CHAPTER - 3

METHODOLOGY

A methodical and cautious analysis of information is of primary importance in any research. In order to obtained consistent results, it is essential to progress systematic methods of data collection and employ suitable and reliable techniques for the analysis of information. The methodology adopted in the current study on "**Socio-economic and Environmental Aspects of Urban Water Consumption in Selected Households**", is described under the following heads.

3.1. Selection of the Problem

3.2. Selection of the Sample

3.2.1(a) Selection of the study area

(b) Profile of Coimbatore district

3.2.2(a) Research design

(b) Selection of the sample respondents

3.3. Sources and Collection of Data

3.4. Quantitative Tools

3.5. Definitions of the Terms used in the Study

3.6. Limitations of the Study

3.1. Selection of the Problem

The world runs on water. Clean, reliable water supplies are vital for industry, agriculture, and energy production. Every community and ecosystem on Earth depends on water for sanitation, hygiene, and daily survival. Yet the world's water systems face formidable threats. More than a billion people currently live in water-scarce regions, and as many as 3.5 billion could experience water scarcity by 2025. Increasing pollution degrades freshwater and coastal aquatic ecosystems. And climate change is poised to shift precipitation patterns and speed glacial melt, altering water supplies and intensifying floods and drought. Humanity's thirst for freshwater has more than doubled since the 1960s, keeping pace with growing populations and economies. One-quarter of the world now faces extremely high water stress, where more than 80 per cent of the available supply is withdrawn every year.

While agriculture and industry withdraw the overwhelming majority of the world's freshwater (70 per cent and 19 per cent, respectively), demand from households is also rising precipitously. World Resources Institute's (2020), Aqueduct platform shows that domestic water demand grew 600 per cent from 1960-2014, at a significantly faster rate than any other sector. Since the 1960s, agriculture has remained by far the largest global user of freshwater, though its rate of growth has been slower than other sectors. Demand for water used to grow crops and livestock grew by more than 100 per cent in the last century, while industrial water demand more than tripled, thanks to rising demand for electricity, fuel and water-intensive goods like textiles.

During this same period, the world's population grew by more than 4 billion, contributing to the six-fold growth in municipal water use. More people, more homes and growing cities require more water than ever before. We must secure water for the 2.1 billion people who lack accessible, safe drinking water, while using this resource more efficiently to prevent crises and reduce water stress. (Otto and Schleifer, 2020).

Urbanization is a global trend in which urban centers have become hotspots for economic and demographic growth. However, rapid urbanization and population growth threaten the sustainability of natural resources, especially water, due to increasing demands on resources and the subsequent generation of wastewater that is often poorly managed particularly in the developing world. India is the second most populated country in the world with over 1.3 billion people, 377 million people (32.2 per cent) of which reside in urban areas. As India's surface water resources are limited and vulnerable to contamination and depletion, there is a high and increasing dependency on groundwater resources. Groundwater is one of the primary sources of urban drinking water in India and particularly of urban areas, as in many parts of the world, but its sustainability depends on effective conservation, protection, and science-based management. Issues like pollution, congestion, water scarcity, slums, traffic, overcrowding, public transport and waste is making many of the India's mega cities increasingly un-believable. With an increase in urban population, will come rising demand for basic services such as clean water, public transport, sewage treatment and housing. Climate change is likely to compound these trends through higher frequency and magnitude of extreme weather events as well as by changing the quantum and pattern of precipitation. What is stress is further the compounded in countries like India with disproportionately low freshwater resources related to population (i.e 4 per cent of global freshwater resources against 18 per cent of global population) and per capita storage of only 210 cubic meters even when the most of its annual precipitation (around 4,000 million cubic meters falls in just three months (MoHUA 2019).

3.2. Selection of the Sample

3.2.1. Selection of the Study Area

Urbanization in India is mainly due to liberalization of its economy after the 1990s, which gave rise to the development of the private sector. Presently, although urbanization is taking place at a fast rate in India, only one-third of its population lives in urban areas. According to the 2011 census, there are 53 cities in India with a population of a million or more; by 2031, that number will rise to 87. Some of these metropolitan areas will become major economic powerhouses that have higher GDP than the current GDP of countries such as Israel, Portugal and the UAE. Cities provide major opportunities for sustainable development, given that they have large numbers of people in a small area, and offer significant economies of scale which provide jobs, housing and services. There is a need to fully realize the potential of Indian cities for ecological, economic and social sustainability. But this urbanization can only be harnessed and sustained by inclusive planning that provides affordable transportation, continuous water supply, modern sewage treatment and a good solid waste management system. The government of India has been channelling funds (which has long been overdue) to renew its urban spaces through various schemes, and has been tweaking its approaches to urbanization by cataloging projects that were successful and those that failed. It is also beginning to see the value of Private–Public Partnerships.

Many large cities like Hyderabad, Chennai, Coimbatore, Vijayawada, Amravati, Solapur, Shimla, Kochi are moving towards acute water crisis. Climate change, early summer, deficit rain-fall, depleting water level, rising population and lack of water management policy is making it difficult for the urban local bodies to meet the increasing demand of water. According to a World Bank report, at least 21 Indian cities are moving towards zero ground water level by 2020, which has already set the alarm bell ringing for policy makers and urban planners.

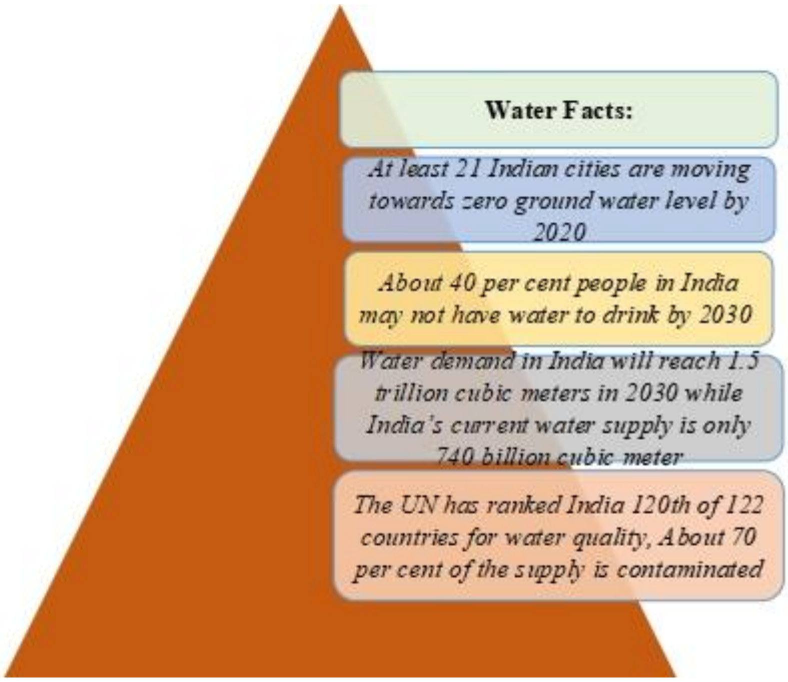


Figure 3: Global Prediction of Water Resources

Tamil Nadu constitutes 4 per cent of India's land area and is inhabited by six per cent of India's population, but has only 2.5 per cent of India's water resources. More than 95 per cent of the surface water and 80 per cent of the ground water have already been put into use. Major uses of water include human/animal consumption, irrigation and industrial use. The demand for water in Tamil Nadu is increasing at a fast rate both due to increasing population and also due to larger per capita needs triggered by economic growth. The per capita availability of water resources however, is just 900 cubic meters when compared to the national average of 2,200 cubic meters. Agriculture is the largest consumer of water in the State using 75 per cent of the State's water resources. The State is heavily dependent on monsoon rains. The annual average rainfall is around 930 mm (47 per cent during the north east monsoon, 35 per cent during the south west monsoon, 14 per cent in the summer and 4 per cent in the winter).

Surface Water Resources of Tamil Nadu

The total surface water potential of the state is 36 km or 24864 Million Cubic Meter. There are 17 major river basins in the State with 61 reservoirs and about 41,948 tanks. Of the annual water potential of 46540 Million Cubic Metres (MCM), surface flows account for about half. Most of the surface water has already been tapped, primarily for irrigation which is the largest user. 24 lakh hectares are irrigated by surface water through major, medium and minor schemes. The utilisation of surface water for irrigation is about 90 per cent.

Ground Water Resources of Tamil Nadu

The utilizable groundwater recharge is 22,423 MCM. The current level of utilisation expressed as net ground water draft of 13.558 MCM is about 60 per cent of the available recharge, while 8875 MCM (40 per cent) is the balance available for use. Over the last five years, the per centage of safe blocks has declined from 35.6 per cent to 25.2 per cent while the semi-critical blocks have gone up by a similar per centage. Over-exploitation has already occurred in more than a third of the blocks (35.8 per cent) while eight blocks (2 per cent) have turned saline. The water level data reveals that the depth of the wells ranges from an average of 0.93 metres in Pudukkottai district to 43.43 metres in Erode. There has been a general decline in groundwater level in 2003 due to the complete desaturation of shallow aquifers. There has been a considerable failure of irrigation wells in Coimbatore District (Tamil Nadu State of Environment and Related Issues 2020).

Due to the widespread Northeast monsoon failure, Tamil Nadu will be facing tough times during the summer in 2019. The State government has declared 24 districts as drought-affected. Moreover, 38 blocks in seven districts have also been declared drought-affected. Out of the 12,524 village panchayats located in 385 blocks, 143 panchayats unions, 2,883 village panchayats and 14,333 habitations would be affected during March while the number would go up in April and May. In April, 222 panchayats unions, 4337 village panchayats and 20,212 habitations would be affected. Similarly, during May, 252 panchayats unions, 5,426 village panchayats and 25,993 habitations would be affected.

The districts which have been declared drought-affected (Hydrological Drought) are: Chennai (serviced by CMWSSB), Dharmapuri, Krishnagiri, Karur, Salem, Vellore, Tiruchirapalli, Perambalur, Tiruvallur, Namakkal, Virudhunagar, Kancheepuram, Madurai, Dindigul, Erode, Pudukottai, Sivagangai, Thanjavur, Viluppuram, Tiruvannamalai, Ariyalur, Nagapattinam, Cuddalore and Ramanathapuram. The government also declared the 38 blocks of Tirunelveli (6), Tiruppur (9), Kanyakumari (6), Thoothukudi (6), Theni (5) Coimbatore (5) and The Nilgiris (1) districts as affected by Hydrological Drought (Indian Express 2019).

Out of 385 blocks in Tamil Nadu,180 blocks have almost exploited the potential and out of the 1.8 million wells in state about 12 per cent are dried up or abandoned due to ground water over-exploitation (Government of TamilNadu, 2003). Out of the 31 districts in the state, 9 districts are (Coimbatore, Dharmapuri, Madurai, Ramanathapuram, Salem, Trichy, Tirupur, Tirunelveli and Kanyakumari) identified as ground water over exploited. Among the 9 districts, ground water exploitation is more pronounced in Coimbatore district.

Administrative units in Tamil Nadu, there are 32 districts, 215 sub-districts,1097 towns and 15979 villages as per Census-2011.The corresponding figures for Census 2001 were 30 districts,201 sub-districts,832 Towns and 16,317 Villages. There is an increase of 2 districts, 14 sub-districts, and 265 Towns (All Census Towns). In respect of villages the number has come down from 16317 to 15979. Tamil Nadu returned a total population of 7,21,38,958 (Provisional) in 2011 Census. Of this, the rural population stands at 37.19 million and the urban population 34.95 million the growth rate of population for Tamil Nadu in the last decade was 15.60 per cent. The growth rate of population in rural and urban areas was 6.49 per cent and 27.16 per cent respectively. In percentage terms, the rural population formed 51.55 per cent of the total population with the urban population constituting 48.45 per cent increase of 4.41 per cent, (Census Report 2011).

Table 14: Details of Top Most Large Cities in Tamil Nadu

Large cities of Tamil Nadu	**Population in million (2011)**
Chennai (Municipal Corporation)	4,681,087
Coimbatore (Municipal Corporation)	1,061,447
Madurai (Municipal Corporation)	1,016,885

Source: ENVIS Centre, Ministry of Environment & Forest, Govt. of India

In accordance with Census report, 2011 Govt. of India, Chennai got the first rank in the cities followed by largest Coimbatore got second rank and Madurai is in third rank these are the largest cities in Tamil Nadu. Hence Coimbatore district has most urbanized in last decades so Coimbatore Corporation was chosen for the study.

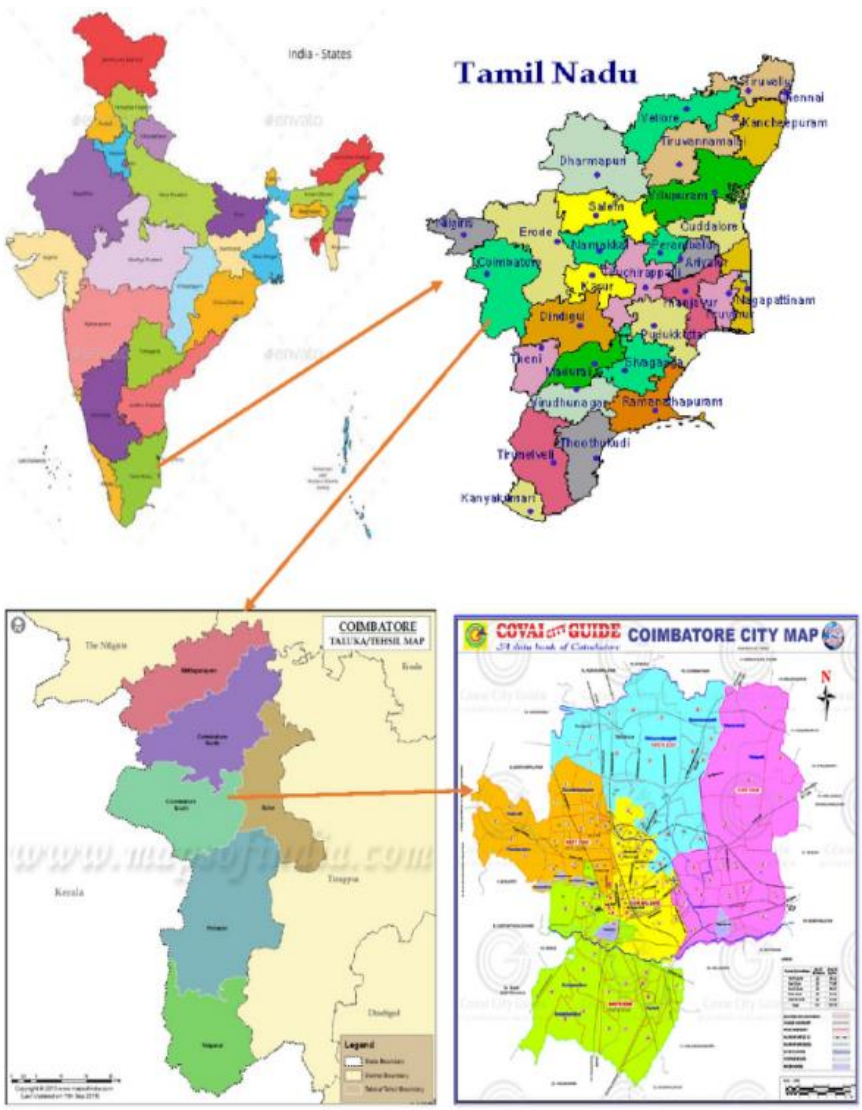


Figure 4: Selection of the Study Area

3.2.1(b) Profile of Coimbatore District

Originally Coimbatore district formed part of the Kongu country, the history of which dates back to the Sangam age. It is found that in early days the area was inhabited by tribes, the most predominant among them being the Kosars who are reported to have had their headquarters at Kosampathur which probably later became the present Coimbatore. Till 1947 when India attained Independence, the region remained under British control who initiated systematic revenue administration in the area. Coimbatore serves as an entry and exit point to neighboring Kerala and the ever popular hill station of Udhagamandalam (Ooty). In 1979 Coimbatore district was bifurcated in to Coimbatore and Erode districts. Again in 2008, four taluks from Coimbatore District namely Tiruppur, Udumalpet, Palladam and Avinashi (Part) were carved out to form part of the newly formed Tiruppur district.

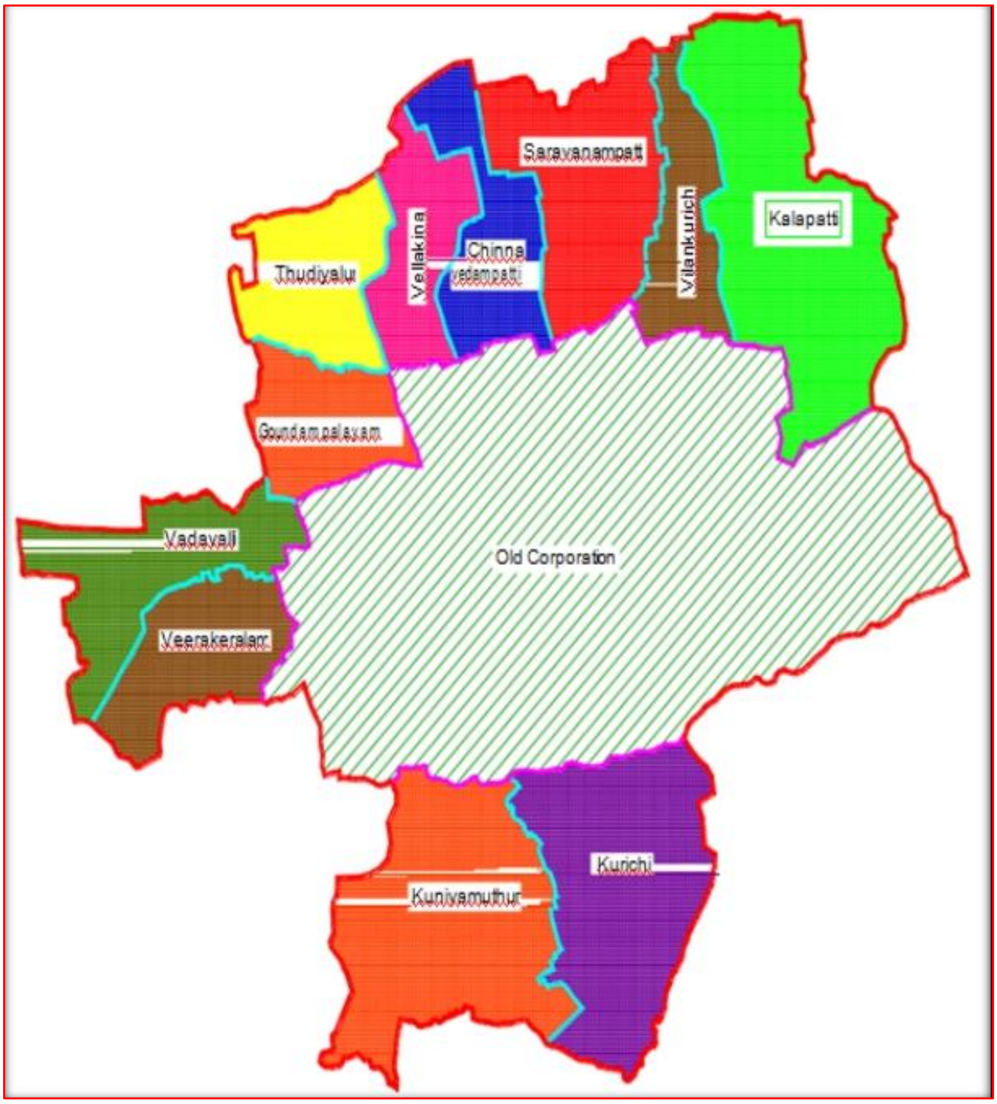
The geographical location details of Coimbatore Corporation as per Survey of India topographical map are Latitude: 10^{o} 58’00” N & Longitude: 76^{o} 58’ 00”E. Coimbatore City is located in an average altitude of 442 m above mean sea level. The City is skirted by River Noyyal, rising from Vellingiri hills on the West Limestone is found in abundance in the hills near Madukarai, which is being used in the manufacture of cement. The chief varieties of soil available in the city are red sand and gravel with a moderate area of black loam. The city is located on the banks of the Noyyal River surrounded by the Western Ghats and is administered by the Coimbatore City Municipal Corporation. In 2012, the Corporation won the Best Corporation Award in Tamil Nadu. Coimbatore City Corporation has been adjudged the best among 100 corporations selected from across the country by Skoch, a Gurgaon-based independent group dealing with social economic issues.

Coimbatore City is now emerging as a major industrial, textile and Information Technology hub of Tamil Nadu. Major National and International Computer companies are planning to start their software parks at Coimbatore in the near future. Thereby job opportunities and population are expected to increase manifold. In 1866, Coimbatore was constituted as a Municipal town with an area of 10.88Sq.Km. Coimbatore Corporation was upgraded from special grade Municipality to Corporation in the year of 1981 spreading over an area of 105.60 Sq.Km.

According to 2011 census, Coimbatore has population of 3,458,045 of which male and female were 1,729,297 and 1,728,748 respectively. Average literacy rate of Coimbatore in 2011 was 83.98 compared to 78.50 of 2001. At gender wise, male and female literacy were 89.06 and 78.92 respectively. Out of the total Coimbatore population for 2011 census, 75.73 per cent lives in urban regions of district. In total 2,618,940 people lives in urban areas of which males are 1,310,265 and females are 1,308,675. Average literacy rate in urban areas of Coimbatore district as per census 2011 is 87.82 per cent of which males and females are 92.09 per cent and 83.56 per cent literates respectively. As per 2011 census, 24.27 per cent population of Coimbatore districts lives in rural areas of villages. The total Coimbatore district population living in rural areas is 839,105 of which males and females are 419,032 and 420,073 respectively. Literacy rate in rural areas of Coimbatore district is 72.16 per cent as per census data 2011.

As Coimbatore is urbanizing rapidly, the construction industry plays a crucial role in the urbanization of the city. Out of the total Coimbatore population for 2011 census, nearly 75.73 per cent lives in urban regions of district. Over the last two decades, the construction industry has grown tremendously hence become one of the main engines of growth and development. It has provided infrastructure that other sectors of the economy rely on to produce goods and services as well as housing which is a basic human need. Coimbatore has been ranked eighth among the first batch of 20 smart cities in the implementing and completing projects under the Smart city Mission in the last three years. The construction sector had an important role in the process of developing Coimbatore into a smart city.

Now the Corporation area has been extended as per the Tamilnadu Government order with the inclusion of local bodies adjacent to Coimbatore. The extended Corporation area is effective from 2011. Now the total extent of Coimbatore Corporation is 257.04 Sq.km. The population of the Corporation as per 2011 Census is 16, 17,711. As Coimbatore is exposed to the Palghat gap of Western Ghats it enjoys a salubrious climate, this has attracted a large number of textile mills to this region. For the same reason the city is called 'poor man's Ooty. The average maximum and minimum temperature are 35.8ºC and 22.4ºC respectively. The average rainfall in the city varies from 600mm and 700mm. The South West monsoon fetches rains during the period June to August and North East monsoon during October to December.



Source: Coimbatore Corporation (2018).

Figure 5: Coimbatore Corporation Map

Coimbatore Corporation consists of 100 wards and is headed by a Mayor who presides over a Deputy Mayor and 99 other councilors who represent the wards. The Mayor is elected directly through a first past the post voting system and the deputy mayor is elected by the councilors from among their numbers. For administrative purpose the Coimbatore Corporation is divided into five zones namely North, South, East, West, Central headed by a chairman (CCMC District Profile 2019).

Table 15: Details of Educational and Other Infrastructural Facilities of Latest Available Year

S.No	Particulars	Numbers /Values
1	**Educational facilities**	
a)	Pre-primary	413
b)	Primary	1365
c)	Middle	480
d)	High	162
e)	Higher-Secondary	172
2	**Professional colleges**	
a)	Medical	5
b)	Engineering	39
c)	Agriculture	1
d)	Veterinary / Fisheries	0
e)	Universities	6
f)	Law college	1
3	**Number of Arts and Science Colleges**	**49**
4	**Institutional Credit Facility**	
a)	Name of the Lead Bank	Canara bank
b)	Number of branches of lead bank in the district	32
c)	Other Commercial Banks	454
d)	Primary Land Development Bank	13
e)	District Central Co-operative Banks	1
f)	Urban Banks	6
g)	Primary Agricultural Co-operative Credit Society	265
h)	Housing Co-operative Societies	107
i)	Employees Co-operative Societies	126
j)	Weavers Co-operative Society	79
k)	Industrial Co-operative Society	21
l)	Khadi and Village Industries Societies	27
m)	Industrial Co-operative Societies	21
n)	Primary Co-operative Stores	58
o)	Co-operative Sugar mills	1
q)	Other Marketing Society (please specify)	0
5	**Agricultural Marketing and Processing**	
a)	Number of Regulated Markets	18
b)	Number of Co-operative Marketing Society	9
c)	Number of Permanent Markets / Central Markets	18
d)	Number of weekly markets / shandies	32
e)	Number of drying yards	85
f)	Number of storage godowns	77
g)	Number of cold storage units for agricultural Produce	8
h)	Number of agro based / agri-based processing Industries	-
i)	Small scale	-
ii)	Medium scale	-
iii)	Large scale	-

Source : G returns - State Statistical Dept, Coimbatore

Rainfall in Coimbatore District

The normal rainfall of the district is around 650 to 700 milli meter. The highest percentage of rainfall of 44 per cent of the total rainfall is received during north-east monsoon, while the south west monsoon contributes 37 per cent and the summer season rains account for about 17 per cent. Though the south west monsoon helps in the filling of several dams in the Western Ghats that benefit the district, the south west monsoon contributes only about one third of the total rainfall of the district. The rainfall during the south west monsoon in the plains would be much lower. The rainfall during winter season is negligible. Rainy months of the district can be grouped into three seasons. Summer rain from March to May where the South-West monsoon rain from June to middle of September, North-East monsoon rain from October to December. The following table shows the Rainfall (in mm) during different seasons in 2019-20.

Table 16: Details of Weather Data 2019-2020 in Coimbatore District

Month	Rainfall		Temperature ^{0} C		Humidity	
	Actual	Normal	Maximum	Minimum	Actual	Normal
Summer						
March, 19	27.00	10.2	36.05	22	41.23	61
April, 19	36.80	17	37.04	25.08	47.76	55
May, 19	35.50	52.7	36.35	25.01	57.75	50
South West Monsoon						
June, 19	0	17	31.05	22.55	59.09	54
July, 19	9.30	42	31.76	23.07	61.32	55
August, 19	47.80	68.5	31.83	23.18	64.62	56
September, 19	233.1	30.1	31.22	22.92	61.00	55
North East Monsoon						
October, 19	121.2	68	31.25	11.85	60.97	62
November, 19	168.8	146	30.84	22.85	54.04	63
December, 19	120.8	118	29.76	20.316	40.48	72
Winter						
January, 20	0	41.4	30.46	19.62	39.3	73
February, 20	0	14	32.68	20.46	41.00	77
Total/Average	**810.9**	**625.1**	**32.44**	**23.63**	**628.56**	**733**

Source: TamilNadu Agricultural University, (2019-2020)

In summer months of April and May the minimum temperature is in the summer months of April and May the minimum temperature is 23.40^{0}C and the maximum temperature is 34.85^{0}C resulting a mean average temperature in summer as 29.12^{0}C. Similarly, during winter periods of October to March the minimum temperature is 19.85^{0}C and the maximum temperature is 30.83^{0}C resulting a mean average temperature in winter as 25.34^{0}C. During rainy periods of June to September the minimum temperature is 22.45^{0}C and the maximum temperature is 31.52^{0}C resulting a mean average temperature in rainy season as 26.99^{0}C. All together Coimbatore enjoys a pleasant weather throughout the year. The district has a very pleasant climate. In the district, maximum temperature is recorded in the month of April and minimum temperature is recorded in the month of December. The following table shows the temperature (in celsius) and humidity at Coimbatore station in 2019-20.

Rain fall

The rainy months for this district are as follows:

1. Summer rain during March, April and May
2. South-west Monsoon rain from June to September
3. North-east monsoon rain during October, November and December and
4. Winter rain during January and February.

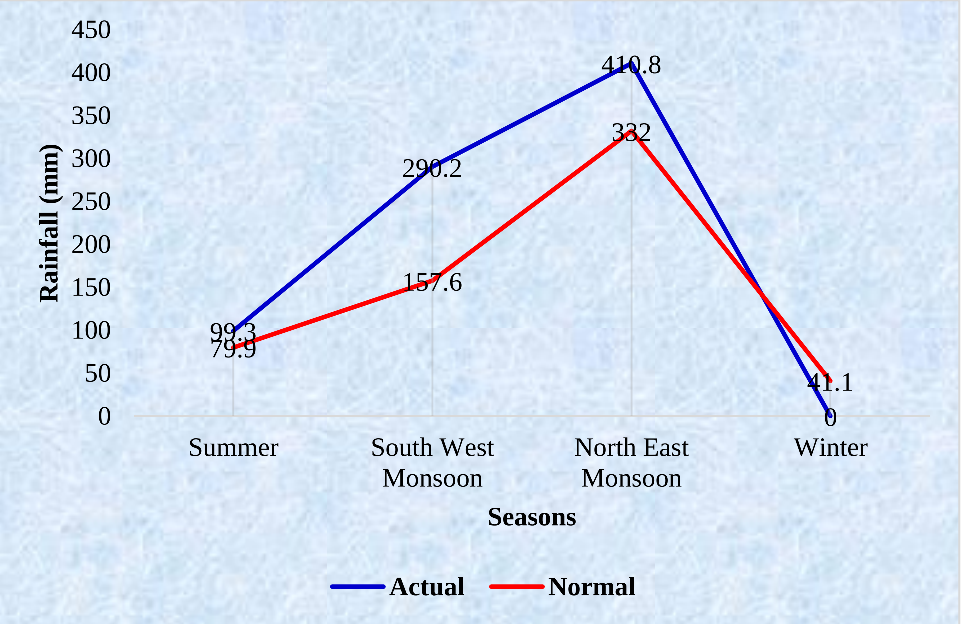


Figure 6: Season Wise Rainfall Data in Coimbatore District, (2019-20)

The district receives rain heavily during north – east monsoon and south- west as shown in Figure 6. The north- east monsoon chiefly contributes to the rainfall in the district and summer rains are negligible.

Water supply in Coimbatore Corporation

The demand for water in urban areas of Coimbatore district determined by many factors. The supply of water in the urban area is determined by the availability of water in the main sources of water like dams, Lakes and Tube wells in the locality and other factors like distribution leakage. Wards were considered for analyzing the objective set for the study. Data regarding demand, Consumption and Supply of water were collected and analyzed. Demand for water, Actual consumption and their LPCD are collected from the primary survey and the water supply details is collected from the officials from the concerned water authority offices. The demand consumption gap and demand supply gap in the selected wards of te corporation are discussed below.

Water Supply in Coimbatore Corporation - Historical overview

Before 1931, Coimbatore had no permanent water source and the water supply was dependent on the Northeast monsoon rain only. When the urbanization started in the thirties, a new water supplying scheme had just been completed. It resulted in bringing 11. 3 MLD (million liters of water per day) as a diversion of surface water from the Siruvani River. The water scheme with water coming from the Siruvani dam with catchment in Kerala leading to Coimbatore with suburbs and surrounding villages, was the beginning of the interstate collaboration between Tamil Nadu and Kerala In 1931, the per capita supply per day was then 126 liters. However, the very rapid population growth due to sudden increased industrialization reduced the per capita supply to 36 liters per day in 1971.

It was understandable by the year 1971 that action was needed to something about the decreasing per capita water supply. Consequently, during 1974 a second phase of the Siruvani scheme was initiated it included 33 km of new pipelines from the source to Coimbatore. Meanwhile, the population in several areas governed by Panchayats used only ground water to cover all demands, including drinking. The water supplying system was a basic system with open wells as sources. The ground water was pumped up to overhead tanks and distributed through a number of public taps and house connections. In the year 1981, when the extension areas were included into the Corporation, Siruvani water was also made available through a pipeline system. The existing ground water house connections have been removed. In 1996 considering the ground water situation, the heavy withdrawal of ground water during the last three to four decades has resulted in a gradual lowering of the ground water table. Another reason for the lowering of the ground water table is believed to be a change in climate.

The urban population of India has grown dramatically in the last decades as a consequence of the overall population growth in India and migration from rural areas. The population of Coimbatore, situated in the state of Tamil Nadu, has reached over a million compared to around 450000 inhabitants in 1961, predominantly caused by the economic expansion due to population and industrial growth in combination with a semi-arid climate, scarcity of water is a fact and the water supply is in brief mainly dependent on what the monsoon brings. The seasonal variations are marked. The city has as a solution an interstate-collaboration with the Kerala state and is supplied with surface water from the Siruvani river and in the near future an additional supply is implemented including water from the Bhavani river, the Pillur scheme. Within the city, excess extraction of ground water as well as pollution has made the ground water importable in many areas due to high saline content. Shortage of water creates a problematic situation with competing demands from the domestic, industrial and agriculture sectors, water scarcity actually limits the industrialization of the city. The allocation policy of the authorities regarding Siruvani water is 90 per cent distributed to the domestic sector and 10 per cent to the industrial sector. The central parts are favored compared to suburbs, which have only half their supply, and poor urban households are generally more affected by lack of water than high income groups. The urbanization has further lead to the authorities not being able to fulfil demands for new housing, drainage and sanitation facilities to all households due to other priorities and lack of resources.

Water Supply System in Coimbatore Corporation: Current Scenario

The population has grown from 0.47 lakhs in 1911 to 9.30 lakhs in the year 2001 with an average annual growth rate of 2.7 per cent and an average decadal growth rate of 27.34 per cent. The population of the Local Planning Authority is 16.40 lakhs covering an area of 105.60 Sq.km. The availability of power, clubbed with raw material availability for textile processing, from 1935, has led to the establishment of many industries resulted in a nearly 52 per cent increase in population during 1941-1951. The city has registered the decadal growth rate of 49.20 per cent during the period 1971- 1981. This is attributed to the up gradation of Municipality to the status of Corporation, whereby additional areas were included in its jurisdiction. The geographical location details of Coimbatore Corporation as per Survey of India topographical map are Latitude: 10^{o} 58’00” N & Longitude: 76o 58’ 00”E. The present water supply to Coimbatore Corporation is 137 mld for a population of 1.10 million at the pro rata supply of 125 lpcd, from two water supply schemes, namely, Siruvani and Pillur.

Siruvani Water Supply System

At present, 75 Mld of treated drinking water from the existing Siruvani Water Supply Scheme is being supplied to the Coimbatore Corporation with head works (Siruvani Reservoir) at Attapady Valley in Palakkad District of Kerala State, at a distance of 40 km from Coimbatore. The raw water is conveyed through a tunnel to the treatment plant at Siruvani Adivaram. After full scale treatment, clear water is conveyed by gravity through 1000 mm PSC pipes to the Master Service Reservoir at Bharathi Park from where it is fed to the Service Reservoirs in Western Zone of the town and distributed through the network of distribution system. The scheme is in operation since 1982.

Pillur Water Supply System

Another scheme with the Pillur Reservoir situated at the foothills of Nilgiris in Western Ghats as source was implemented in the year 1995 for Coimbatore Corporation, 22 Towns and 523 Rural Habitations. The total installed capacity is 125 Mld and Coimbatore Corporation gets 62 Mld from this scheme. Raw water is drawn through intake well cum pump house located in Pillur Reservoir and conveyed through 1500 mm dia. MS pipes and tunnel of length 3.850 km at Periakombai hills to the treatment plant at Velliangadu. The treated water is pumped from WTP through the clear water tunnel of 0.9 Km long at Kattan hills. The water is gravitated from the tunnel to the Master Service Reservoir at Ramakrishnapuram from where it is fed to the Service Reservoirs in Eastern Zone of the town and distributed through the network of distribution system. The requirements of other beneficiaries are tapped at suitable locations.

Status of Water Supply Infrastructure

The City Engineer and his team of Engineers and Staff are responsible for ensuring protected drinking water supply in the city. The city requires 165 Million litres of water daily at present. On an average, the per capita supply is maintained at about 125 lpcd (litres per capita per day) by supplying 137 Mld. Protected water supply for Coimbatore town is provided through two major water supply schemes.

Table 17: Details of Present Water Supply in Coimbatore Corporation

Water Supply Scheme	Water Supply (MLD)
Siruvani Water Supply Scheme	75
Pillur Water Supply Scheme I	62
Total present supply	**137**

Source: Coimbatore Corporation, Detailed Project Report, (2017)

The head works of both water supply schemes are operated and maintained by Tamil Nadu Water Supply and Drainage Board and they supply bulk water to two different Master Service Reservoirs maintained by Coimbatore Corporation. From these two separate Master Service Reservoirs, water supply is being distributed through 49 elevated service reservoirs and sumps about 640 km of existing distribution network. The water level of Siruvani dam touched the dead storage level during 2004 due to monsoon failure and the supply level was reduced to 25 Mld against normal supply of 75 Mld. As a temporary solution the needs of the Siruvani fed area is met with by interconnecting Pillur water supply and Siruvani water supply networks wherever possible.

Present Water Distribution Zones

Initially there were 25 service reservoirs (226.39 LL) in the city. After commissioning of Pillur Scheme-I, the city is served by 46 service reservoirs. Further 3 SRs located at Vysial Street under Siruvani Scheme and Rathinapuri and Maniakarampalayam under Pillur Scheme-I are not in use. The balance service reservoirs of 236.50 LL capacities get water from Pillur Source. The total area has been divided into 5 water supply zones and 43 sub-zones for effective operation and maintenance. Details of existing five water distribution zones are given in the following table.

Table 18: Details of Water Supply Zones

Zone No.	Zone	No.of SRs & Sump	Population	No.of. HSC	Source
I	HLR-Bharathi Park	11	164064	18429	Siruvani
II	LLR-Gandhi Park	10	254706	21387	Siruvani
III	MSR-Ramakrishnaouram	13	169592	22467	Pillur & Siruvani
IV	Singanallur	10	226756	26456	Pillur
V	Sungam	5	210157	17382	Pillur& Siruvani
	Total	**49**	**1025275**	**106121**	

Source: Coimbatore Corporation, Detailed Project Report, (2017)

Water is supplied to the city through the Master Service Reservoirs at Barathi Park & Ramakrishnapuram. These two master service reservoirs are supplying water to other service reservoirs. These two MSRs also supply water to their command area. The MSR at Ramakrishnapuram is fed by the gravity main from clear water tunnel at Katten hill under Pillur Scheme I. The MSR at Bharathi Park is fed by the gravity main of Siruvani Scheme.

Table 19: Existing Water Supply Scenario

Description	Details
City	Coimbatore
Status	Corporation
Area	105.6 Sq.Km
Topography	Elevation Varies from 390m to 440 m
Wards	100
Water Supply Zones	5
SRs & Sumps	49 Nos (41 SR's & 8 Sumps)
Distribution Pipes	1122 Km
HSCs	106121
Present Service Level	Intermittent Supply-125 Lpcd (As per ToR) (Once in 2/3 days for 2 to 3 Hours)
Proposed Service Level	135 Lpcd
Population	11,10,933 (As per 2011 Census population)

Source: Coimbatore Corporation, Detailed Project Report, (2017)

The total length of the existing distribution network in Coimbatore Corporation is around 1122 km. Pipe networks are not laid for some stretches of roads within Corporation boundary. So, there are many uncovered areas in the town and these areas are dependent on water supply through tankers. The total length of roads not covered by existing water distribution system is about 253 km. In each zone, it is noticed that the allotted quantity for that specific zone is distributed to a significantly higher number of water supply service connections than originally stipulated without requisite technical assessment, resulting in low pressure conditions in most of the areas. This results in residents not receiving sufficient quantity of water at minimum residual pressure even during normal season, when adequate supply is distributed to the town. This is primarily due to the indiscriminate extension of pipelines that have been originally designed to serve only a specified number of service connections and distribution zone. In order to eliminate this problem, the entire system has been redesigned with new distribution network covering the entire Corporation area.

Existing Tariff and Cost Recovery

The levy of water charges is under stepped tariff system from 01.04.2003. The corporation is collecting the following service connection charges. The existing water tariff is detailed in Table (20) New Water Supply connection charge is Rs.2000.

Table 20: Existing Tariff and Cost Recovery

S.No	Water Supply (Consumption per month)	Domestic Water Consumption (Per 1000 L)
1	Up to 15000 L	100
2	15001 to 20000 L	6
3	20001 to 150000 L	8
4	Above 150000	10
	Least Charges (per Month)	100
	Deposit Amount	5000

Source: Coimbatore Corporation, 2019.

Sources of Water

Currently there are 5 water supply schemes in Coimbatore Corporation. Namely Siruvani, Pillur, Pillur added, Aliyar Added and K.V. Scheme. The Table (21) explains the amount of water supplied by each reservoirs was given in table (21).

Table 21: Details of Water Supply Reservoirs in Coimbatore City (2019-2020)

Name of Reservoirs	Amount of Water in MLD Per Day
Siruvani	97.1 (36.49)
Pillur I	25 (9.39)
Pillur II	125 (46.97)
Aliyar	8 (3.01)
K V Scheme	11 (4.13)
Total	**266.1**

Source: Coimbatore Corporation, (2019)

Siruvani was the major source of water supply reservoir in Coimbatore Corporation. Which supplied 97.1 MLD of water for the city and the second largest amount of water supplied from pillur II which gives 125 MLD of water per day. And Aliyar was the least resources of water supply in Coimbatore city which shares 8 MLD of water for the city.

Table 22: Ward Wise Details of Water Distribution of Reservoirs

Reservoir Name	No. of Wards	Total Household (Per cent)	Total Population (Per cent)
Siruvani	35	32	35
Pillur	27	29	33
Pillur Added	17	16	10
Aliyar Added	14	14	14
K.V. Scheme	7	9	8
Total	**100**	**100**	**100**

Source: Coimbatore Corporation, (2019).

Lakes in Coimbatore Corporation

The impact of urbanisation on biodiversity observed that the urban agglomeration of Coimbatore expanded from 38 sq km in 1973 to 79 sq km in 1989 and further to 274 sq km in 2010, registering over fivefold expansion, in less than four decades. In terms of spatial pattern, the city developed concentrically during the initial years and later into linear development along the major roads. A review of 2002 land use plan for the city indicated that nearly 75 per cent of land within the corporation limits had developed into urban land use, while the rest was classified as agricultural land, water bodies, vacant areas, and heritage sites. As noted above, Coimbatore district has been ranked lowest in the number of wetlands in Tamil Nadu. Most of the wetlands in Coimbatore are under severe anthropogenic pressure and threat.

Space Application Centre (SAC) in its National Wetlands Atlas has pointed out that Tamil Nadu is wetland rich since it has 6.92 per cent of geographical areas under wetlands. However, the network of manmade wetlands in Coimbatore that is its lifeline as the city has grown around them, contributes only 1.08 per cent of the total area. Although Coimbatore is a prospering city, its lakes are in peril. Inflow of population into the city and increasing growth of more than 40,000 small, medium and large industries including textile mills and foundries has become a strong economic alternative to the poorly irrigated agricultural lands in the city and its suburbs. The industrial pollutants from western and northern portions of the city have disturbed the biotic life in the Noyyal River and associated water bodies. Only during the last few years the city has seen growing concern among a couple of NGOs and research organisations about the sad state of the wetlands and the river, which need to spread far and wide and deep to the public and the authorities for effective actions. Some of the NGOs in the city have taken notable proactive steps to save the wetlands, although these actions need to be more rationalized and customised towards ecological enrichment of the habitats and sustainability; building bunds is an important step but strengthening the bunds into sustainable habitats is a crucial next step.

The City has nine lakes within the Coimbatore Corporation limits set prior to September, 2010, namely Ammankulam, Narasampathi, Krishnampathi, Selvampathy, Kumaraswamy Muthannakulam, Selvachinthamani, Periya Kulam Ukkadam Big Tank, Valankulam and Singanallur. However, during the last couple of decades a part of the Ammankulam was converted into housing blocks by the state government and the other part encroached by slums. The lake, now completely encroached and converted, will be known only as a slum redevelopment scheme; the lost and unsung ecological services and values will remain a myth, to be reminisced by the fading generation.

According to the PWD the lake bed area of the lakes varies and is 19.425 hectares for Narasampathi, 21.853 hectares for Krishnampathi, 16.187 hectares for Selvampathy, 25.495 hectares for Kumaraswamy, 10.522 hectares for Selvachintamani, 136.379 hectares for Ukkadam, 38.85 hectares for Valankulam and 66.773 hectares for Singanallur Lake (Pragatheesh and Jain 2013). Earlier all these lakes were under the control of the Public Works Department (PWD), Government of Tamil Nadu. Recently, the remaining eight lakes were handed over to the Corporation for a lease of Rs 100/yr for a period of 90 years. The wetlands of Coimbatore are known to have served the society for over 800 years and continue to do so despite serious setbacks and pressures. The lakes that were aimed at flood control, ground water recharge and irrigation were indiscriminately exploited for industrial and agricultural purposes in due course of time. With time, the Noyyal River and the interconnected lakes have become the recipients of solid waste, treated and untreated sewage and effluents affecting the water quality (Quadros et. al, 2014).

Selection of the Sample Households

Coimbatore District was selected for the study. As the study was mainly based on primary data, **Multi-stage Random sampling** technique was adopted for the sample selection. The sample selection process used by the investigator is been provided in (Figure-8).In the first stage Coimbatore District was selected for the study. The study is based on Urban water consumption so, the researcher selected only urban area so Coimbatore corporation was selected. In the second stage the researcher has concentrated on zones of Coimbatore corporation namely Nort, South, East, West and Central zones. Each zone had 20 wards in it. In the third stage the investigator has chosen wards with highest population from each zone.

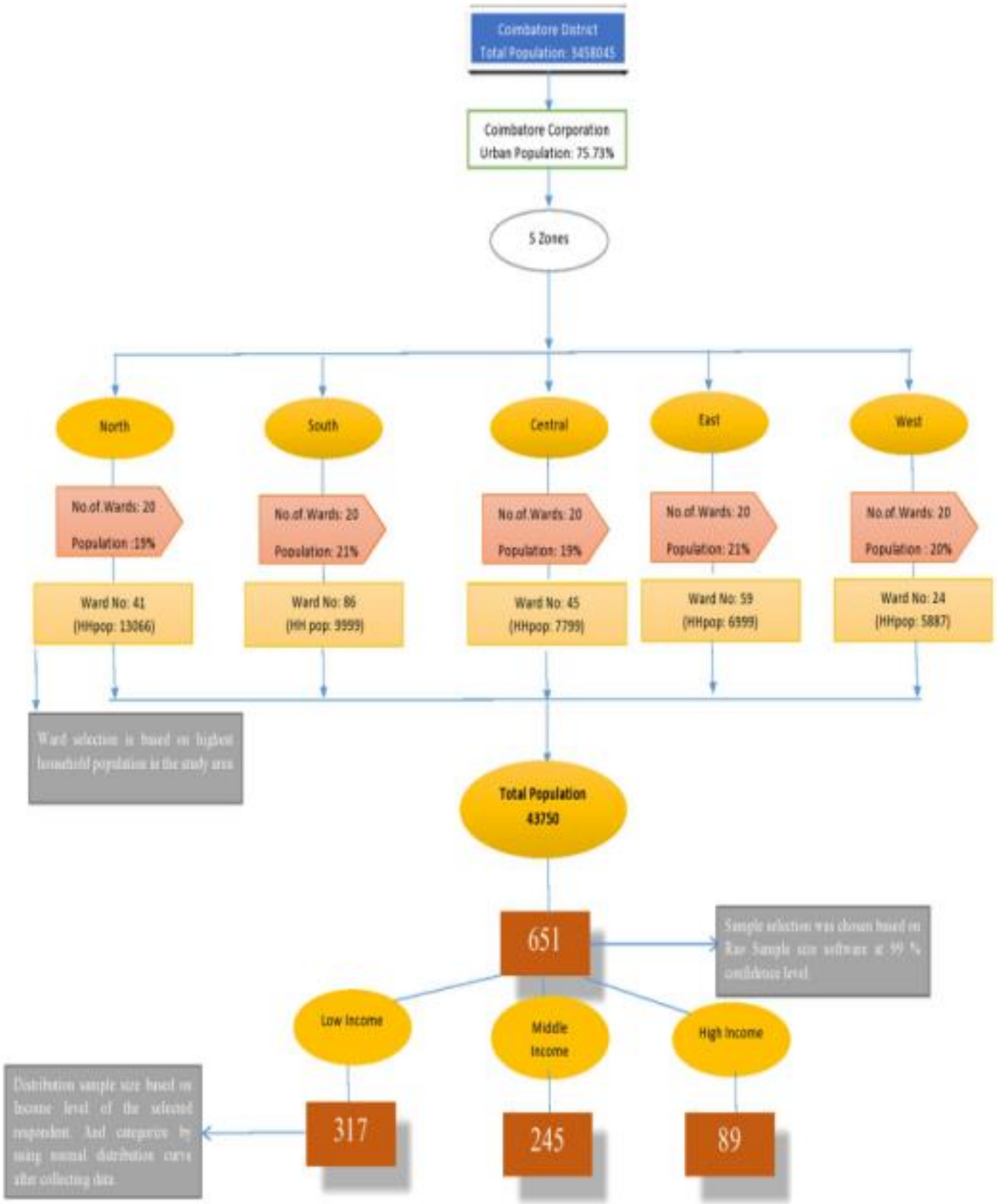


Figure 7: Research Design

Selection of the Sample Households

In the selection of the sample households, the researcher first approached the CCMC Officers, to get details on the ward population and area covered in a particular ward. It was found that in north zone ward no.41 there are 4 areas, in south zone ward no 86 there are 5 areas, in central zone ward no.45 have 7 areas, in east zone ward no. 59 have 5 areas and in west zone ward no.24 have 5 areas were selected. In order to select the sample households for the current study the investigator has used the report gathered from Coimbatore City Municipal Corporation (CCMC) officer (Annuxre-). Based on the report obtained in each zone ward with highest population was selected. The detailed selection of wards for the study is been given in the table 23

Table 23: Details of Selection of Ward in Each Zone

Zone	Ward	No. of Households	No. of Water Connections	Selected No. of Households
North	41	13066	10977	101
South	86	9999	2803	181
Central	45	7799	3874	160
East	59	6999	4571	116
West	24	5881	2796	93
Total		**43744**	**25021**	**651**

Source: Coimbatore Corporation, (2019).

Table 24: Zone Wise Distribution of the Selected Sample Households

S.No	Area Covered \ Income Group	LI	MI	HI	ALL
North Zone					
1	Ganapathy	12	9	3	24
2	Police Quarters	3	25	1	29
3	Gandhi Managar	8	13	8	29
4	Sivanandhapuram	9	8	2	19
	Total	**32**	**55**	**14**	**101**
South Zone					
1	KarumbuKadai	31	14	5	50
2	Kuniyamuthur	24	7	3	34
3	Veerapandipirivu	34	8	5	47
4	Selvapuram	12	23	2	37
5	Ukkadam	7	5	1	13
	Total	**108**	**57**	**16**	**181**
Central Zone					
1	Tatabad	4	3	2	9
2	Koundampalayam	17	11	3	31
3	Sanganoor	2	5	2	9
4	Gandhipuram	7	5	2	14
5	Nallampalayam	14	6	4	24
6	Metupalayam	17	15	0	32
7	Ganapathy Pudhur	24	15	2	41
	Total	**85**	**60**	**15**	**160**
East Zone					
1	Neelikonampayam	24	12	1	37
2	Peelamedu	9	4	4	17
3	Singanallur	17	10	5	32
4	Press Colony	7	9	4	20
5	Ondipudhur	3	4	3	10
	Total	**60**	**39**	**17**	**116**
West Zone					
1	Selvapuram (N)	10	8	4	22
2	P.N.Palayam	5	6	5	16
3	R.S.Puram	2	8	8	18
4	Ramanathapuram	5	9	3	17
5	Gandhi Park	10	3	7	20
	Total	**32**	**34**	**27**	**93**
	Grand Total	**317**	**245**	**89**	**651**

Rao sample size calculator software (Annexure 1) was used by the investigator for the study to gather 651 sample households from 43744 total sample size at 99 per cent confident level. Based on random sampling technique, households was chosen for collecting data

Table 25: Income Wise Household Group Classification

Income Group	US $	Per Day (Rs)	Per Month (Rs)	Classification of Income Group
Poor	Less 2	Fewer Rs. 140	Less Rs.4500	Low Income Group
Low Income	2.01 -10	141 - 700	4,501 - 21,000	
Middle Income	10.01 - 20	701-1,400	21, 000 - 42, 000	Middle Income Group
Upper Income	20.01 -50	1,401 - 35,000	42,001 - 1,05,000	
Higher Income	50 $ & above	35,001 and above	1,05,000 and above	Higher Income Group

Source: Central Government Report (2020).

Using CGR (2020), the sample respondents were classified in Lower Income Group (LIG), Middle Income Group (MIG), and Higher Income Group (HIG). Based on the income group the respondents demand and supply of water consumption was studied.

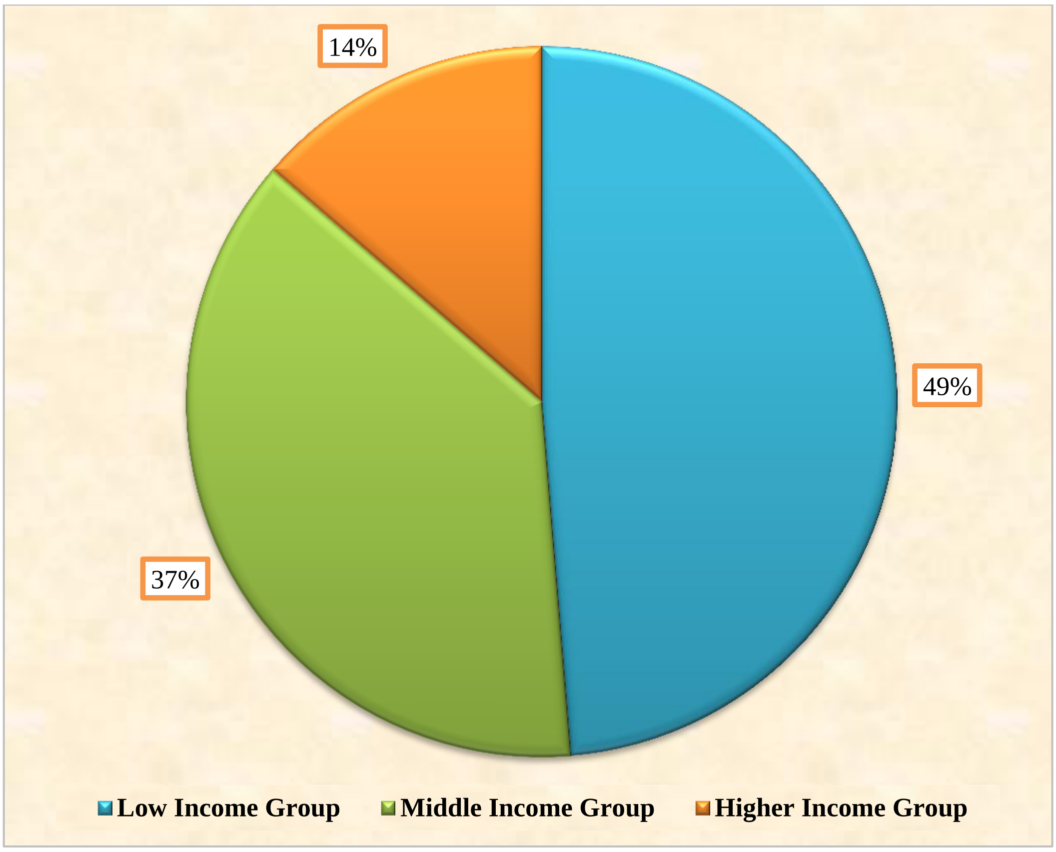


Figure 8: Income of the Selected Respondents

Sources of Collection of Data

The period of the study was from the year 2017-2020. The data for the study were collected from both primary and secondary sources. The information on Country, Sate and district profile, Corporation details, Source of water supply, water distribution Pattern, Population details, ward details and other information's were collected from the following reports and Government Organizations.

1. Tamil Nadu Water Supply and Drainage Board (TWAD), Tharamani, Chennai. (2018)
2. Tamil Nadu housing board (2018)
3. Indian Census Reports (Government of India)
4. Tamil Nadu State of Environment and Related Issues, Tamil Nadu State Council for Science, Technology and Environment (Government India)
5. Tamil Nadu Agricultural University, Coimbatore (Economic and Statistical Department and Water Technology Center)
6. District Statistical Office, Coimbatore.
7. Public Welfare Department, Coimbatore.
8. Pollution Control Board, Coimbatore
9. Zonal Offices (North, South, Central, East and West), Coimbatore.
10. Tamil Nadu Water Supply and Drainage Board (TWAD), Coimbatore.
11. Tamil Nadu Urban Studies Centre, Coimbatore.

Primary data were collected through personal interview method from the sample Household respondents. Interview schedules were used to collect details related to the study from the sample Household respondents. A pilot study was conducted to identify the gaps in the interview schedule. On the basis of observation, during the pilot study, the schedule was modified (Annexure II) and the survey was conducted between September 2018 and May 2019. The data were collected through a structured questionnaire. The volume of vessels in which households store water was assessed and the number of vessels of water used in different activities like bathing, clothes washing, utensil cleaning, house cleaning, watering the garden etc. were estimated.

The quantity of water contained in the vessels was assessed by physically measuring the quantity of water contained in a vessel. A pilot survey of ten houses using different kind of vessels was conducted for this purpose. In this way, the average size of the vessel was assessed and this average was used to work out the quantity of water used for different activities. The average size of the vessel was 9.30 liters.

Where running tap or piped water was used in some activities, the duration for which the tap was used was estimated and the quantity of water delivered per minute from the tap was measured. The quantity of water per minute was multiplied with time and the volume of water used in running tap was measured. The quantity of water used in flushing toilet was measured by volume of bucket used and flush tank capacity.

The data were analyzed, using the simple statistical techniques, so as to examine the activity wise consumption of water and the relationship between per capita and per household consumption of water with household type, education, occupation and household income of the households.

Ethical clearance (AUW/ IHEC/19-20/ECO/04) was obtained before selecting sample and conduct of the study is enclosed in Appendix IV.

Quantitative Tools

The data collected were arranged and tabulated for giving precise and concise information. Further, the following tools were applied to analyze the data.

Table 26: Details of Quantitative Tools used in the Study

Analysis	Action
Chi-Square Analysis	To find the association between LPCD and water Usage
Multiple Regression Analysis	To find the relationship between LPCD and Other Independent Variables
	To find the relationship between the Treatment cost of waterborne disease faced by the selected urban households
Garret Ranking	To find the preference of water in daily usage activities
	To find the problems faced by the respondence with their urban water supply
Factor Analysis	To find the factors influencing the respondence prefer for secondary water sources
	To find the factors influencing the respondence towards water saving behaviour
Probit analysis	To find the willingness to pay for improved water supply among the selected households
ANOVA	To find average water consumption between the income groups

Factor analysis

To identify the factors which influence the households prefer the secondary source of water. For this purpose, the researcher has used Factor Analysis Approach. The general purpose of factor analysis is to find a way in condensing the information contained in a number of original variables into a smaller set of new, composite dimensions (factors) with a minimum loss of information. Th-e suitability of the data for factor analysis can be tested on the basis of following criterion:

(i) A visual inspection of the correlation data matrix can reveal whether there are sufficient correlations to justify factor analysis.

(ii) Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) is another measure to quantify the degree of inter-correlation among the variables and appropriateness of factor analysis. The index ranges from 0 to 1. Small values of KMO measure indicate that a factor analysis of variables may not be a good idea, since correlation between pairs of variables cannot be explained by the other variables. A high value between 0.5 and 1.0 indicates that factor analysis is appropriate technique to be used.

To obtain factor solutions two basic models: common factor and principal component analysis are needed to be used. Principal Component Analysis is used to summarize most of the original information in a minimum number of factors for prediction purposes. Common Factor Analysis is used to identify underlying factors or dimensions reflecting what the variables shares in common. In this study, principal component method of factoring was used. It is a statistical technique that linearly transforms an original set of variables into a substantially smaller set of uncorrelated variables that represents most of the information in the original set of variables. The linear combinations of variables are used to account for variation of each dimension in a multivariate space. The variance of factors is called Eigen Values, Characteristic Roots or Latent Root. Communality is the amount of variance an original variable shares with others. Factor loadings are the correlation between the original variable and the factor. Squared factor loadings indicate what per centage of the variance in an original variable is explained by a factor. There are four criteria to determine the number of factors to be extracted.

(i) Prior criteria
(ii) Latent root criteria
(iii) per centage of variance criteria and
(iv) Screen test criteria

In latent root criteria, only those factors which have latent roots greater than one are considered. In percentage of variance criteria, that the cumulative percentage of variance extracted by successive factors must be greater than 60 is good enough in social science. At least one factor more than latent root criterion is usually extracted. In this study, firstly latent roots were examined and then the Screen test was used. percentage of explained variance was also considered. And then loading is rotated to make them more interpretable by making the loading for each factor either large or small, not in between. For rotation, Orthogonal or Oblique method can be applied. In orthogonal rotation method, the axes are maintained at 90 degree so that the resulting factors are uncorrelated. In Oblique Rotation method, the axes are rotated, without maintaining the 90 degrees angel between them. Within orthogonal method, either Varimax or Quatrimax method can be employed. Varimax method simplifies the columns in a matrix whereas Quatrimax method stresses on simplifying the rows. In this study, Orthogonal Rotation along with the Varimax method of rotation was used in order to have more clearly in factor solution. The Varimax criteria maximize the sum of the variance of the square loadings within each column of the loading matrix.

In the current study factor analysis has been used for analyzing the push and pull factors of migration. As a first step there were two tests framed for this analysis namely, Kaiser-Meyer-Olkin measures of sampling adequacy (KMO) and Bartlett’s Test of Sphericity have been applied to test whether the relationship among the variables has been significant or not.

Garret ranking

In the study the researcher use Garrett’s ranking technique for analyse the preference of water in daily use and the problems faced by the selected households by urban water supply. As per this method, respondents have been asked to assign the rank for problems and the outcomes of such ranking have been converted into score value with the help of the following formula:

$$Percent position = \frac{100\,(\mathrm{Rij} - 0.5)}{\mathrm{Nj}}$$

where,

Rij = Rank given for the ith variable by jth respondent and

Nj = Number of variables ranked by jth respondents.

The per cent position of rank obtained is converted into scores by referring to the table given by Henry. E. Garrett and Woods worth R.S. (1968). The scores of each individual were added and then total value of scores and mean values of scores were calculated. The mean scores were arranged in descending order and the corresponding ranks were allotted.

Multiple Regression Analysis

Multiple Regression is the determination of a statistical relationship between two or more variables. It is concerned with the prediction of the most likely value of one variable when the value of the other variable is known in simple regression, there are only two variables, on variable defined as independent is the cause of the behavior of another one defines as dependent variables.

1. Multiple regression analysis is used to understand the relationship between LPCD and variables such as education of the respondents, occupation of respondents, type of family they were living in, number of members in their family, total distance for water collection, and sources of water and time spent for water collection.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \mu$$

Where Y=LPCD

X_1 = Education

X_2 = Occupation

X_3 = Age

X_4 = Income

X_5 = Family Size

X_6 =Type of Family

X_7 = Total Expenditure

X8=Total Distance for Water Collection

X9=Sources of water

X10=Time Spent for water collection

μ = Error term

2. The researcher tried to examine the relationship between the Treatment cost of water borne disease and its determinants in this secession for which they have used multiple regression analysis.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \mu$$

Where Y= Treatment Cost

X_1 = Medical Expenditure

X_2 = Total Expenditure

X_3 =Affected Person Men

X_4 = Affected Person Women

X_5 = Affected Person Children

X_6 = Water bone Disease Viral

X_7= Water bone Disease Bacterial

X_8= Water Related Disease

μ = Error term

Willingness to Pay Theory

Willingness to pay, sometimes abbreviated as WTP, is the maximum price a customer is willing to pay for a product or service. It's typically represented by a dollar figure or, in some cases, a price range. While potential customers are likely willing to pay less than this threshold, it's important to understand that, in most cases, they won't pay a higher price.

"What the concept of 'willingness to pay' is telling us is that whatever your willingness to pay for a product might be, and wherever it comes from, you're just not going to pay more than that [amount] for it," (Anandh 2020). Willingness to pay can vary significantly from customer to customer. This variance is often caused by differences in the customer population, typically classified as either extrinsic or intrinsic.

Extrinsic differences are observable. They're factors you can generally determine about a person without needing to ask them directly. A customer's age, gender, income, education, and where they live can all be extrinsic differences that impact their willingness to pay.

Intrinsic differences, on the other hand, are a person's characteristics you wouldn't know about without asking them directly. They're hard to observe and often called "unobserved differences." An individual's risk tolerance, desire to fit in with others, and level of passion about a given subject are all examples of intrinsic differences that can impact their willingness to pay.

In the current study willingness to pay theory has been used in order to identify the respondent's willingness to pay an extra amount for secondary water sources in the selected area of Coimbatore urban area.

The researcher tried to examine the relationship between the Willingness to pay for improved urban water services and its determinants in this secession for which they have used Probit model

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \mu$$

Where Y= Willingness to Pay

X_1 = LPCD

X_2 = Total Distance for Water Collection

X_3 = Sources of Water

X_4 = Time Spent for Water Collection

X_5 = Family Size

X_6 =Family Income

μ = Error term

Anova

To examine whether there exists any discrepancy among different income groups of households With their average water consumption under study, one way ANOVA was conducted for each of the select demographic factors.

At the heart of ANOVA, is the notion of variance. The basic procedure is to derive two different estimates of population variance from the data, then calculate a statistic from the ratio of these two estimates (between groups and within groups variance). The F ratio is the ratio of 'between-groups' variance to 'within-groups' variance. A significant F value indicates that the population means are probably not equal. Before ANOVA was conducted, it was ensured that the necessary assumptions were met. The two assumptions of concern were population normality and homogeneity of variance.

Simple Percentage

Percentage (per cent) is used even if there are not a hundred items. The number is then scaled so it can be compared to one hundred. Proportions are one way of writing number.

A. Graphs

To represent the findings through graphs, bar and pie diagrams were drawn

Terms Used

Water: A colorless, transparent, odorless liquid that forms the seas, lakes, rivers, and rain and is the basis of the fluids of living organisms.

Water demand: Water demand is defined as the volume of water requested by users to satisfy their needs. In a simplified way it is often considered equal to water abstraction, although conceptually the two terms do not have the same meaning.

Water Supply: *Water supply* is the provision of *water* by public utilities, commercial organizations, community endeavors or by individuals, usually via a system of pumps and pipes.

Urbanization: Urbanization (or urbanisation) refers to the population shift from rural to urban areas, the decrease in the proportion of people living in rural areas, and the ways in which societies adapt to this change. It is predominantly the process by which towns and cities are formed and become larger as more people begin living and working in central areas..

Urban area: An urban area is the region surrounding a city.

Water Scarcity: Water scarcity can be defined as a lack of sufficient water, or not having access to safe water supplies.

Water Stress: A situation in which the water resources in a region or country are insufficient for its needs.

Water Resources: Water resources are sources of water that are useful or potentially useful to humans. It is important because it is needed for life to exist.

LPCD: Total consumption of water for a water supply system in a year divided by the population and the number of days in the year is called per capita demand. It can be expressed in liters per capita per day.

Domestic water: Domestic water use is water used for indoor and outdoor household purposes— all the things you do at home: drinking, preparing food, bathing, washing clothes and dishes, brushing your teeth, watering the garden, and even washing the dog.

Water consumption: Water consumption" is the portion of water use that is not returned to the original water source after being withdrawn

Households: Those who dwell under the same roof and compose a family also : a social unit composed of those living together in the same dwelling

Water Service Connection: means the water or recycled water pipe, valves and other facilities by means of which the utility conducts water or recycled water from its distribution mains to the meter and meter box located at a specified place of delivery of water to a parcel of land.

Stand Post: Public stand posts provide points where a local community may draw water from a piped water distribution system. They usually comprise a connection to the water main, a suitably supported riser pipe and a tap. Their design and construction has a major influence on their durability, effectiveness and hygiene.

Borewell: A deep, narrow well for water that is drilled into the ground and has a pipe fitted as a casing in the upper part of the borehole, typically equipped with a pump to draw the water to the surface.

Market Water: Water marketing is the transfer or sale of water or water rights from one user to another, typically from an agricultural to an urban water agency, often without investing in new infrastructure. Most exchanges involve a transfer of the resource itself, not a transfer of the right to use the water.

Willingness to pay: Willingness to pay (WTP) is the maximum price at or below which a consumer will definitely buy one unit of a product.

Limitations of the Study

1. Reluctance on the part of the respondents to give data.
2. Obtaining information from the concerned offices was difficult.
3. Absence of respondents at home during data collection.
4. Information about the number of public taps and consumers depending on them is not included in this study.
5. Absence of standard methods for assessing the water supplied to each ward of the study area.
6. The personal bias of the respondents affected data collection.
7. It is a micro level study. Thus, the findings of the study may not be applicable to the macro level.
8. The study has used the 2011 census data on water availability and other related variables are collected from Central water commission and Ministry of water resources (2011) Government of India.
9. The study conducted from 2017-2018 and 2018-2019 If resent data have been available the results might have been different.