigation in West Bengal

Year	Govt. Canal	Tank	Tube Well	Others	Total
2001-02	956	290	1087	520	2853

2002-03	1006	273	1120	450	2849
2003-2004	1000	266	1167	521	2954
2004-05	1008	266	1005	520	2799
2005-06	1066	245	1153	585	3049
2006-07	1191	248	1212	534	3185
2007-08	1284	268	1225	488	3265
2008-09	1173	281	868	482	2804
2009-10	1119	273	917	416	2725
2010-11	673	272	963	430	2338
2011-12	1115	292	904	476	2926
2012-13	1102	299	781	642	2825

Source: District Statistical Hand Book, Govt. of West Bengal, 2012.

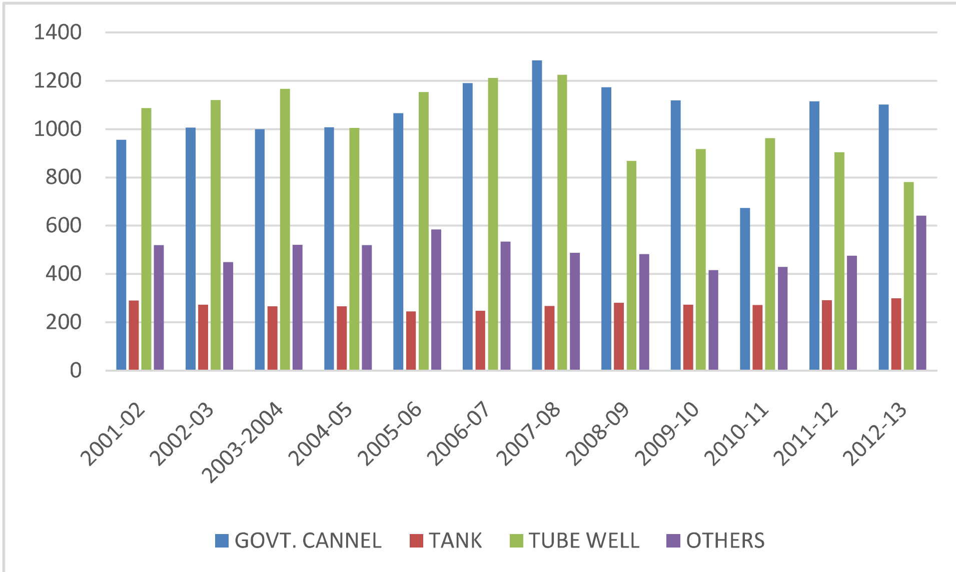

Figure 22: Different Sources of Irrigation in West Bengal

Percentage share of different sources of irrigation in West Bengal from 2001-02 to 2012-13 is summarised in Table 16.

Table 16: Percentage share of source of Irrigation in West Bengal

Year	Govt. Canal	Tank	Tube Well	Others	Total
2001-02	33.5	10.2	38.2	18.2	100
2002-03	30.3	9.6	39.4	15.8	100
2003-2004	33.9	9.0	39.4	17.6	100
2004-05	37.4	9.9	37.3	19.3	100
2005-06	35.0	8.0	37.9	19.2	100
2006-07	37.4	7.8	38.0	16.9	100

2007-08	39.3	8.2	37.5	15.0	100
2008-09	41.8	10.0	30.8	17.1	100
2009-10	41.0	10.0	33.6	15.3	100
2010-11	27.2	11.0	38.9	17.3	100
2011-12	38.1	10.0	30.9	16.3	100
2012-13	39.0	10.6	27.6	22.7	100

Source: District Statistical Hand Book, Govt. of West Bengal, various issues.

It is observed from the Table 16 that the contribution of Govt canal, tube well and other sources of irrigation had been increased between the periods 2001-02 to 2012-13, while percentage of tube well irrigation is declining steadily. This is due to the depletion of ground water level in various parts of West Bengal. But the alternative forms of irrigation is showing increasing trend.

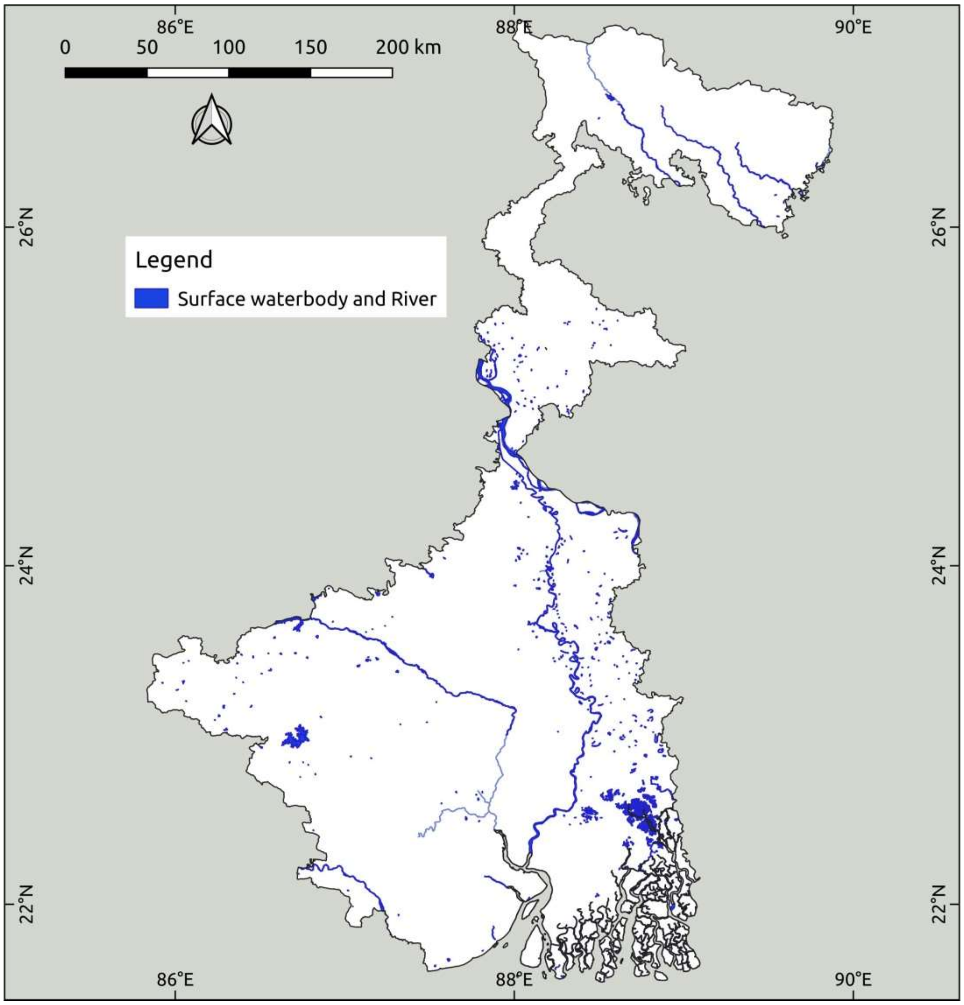

Figure 23: Surface water bodies in West Bengal

Source: Generated by the author

Water Demand in West Bengal:

Water demand for various sectors in West Bengal is represented in the Figure 24. It indicates that actual and projected demand of water for agricultural sector is increasing over the time. In 2000 demand for water in agricultural sector was nearly 50 percent of total water demand which increased to 59 percent in 2011. Projected demand for water in 2025 will be almost 66 percent.

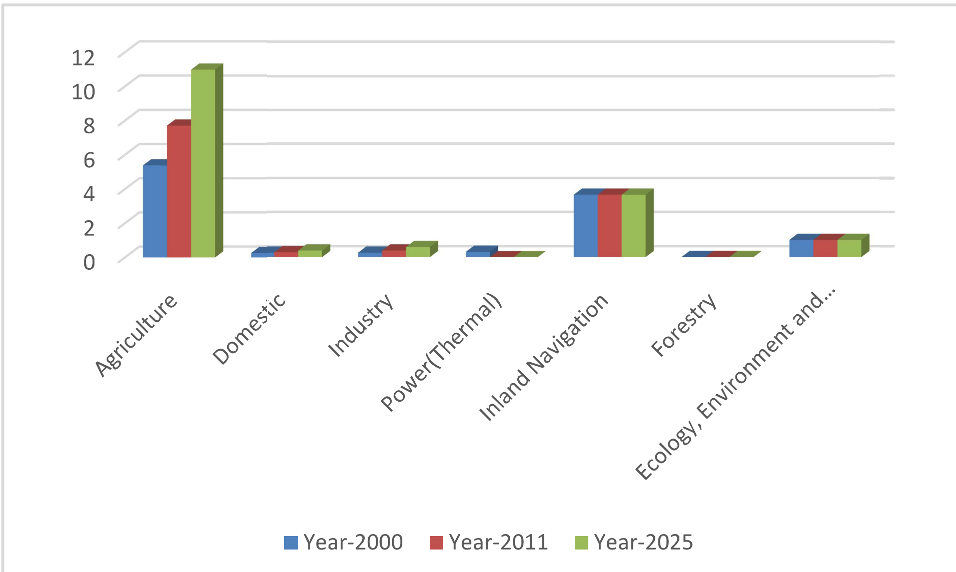

Figure 24: Water Requirement in West Bengal

Source: State Irrigation Department, Govt of West Bengal

Trends of tank irrigation in West Bengal:

Over the time use of tanks in irrigated agriculture in West Bengal is showing a downward tendency. Lack of maintenance, absence of water user association (WUA) and proper Govt. policies are the main constraints behind the declining trend of tank irrigation in different district of West Bengal. This is explained to the Table 17 and Figure 25.

Table 17: No of Tanks and Ponds in 4th and 5th MI Census in West Bengal

Name of District	No .of Tanks/ Ponds in third MI Census(2000-01)	No. of Tanks/ Ponds in fourth MI Census(2006-07)	No. of Tanks/ Ponds in fifth MI Census(2013-14)
Bankura	1131	1944	6176
Birbhum	7611	9528	8189
Burdwan	3448	1342	610
Cooch Behar	141	46	46
Dakshin Dinajpur	4101	767	152
Darjeeling	3	11	3
Howrah	1768	799	314
Hooghly	4043	1468	499
Jalpaiguri	46	56	82
Malda	3569	1646	458
Midnapore	25045	2100	1282
Murshidabad	709	873	494
Nadia	14	3	5
North 24 Parganas	672	349	179
Purulia	104	37	1343
South 24 Parganas	16613	9151	2272
Uttar Dinajpur	124	32	26
Total	69142	30152	22184

Source: Third (2000-01), Fourth (2006-07), Fifth (2013-14) Minor Irrigation Census Report Govt. of India.

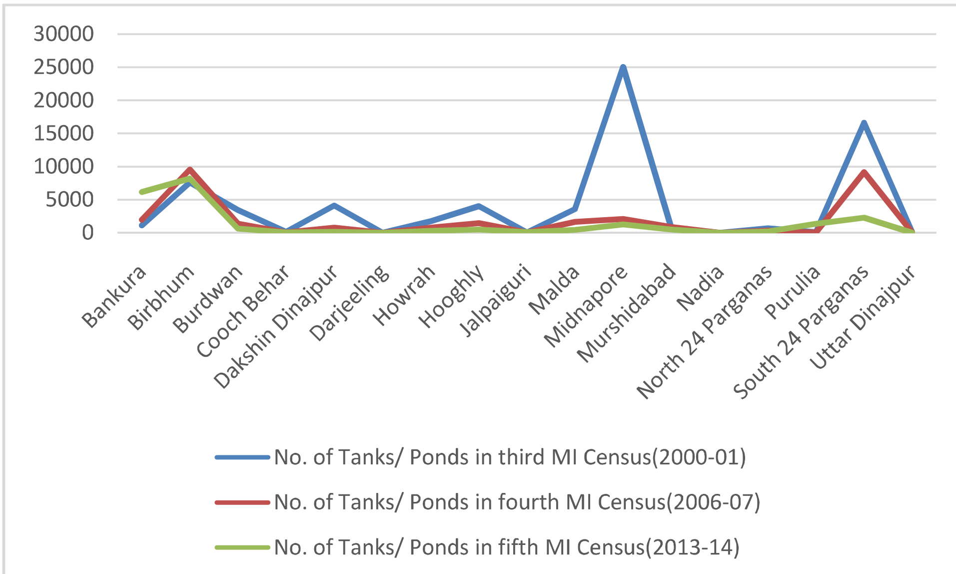

Figure 25: Changes of Tank in West Bengal

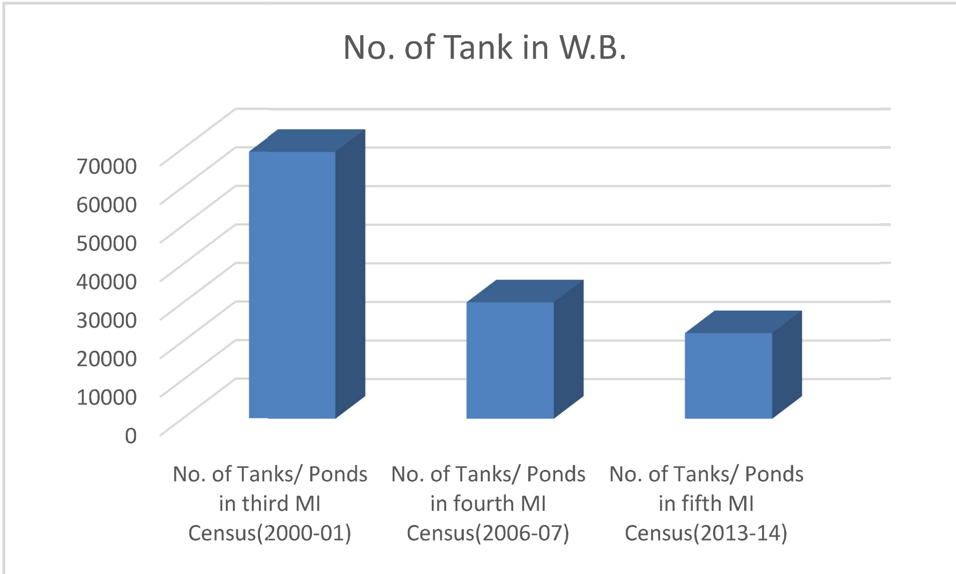

Figure 26: No of Tank in West Bengal

1.12 Classification and Suitability of Irrigation Water:

The concentration of salts in any medium is described by the term "salinity". These salts are calcium, magnesium, sodium, potassium, chloride, bicarbonate, carbonate, sulphate and others. Electrical conductivity is generally used to represent the soil salinity; the common unit of salinity is DeciSiemens per meter (dS/m). It is proportional to the concentration of the dissolved salts in water. (Fipps, 2003)

Salinity problems are prevalent in this region. The adjacency to the sea is one of the major causes of salinity of the water. It can have a considerable impact on crop yield. All irrigation water contains dissolved salts, however, the amount of the dissolved salts vary depending on the source of the irrigation water.

Soils irrigated with water will contain a similar mix but usually at a higher concentration than in the applied water. The irrigation water quality, management and drainage condition influence the amount of salt accumulation in the soils. The concentration of salts in the soil must be at a below the tolerance level of a crop to prevent production loss (Hanson et al, 1999).

Beside the salinity of water and soil, under certain soil texture conditions, a sodium imbalance can further reduce crop production.

The high sodium concentration relative to the calcium and magnesium concentration in irrigation water may reduce infiltration capacity of the soil. The condition is termed as sodacity. The Sodium Adsorption Ratio (SAR) is one of the most popular methods to assess the sodacity in soil and water (USSL, 1954). It is more reliable method to assess the sodium percentage. The empirical formula is given as follows:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{1}{2}(Ca^{2+} + Mg^{2+})}}$$

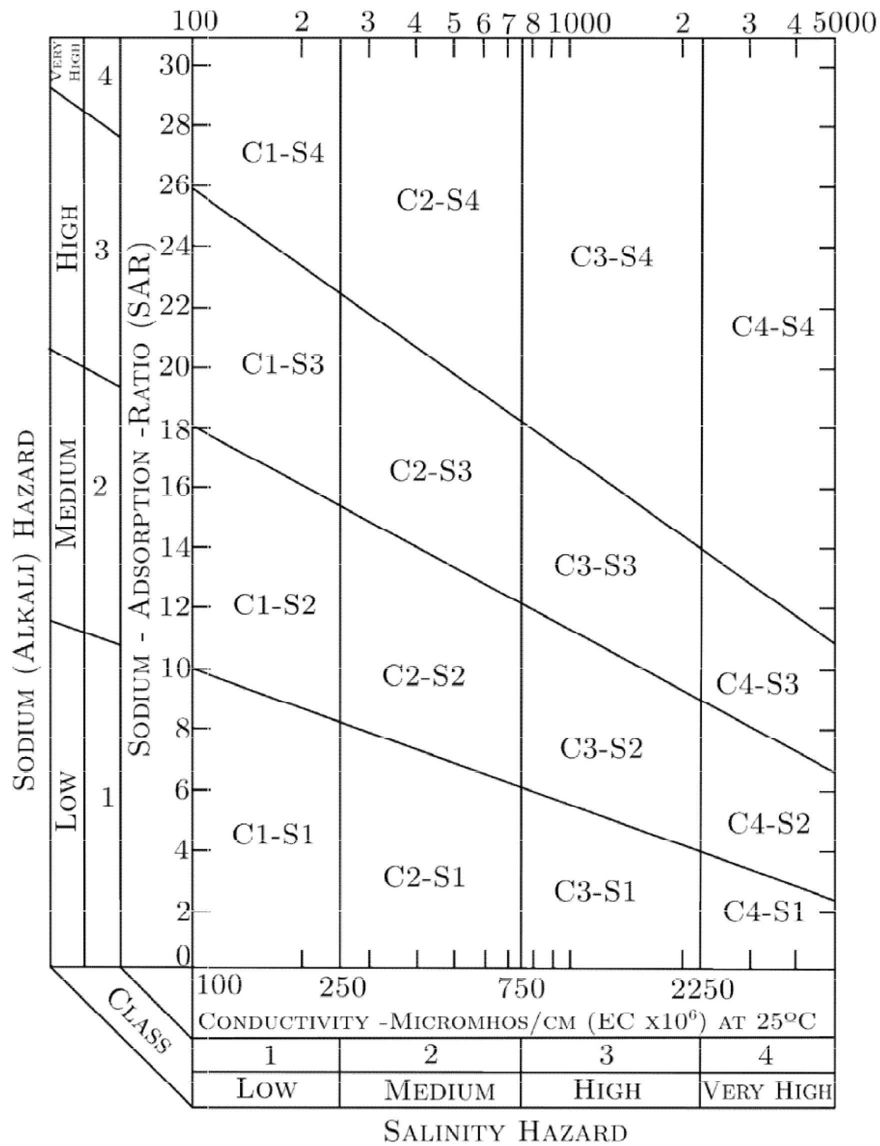

Figure 27: USSL diagram for classification of irrigation water

The quality of irrigation water can be determined in several way including the degree of acidity or alkalinity (pH),electrical conductivity (EC), residual sodium carbon-ate (RSC), and sodium adsorption ratio (SAR). The united Sate Salinity Laboratory (USSL) has devised an irrigation water classification scheme based in the EC and SAR values (USSL, 1954). Figure 27 is the outcome of the scheme. The details of each classes is given in table 18.

Table 18: Classification of Irrigation water based on salinity and sodium hazards (USSL)

Salinity Hazard	**Class**	**Remarks**
Low	C1	Safe water and can be used for most crops. In case of low permeability soil some leaching may be essential.
Medium	C2	Irrigation can be applied for low sensitive crops. In case of low permeability soil some leaching are essential.
High	C3	Moderate and good salt tolerant crops can be grown on soil with moderate to good permeability. Leaching is essential to prevent salt accumulation.
Very High	C4	Not suitable for irrigation under normal condition. Only salt tolerant crops on soil with good permeability should be grown. Special leaching is required to remove the excess salt.
Low	S1	Suitable for irrigation on almost all soils with little chance of developing harmful levels of sodium.
Medium	S2	Under low-leaching conditions, an alkalinity problem may

		arise in fine-textured soils. Coarse-textured soils with good permeability are suitable.
High	S3	It may create an alkalinity problem. Special soil management like good drainage, heavy leaching and use of gypsum are required for this water.
Very High	S4	Not suitable for irrigation purposes.