Urbanisation and Water Resources Management:
A Study of East Sikkim District

A Thesis Submitted

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Degree of Doctor of Philosophy

By

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This Thesis is dedicated to my grandmother

Late. Sumi Sherpa

Date: 06/03/2020

DECLARATION

I, Lakpa Doma Sherpa, hereby declare that the research work in the thesis entitled **"Urbanisation and Water Resources Management: A Study of East Sikkim District"** submitted to Sikkim University for the award degree of **Doctor of Philosophy** in Economic is my original work. This thesis has not been submitted for the awards of any previous degree of this university or any other university.

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"Urbanisation and Water Resources Management: A Study of East Sikkim District"

submitted by **Lakpa Doma Sherpa** under the supervision of **Dr. Komol Singha**, Associate Professor, Department of Economics, School of Social Sciences, Sikkim University.

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CERTIFICATE

This is to certify that thesis entitled "**Urbanisation and Water Resources Management: A Study of East Sikkim District**" submitted to the Sikkim University for partial fulfilment of the degree of **Doctor of Philosophy** in the department of Economics, embodied results of investigation carried out by Lakpa Doma Sherpa under my supervision and guidance.

I, further, declare to the best of my knowledge that no part of this thesis has been submitted for any other degree, diploma, associateship and fellowship. All the assistance and help received during the course of investigation have been duly acknowledge by her.

We recommend this thesis be placed before the examiners for evaluation.

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Lakpa Doma Sherpa

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LIST OF ABBREVIATIONS

Asian Development Bank	ADB
Atal Mission for Rejuvenation and Urban Transformation	AMRUT
Bureau of Indian Standard	BIS
Biochemical Oxygen Demand	BOD
Compound Annual Growth Rate	CAGR
Central Ground Water Board	CGWB
Central Pollution Control Board	CPCB
Gross Domestic Product	GDP
Geographic Information System	GIS
Government of India	GoI
Government of Sikkim	GoS
Gross State Domestic Product	GSDP
Jawaharlal Nehru National Urban Renewal Mission	JNNURM
Kilo Litre	KL
Litre Per Capita Per Day	LPCD
Millennium Development Goals	MDGs
Multiple Linear Regression Modal	MLRM
Most Probable Number	MPN
Ministry of Urban Development	MoUD
Non-lapsable central pool of resources	NLCPR
North Eastern Council	NEC
North Eastern Region	NER
Ordinary Least Square	OLS
Panchayat Raj Institutions	PRIs
Rajiv Gandhi National Drinking Water Mission	RGNDWM
State Annual Action Plan	SAAP
Sustainable Development Goals	SDGs
State of Environment Report Sikkim	SERS
State Pollution Control Board	SPCB
Total Educational Institute	TEI
Total main worker in non-agricultural activities	TMWNAA
Total Number of Registered and Functioning Industrial units	TRI
Total Registered Vehicles	TRV
Total Urban Households	TUHH
Total Urban Population	TUP
Urban Development and Housing Department	UDHD
Urbanisation Index	UI
Urban Local Bodies	ULB
United Nation	UN
United Nation Development Planning	UNDP
Variance Inflation Factors	VIF
World Health Organization	WHO
Water Security and Public Health Engineering Department	WS&PHED
Water Quality Index	WQI

CHAPTER I

PRELUDE TO URBANISATION

1.1 INTRODUCTION

Urbanisation is a dynamic process, which links with the growth of urban centres, changes in the economic activities and rise in population. The rapid urbanisation of the twenty-first century is marked as a period of industrialisation, modernisation, economic agglomeration that reflects the economic development and social transformation of any region (McDonald et al. 2014). Urbanisation has also got its impact on transforming economic and social value of the people (Lollen 2015; Brown et al. 2009; Montagomery 2008; Jenerette and Larsen 2006). According to the United Nations' Development Programme report, around 3.6 billion people are living in the urban areas in 2011 and it could add another 2.6 billion additional urban dwellers by 2050 (UNDP 2015). All the new urban dwellers (additional 2.6 billion) will require water for various purposes, but there is little knowledge about where these urban centres and additional population obtaining their water supply network from and the implication of infrastructure for the global water cycle (Padowski and Jawitz 2013). When the urban centres started rising at a very fast pace during the era of industrial revolution in the developed nations and thereafter in other nations, the provision of clean water became increasingly an important issue (Vo 2008; Biswas 2006). According to the United Nation's Millennium Development Goals (MDGs) report 2015, though around 147 countries globally have met the drinking water target, halve the proportion of people of these countries are still not able to reach or afford safe drinking water. Despite this achievement of providing safe drinking water, the water scarcity affects 40 percent of the people in the world, and it is projected to increase further (UNDP 2015, pp.7-8).

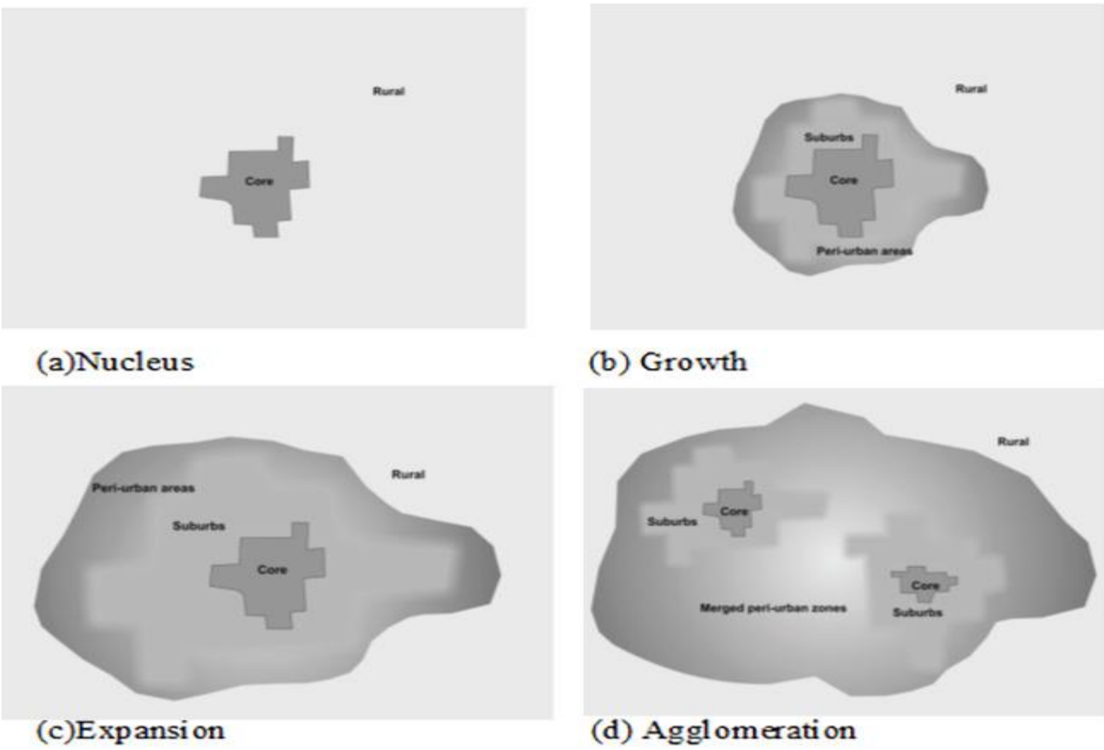
However, the pace and pattern of urbanisation have not been same everywhere, vary from country to country and region to region because of its various policy measures, which in turn, shapes the growth of urban centres. The urbanisation phenomenon is everywhere, but looking at the number of urban centres and by population size, it varies from 50,000 in Japan, 5,000 in India, 2,500 in United States and 1,000 in Canada (Lollen 2015). Though the concept of urban centre or urbanisation is also not uniform and same everywhere. It is well defined and accepted in different ways by different countries. In India, urbanisation is considered or an area is called as urban centre if at least one of the following conditions given below (out of the two) is satisfied (GoI 2018):

a) All administrative units that have been defined by statute as urban like Municipal Corporation, Cantonment Board or notified town area committee, etc. Further, the statutory towns with population of one lakh and above are categorised as towns.
b) A place satisfying the following three criteria: 1) a minimum population of 5,000 people, 2) at least 75 percent of male working population engaged in non-agricultural activities, and 3) density of population of at least 400 persons per sq. km.

1.2 URBANISATION PATTERN AND EXPANSION

According to Bhagat and Mohanty (2009) urbanisation is interlinked with the migration and economic activities. Though the casual relation between these two is not established scientifically, one thing is clear that the migration is very much intertwined with the urbanisation process. As per the concept adopted in India, migration is reported by place of birth and place of last residency. By definition of the former concept, by place of birth, around 84.2 percent people in India are migrated from one part to another and 85 percent of the people are reported to have migrated from the last place of residence (Registrar General of India 2001). Another research study conducted by Shah and Kulkarni (2015) on the topic of urban continuum, depicted in Figure 1.1, shows the four stages of urban expansion that are taking place in the urbanisation process.

Figure 1.1: Urban Continuum



Source: Shah and Kulkarni (2015)

As core expanded and agglomeration taking place in urban areas (as shown in Figure 1.1), the need for water supply resources arises in different-sized urban settlements at various stage of growth (Shah and Kulkarni 2015). In the context of India, urbanisation process is seemed to be an unplanned and unmanaged growth, which in turn, leads to urban sprawl (Banerjee 2009). When the urban dwellers increase to more than double or increase to 800 million by 2050, it consequently might lead to pressure on the available physical, social and economic infrastructures like urban transport, supply of water, educational and health institutions (Shah and Kulkarni 2015). The changing pace and pattern of the development activities and their land use planning for the housing and the industrial areas have a considerable impact on the environment as well as on livelihood of the people. The changing land-use patterns have altered the water bodies, especially the river courses, along with major shift to deforestation, converting the agricultural lands into towns and cities. Industrial discharged effluents through pipes into rivers has severely impacted on water quality, which in turn, leads to increase in bio-chemical oxygen demand[1] and decrease in dissolved oxygen concentration in the river downstream (Brown et al. 2014). However, improvement in technological treatment plant can enhance the water quality largely in developed world and aquatic ecosystem (Ibid 2014). Environmental degradation and pressure on land have been taking place at the very fast pace and causing excessive water pollution, water shortage in the urban centres (Shah and Kulkarni 2015; Banerjee 2009). The negative impact of urbanisation on the environment of the cities and urban centres are the serious issues documented in most of the urban environmental research. The effects of urbanisation are critical. According to the Ministry of Urban Development, Government of India, 20 percent of the country's urban households do not have access to safe drinking water service because of the improper waste management system in the country (Sridhar and Reddy 2010). The poor governance and the institutional overlapping activities lead to poorer public service delivery in most of the cities of India (Ibid 2010).

[1] Bio-chemical oxygen demand is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period.

According to the 74th Amendment of the Constitution of India, the roles, responsibilities, governance structure, etc. of the urban local bodies (ULBs) have been clearly laid down. This includes formulation of plans for economic development and social justice, urban planning, water supply, sanitation, solid waste management, public health, urban forestry, environmental protection, slum improvement, urban poverty alleviation and among others. The state finance commission and the statutory district planning committees are empowered for urban planning, so that they (ULBs) are able to exercise their autonomy fully. However, implementation of the Amendment has been uneven across states. In order to encourage states to improve basic services and ensure good urban governance, the Central Government has launched the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in 2005. Infrastructure is one of the indicators for urban service delivery system and poor infrastructure leads to a significant gap in water service delivery system in the country. Therefore, it is believed that there should be a reasonable tax must be charged for basic services in order to meet at least the operation and maintenance charges. Of course, it needs further investigation.

1.3 URBANISATION ISSUES AND PROBLEMS IN SIKKIM

Sikkim lies in the Eastern Himalayan range, which is a source of fresh water to the inhabitants. The various water resources are available in the form of glaciers, rivers and natural springs. Around 84 glaciers covering an area about 440.30 km^2 (SER 2016) is present in the state of Sikkim. The state has two important rivers namely, Rangeet and Teesta. The gravity-based water supply from different lakes and springs of Sikkim serves the major sources of domestic drinking water to the inhabitants (Ibid 2016). The entire area of Sikkim is hilly with steep slope and 84.31 percent of it is covered with forests. The retention of rain water under the ground seems to be very high in the state because of the less surface run-off due to vast forests cover. The rainfall record was more than 3800 mm in the Sikkim (CGWB 2008). In the state, urbanisation process seems to be very rapid, especially in the East Sikkim district, in which the capital city, Gangtok is also situated and most of the industrial units are concentrated. With this rapid urbanisation process in the East Sikkim district, should there be any water issue? The Registrar General of India (2011) observed, as there should not be any major problem regarding the domestic water resources in Sikkim because of the availability of water sources vis-a-vis small population size in the state. But the population in the state, especially in the East Sikkim district, has been increasing rapidly (may be referred the data in the following sections). Majority of the state's population is concentrated in and around the Gangtok city, which falls under the East Sikkim district of Sikkim. Therefore, the issue needs a thorough assessment and proper study.

When we assess very closely, it is seen that the rapid urbanisation process in Sikkim is a very recent phenomenon, started in the last 20-30 years. But, the pace of urbanisation process in Sikkim seems to be faster than that of the all India scenario (data may be corroborated in the following sections). As per population criteria, in the 2011 population census, the total population of Sikkim stands at 6, 10, 577 (which is the sum total of 43,709 in North Sikkim district, 1, 36, 435 in the West Sikkim district, 1, 46, 850 in South Sikkim district and 2, 83, 583 in East Sikkim district). Of the total, 25.15 percent of the state's population live in the urban areas. Particularly, in the East Sikkim district comprising of 964 km^2 of the state's total geographical area (7, 096 sq. km.), a total of 43.19 percent of the district's population live in urban areas while 56.81 percent live in the rural areas. The major urban centres in the East Sikkim district, according to Population census 2011 are, Gangtok (capital city of Sikkim), Singtam, Rangpo and Rhenock (Census town). The distribution of workers (male) working population in non-agriculture activities in East Sikkim district is 97.93 percent (Registrar General of India 2011). The growth of urban towns has increased from one in 1981 to eight in 2001 and the growth rate of population residing in urban areas has increased from 2 percent in 1951 to 11 percent in 2011 in Sikkim (Ibid 2011).

To cater the ever increasing water requirement in East Sikkim district, the central programme called, the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) has been in place since 2005. Though state claims that the supply of water is sufficient for the inhabitant, albeit no exact quantification is made. There is no guarantee that quality drinking water is being provided to the public in the urban centres of East district in Sikkim. In fact, the water quality of rivers in Sikkim seems to be deteriorated with the growth of urbanisation and industrialisation, especially in the Rangpo, Singtam, and Ranipool urban centres in East Sikkim district. As per information provided by the State Pollution Control Board (SPCB), in 2010, the faecal coliform bacteria count found in the river water at Rangpo area was recorded at 220, and increased by 255 in the year 2013, which exceeds the permissible limit (0 counts/100 ml) set by the World Health Organization[2] (WHO 2008; Metzger and Moench 1994). It also indicates that the contamination of river water leads to the water crisis in the urban centres located on the riversides. This might possibly due to the ever-increasing urban migration and the newly established industries, which include a number of pharma companies.

Understanding the ever-increasing demand for water in this new state, for managing the water supply in East Sikkim district, a large amount of funds has been allocated for infrastructure development by the state government as well as various

[2] World Health Organization set one of the essential parameters to measure the water quality is total coliform. It is recognized as suitable microbiological indicator of water quality. The presence of the coliform bacteria in drinking water indicates that disease causing organisms may be present in the water system

institutions of the Central government. How far the service delivery of water is sufficient for the urban centres in East Sikkim district requires a thorough assessment. The Sikkim Water Supply and Water Tax Act 1986 regulates the supply of water, realisation of charges for supply of water and tax on water. Under this Act, the state government is supposed to provide water supply to different sectors such as domestic, commercial and others. In order to supply of water, the government necessarily should construct and maintain water work infrastructure in the forms of stand popes, wells or pumps, etc. The supply of water for domestic sector under this Act means the supply for household requirements, barring some commercial activities (GoS 1986, pp. 1-2).

In nutshell, the trend of urbanisation in Sikkim has been very rapid and its causal effect on natural resources and environment has also been noticed and catastrophic. Following the growth of urbanisation, the water supply management of the government has become one of the most important challenges, not only in the urban centres, but also in the rural areas. This raises a big question, whether the rapid urbanisation process is moving at the same pace with water resources management[3] in Sikkim, especially in the East Sikkim district.

One of the important issues concerning the governance, managing various departments in Sikkim, is not happening under the single umbrella. Different divisions of administration are looking at different bodies. Therefore, managing the issues related with water under the division of Public Health Engineering Department (PHED) requires lengthy procedures and requires prior permission from other departments. For instance, for repairing a damaged public water supply network requires to take prior permission from the Urban Development and Housing Department (UDHD) to dig the

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[3] Water resources management is the aggregate of policies and regulation used to provide clean water to meet human needs in different sectors and its jurisdictions in order to sustain the water natural system upon which we depend.

road sides where the water pipelines are laid. This takes a lot of time for one administrative works before getting into the exact work. There is also an issue related to the revenue incurred for operation and maintenance of expenditure of water supply as well as rebuilding of road areas. Since the urban planning is in the infant stage, there is no appropriate blue print for the urban management for water supply network and distribution to the growing population in the state. Let us take a case of the urban water supply distribution network in Siliguri, which is one of the cities in Darjeeling district, under West Bengal state in India, is controlled by the municipality, and its administrative setup and water distribution are under a single unit that looks after all the divisions of proper management of water to the public. The single unit can handle the matter properly without any delay. There is a process of decentralisation of all the institutions under one umbrella, i.e. Municipality. But such decentralisation process under water work is not present in the state of Sikkim.

Increase in population, urbanisation and industrialisation together with spatial and temporal variations in water availability, water quality problems, etc. lead to the higher demand for quality drinking water in Sikkim. The availability of quality water resources per capita has not only declined, but also the quantity of it has reduced over the years. Realizing the shortage of quality and quantity water resources, the government of Sikkim was compelled to organise a workshop on the importance of drinking water under the theme, "*Hamara Jal Hamara Jeevan*" (our water our life) in 2015 at in Gangtok (GoS 2015-16). This workshop was a part of the "India Water Week 2015" to address the issue of water resources management at the local level and to generate awareness to the public regarding the need for water conservation practices. Since the declining of snowfall and perennial water stream in the hills and depletion of ground water level in the plain areas, the issue was needed to consider very seriously by every stakeholder and decided to take proactive measures like afforestation and adoption of rain water harvesting techniques for water conservation.

1.4 ORGANIZATION OF THE STUDY

For convenient of the general readers, the present thesis is divided into seven chapters. In chapter I, it starts with a brief introduction of urbanisation and water resources management, followed by the urbanisation pattern and its expansion and issues related to the water resources in the study area, the East Sikkim district. The second chapter focuses on the literature review and the conceptual framework. In chapter III, this chapter covers objectives, methodology and implications of the study areas. In this section, the methodology and techniques employed to justify the research questions or objectives set are also presented. Chapter IV deals with the analysis of data collected through the secondary sources on urbanisation trends, patterns, and water quality issues in Sikkim and at the national level. In chapter V, using primary data, the section focuses and analyses on the microscopic study of East Sikkim district and the major findings. In chapter VI, urban water policy and reforms and its implementation at the state level are discussed. Last chapter (Chapter VII) summarises the study, makes concluding remarks of the study and provides some feasible recommendations for the benefits of policy makers and researchers.

CHAPTER II

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 BACKGROUND

Urbanisation process, which is rapidly taking place in the modern world today, is also linked with the demographic transition and migration theory, and that includes rural-urban migration. One group of researchers (Dyson 2011; de Vries 1990) believe that the decline in urban mortality leads to urban transitional growth, while others (Preston 1979; Harris and Todaro 1970; Lewis 1954) hypothesis that urbanisation is actually triggered by migration activities. Wagner and Ward (1980) further stated that, the natural increase in population and migration have equally contributed to the growth of urbanisation.

In literary term, demographic transition refers to the population cycle, changing from one demographic pattern to another. As per traditional population theory believes in changing demographic transition into three stages. In the first stage, population growth remains at the balanced state because of the high birth and death rate. In the stage two, rapid population growth happens due to the falling in mortality rate with increasing fertility rate as a result of the advancement of medical sciences. Therefore, rapid population growth leads to urbanisation through a various channel of economic activities like industrialisation, modernisation, commercialisation, etc. But, in stage three, manageable rate of natural increase in population is achieved because of the falling both birth and death rate. Through the operation of population composition such as mortality, fertility and migration, it can possibly change the structure of areas from being predominantly rural to urban centres (Dyson 2011). In the case of developing countries, the activities of migration and the economic activities have much more influenced on the agglomeration process of the urban centres (Ibid 2011). Most of the traditional studies on urbanisation have been centred on migration, agglomeration and its carrying capacity. In fact, the classic model of rural-urban migration and expansion of urban centres propounded by Arthur Lewis also endorsed that the process of urbanisation is inevitable. A study done by Bocquier and Costa (2015) in Sweden and Belgium found that the engine of urban growth is related with demographic transition, conferred with unstable and negative relations in the urban growth process. While the process of migration bears a direct or positive relationship with the urbanisation phenomena in the long run. It is evident in most of the developing countries, which was explained through the differences in expected income rather than actual income between urban and rural areas (Harris and Todaro 1970). When urbanisation is associated with industrialisation, which further creates economic growth in developing countries, it experiences a faster rate of rural-urban migration (Preston 1979). But, in the countries where economic growth occur at the very slow pace, urbanisation process expedites due to natural increase of the population (Ibid 1979). The land-use change patterns occurred must faster than the population growth in urban centres, showed the positive relationship between urbanisation and economic growth (Bai et al. 2017). In China, as urbanisation increases, there has been a positive relationship between industrialisation, consumption and energy and carbon emission (Ibid 2017).

At the conceptual level, defining urbanisation process has not been same everywhere because of various factors that determine the growth of urban centres. It also varies from country to country and region to region. Mostly, the definition of urbanisation accepted by respective countries is based on their suitable parameters that fit into urban context. Some countries take density of population as the sole parameter of defining urbanisation, while others consider population size along with working population engaged in non-agricultural activities is considered as basic criteria of defining urbanisation (Lollen 2015). Historically as well, the pace and pattern of urbanisation were different in different parts of the world. In the following sections, we will discuss the urbanisation growth theories in the context of developed and developing countries.

2.2 URBANISATION CONCEPT IN DEVELOPING COUNTRIES

The basic conceptual framework for urbanisation in the developing countries emerged from the colonies (colonised countries), which were ruled by the developed nations. Urbanisation theory in the developing countries are linked with modernisation theory, dependency theory and world system theory (Fox 2012). The modernisation theory emphasises on economic growth and the start-up programmes with the industrialisation process in the developing countries, mainly because of the backwardness of the regions and weak technological set ups. But, the proponents of dependency theory emphasise the disadvantage sides of the developing countries vis-a-vis developed world nations. In order to accrue economic globalism, the poorer countries should involve in the market for trading or exchange in traditional patterns of agricultural produces indirectly needed for the product manufacturing in the countries (Clark 2000, pp. 20-21). The world economy in a way help to bridge the gaps between economic expansion and contraction through the various links of interconnected exchange among nations due to urban development (Ibid 2000).

Both modernisation and dependency theory help in the expansion of the urban centres and provides opportunity for market-led urban growth. The world system theory taking international linkages provides the scope for further urban growth. The growth process of urbanisation in developing countries over the last 10 decades seems to have highly concentrated in urban cities and towns (Henderson 2002) and also in next 30 years, the world's population growth will be expected mostly in developing countries' urban centres (Cohen 2006). The percentage share of urbanised region in the developing nations started rising comparatively at the faster pace. For example, the United States started becoming urbanised 70 percent in 1960 to 75 percent in 1990 compared to the developing countries like Republic Korea where 40 percent of the country were urbanised in 1970 and rose to 78 percent in 1990. The developed countries took almost 90 years to achieve 75 percent of urbanisation level but within 20 years developing countries have been able to reach the same level of urbanisation (Henderson 2002). At the same time, developing countries are facing the major challenges in connection with urbanisation compared to developed nations. With this rapid growth of cities and towns, developing countries have witnessed the shortage of the necessary institutional capacity to manage urban governance (Cohen 2006). In the process of urbanisation, the fundamental changes that will happen is with regards to the urban management and the governance of urbanisation. As the population growth involves in it, many problems are likely to come up with the rise of population in the urbanisation process and in the urban centres. In developing countries, people with social capital will likely to have more influence on reaching the basic public services. But poorer people can have drastically lower level of those public delivery services. In a large number of urban residents in developing countries, if proper policy management is not present, then there will be major environmental health challenges linking with insufficient access to clean drinking water, inadequate sewerage facilities and insufficient solid waste management (Ibid 2006). Cities also discharged ever increasing amount of waste into the air, freshwater bodies, etc. and which in turn leads to alarming water quality and aquatic ecosystem.

The influx of population in urban centres leads to rise in demand for water. Urban water services delivery is important for a country's economic growth, for increase in productivity and reduction in poverty (Mathur and Thakur 2006). The theory and evidence suggested that there exists a positive relationship between growth of urbanisation and water demand (McDonald et al. 2014). In a similar fashion, a study conducted by Jiang et al. (2014) found that as urban growth increases caused to increasing demand for fresh water. Since most of the studies on urbanisation link with the water security due to its increasing demand with the rising population and economic development (Shaban and Sharma 2007). This rising pattern of water scarcity poses a greater threat to water sustainability in different parts of the world. The United Nation's sustainable development goals (SDGs) are also working in a way to provide the clean water and sanitation for all by 2030 (UN 2018).

As of the causal direction, Jiang et al. (2014) found in China that economic growth is mainly caused by urbanisation and non-agricultural productivity. But at the same time, with these rising economic activities the opportunity cost for water use and allocations of water among various users have increased. The rise in urban centres leads to rise in demand more domestic water and industrial sector, and on the other hand, reduction in the amount of water allocated in the agricultural sector. McDonald (2014) further stated that effective assessment of urban water requirements should take into consideration of infrastructure as well as financial development for limiting water stress in any areas. In this setting, Mathur and Thakur (2006) discussed about the reform, which is required in urban water sector in India through appropriate price setting. Water being considered as a "commodity" by the World Bank in 1990, the Eight Five Year

Plan (1992-1997) of India emphasised that water should be supplied based on its effective demand, backed by cost recovery principles and also managed by private agency (Sampat 2007).

Mathur and Thakur (2006) stated that water pricing charged in most of the cities and towns in India are low as compared to the expenditure incurred in its provision. On an average, price recovered from the sale of water and other charges are approximately 22 percent to 25 percent lower than its maintenance and operation expenditures (Ibid 2006). Consequently, this led to poor service delivery to public in terms of areas coverage for the services. Pierce (2016) also found that most of the cities in India collect far less revenue than the required amount to cover the existing cost of providing basic public services delivery such as water and sanitation, electricity and waste collection. In India, to render this water services delivery in cities, the revenue used is less than 1 percent of Gross Domestic Product (GDP) compared to 5 percent in Brazil and 6 percent in South Africa, which is even far lesser than the revenue required to maintain the urban sustainability (Ibid 2016). Therefore, proper reforms are needed in water sector with the growing urbanisation to mitigate the water problems and enhance the service delivery to the water users.

2.3 CONCEPT ON CONNECTING URBANISATION AND WATER

The twenty-first century is marked as a period of rapid transformation of the people's life, moving from rural to an urbanised life. This period of rapid urbanisation is linked with modernisation and industrialisation, which reflects economic transformation and development. Many cities around the world have experienced a drastic upsurge in economic growth, due to agglomeration, population growth with human capital, technological development and political changes (Liu et al. 2015). In reality, urbanisation has not only linked with the economic growth, but also led to transformation of the people life socially, culturally and politically (Lollen 2015; Brown et al. 2009; Montagomery 2008; Jenerette and Larsen 2006). In 2018, around 1.7 billion people, which account for 23 percent of the world population, lived in the city. It is further expected to rise and 28 percent of the population that will be concentrating in cities by 2030 and the urban population is projected to increase in all class sizes, while rural population is projected to decline from 45 percent in 2018 to 40 percent in 2030 (UN 2018). Population growth in the less developed countries' urban areas are more rapid. On an average, annual growth rate in these nations is 2.4 percent per year between 2000 and 2030 (Boberg 2005). This growth is generally caused by several factors such as natural increase in population, indicating more birth and less mortality, accompanied by high rural to urban migration and inclusion of rural areas into peri-urban or urban areas (Rukmani 1994). There exists a significant difference in pace and pattern of urbanisation in the world. This variation are visible everywhere, in the developed, developing and less developing regions. The countries like Caribbean and Latin American nations have been highly urbanised in the last few decades, which account for 75 percent of the population living in urban areas in 2000, higher proportion compared to Europe. It is expected that these regions will undergo a rapid population growth of 84 percent in 2030. In Asia and Africa, where half of the population lived in rural areas. Urban areas are expected to grow by 57 percent in Africa and 23 percent in Asia from 2018 to 2030 (UN 2018).

Migration does influence growth of urban centres, especially in the developing countries. United Nations estimated that 50 percent of urban growth in the early 1980s was due to the net migration, movement of population from rural to urban areas and reclassification of rural areas into urban. During this period, in China, urban growth was 72 percent, much higher than that of the other Asian nations, which was estimated at 45 percent (UN 2015). Despite the rural-to-rural and urban-to-urban migration prevalent in many countries, much attention is given by the policy makers more on to understand the transitional phase from rural-to-urban migration.

The population size matters a lot when it comes to the use of resources including water consumption. Their relationship is non-linear in terms of resources availability and population size (Boberg 2005). The magnitude of the population growth severely impacts on the fresh water resources availability. As urbanisation increases the resources associated in it will definitely increase. Urbanisation affects the required quantity and quality of water supply. The quantity demand for water vary in different economic activities and in different stages. The demand of water is very high in agriculture, followed by industries and domestic sectors, and it depends upon the different income groups as well. In low income countries, to manage the urban water supply is very difficult. The water allocation and governing systems are mostly found to be very ineffective in poor countries and that leads to demand-supply gap. There is also a wide difference in per capita water use in domestic sector. In developed countries, the use of per capita freshwater is high. In United Kingdom and United States of America, around 334 litres and 578 litres of water respectively were used per person per day compared to the less developing countries like Africa where around 47 litres of water is found to be used per person per day and 95 litres per person per day in Asia (Ibid. 2005). This implies that the high income countries are found to have consumed more water per capita and water withdrawal is also high in those countries. Water use per capita also goes up slightly high as countries move from the low income to lower middle income, to upper middle income and further to the high income level. When economy grows the proportion of water consumption demand in domestic and industrial sectors will increase by 55 percent in the year 2050 (UN 2015).

2.4 URBAN WATER PRICING

In most of the countries, the water pricing is either based on volumetric or non-volumetric consumption to the end users. The urban water is usually billed on a volumetric basis (Mann 1970), and therefore, water pricing acts as an important instrumental tool for the conservation of existing resource, improving efficient used, bringing social equity and securing financial sustainability of water used today and tomorrow (World Bank 1999). The basic reasons for implementation of volumetric consumption of water in most parts of the cities is likely to put forth with the arguments as creation of an incentives in terms of repairing water leakages pipes as well as to account for un-accounted water consumption and proper water resources management. The volumetric account of water does have effect on water users, because they do respond to a price increase from zero to some positive rate after imposition of metering system (Howe and Linaweaver 1967). Water pricing is one of the important reforms in water sector. Proper price setting for water will increase the revenue and enhance the water coverage amongst different users. But selecting appropriate pricing is a central problem in economics (Sorenson et al. 1978). Most of the price setting for water is decided through the control over the water resources management. Based on the rules and regulations of the countries, one holds authority to manage and provide water to the end users. In some countries, water is totally controlled by the command authority who acts as a sole responsible agent to provide the water to the common public and charge the administered prices. The administered price is basically imposed by public agency in the absence of an interactive market process (Ayoo and Horbulyk 2008). In most of the developed countries, the provision to provide water to the consumers was also managed by private agency and charged the market price for the water consumption. Market price are set by the private agents depending on the consumer demand and supply (Ibid 2008).

2.5 RESEARCH GAP

As urbanisation increases many problems are likely to emerge. It may be in connection with allocations of resources amongst users who hold the available resources. Many studies on urbanisation and water resources management were found to have conducted in isolation. In urban East Sikkim district, so far, no comprehensive study on urbanisation and water resources management has been conducted to figure out the issues concerning domestic water supply. In this study, we are juxtaposition urbanisation and water resources management together and assessing/examining water issues caused due by urbanisation.

In this study, a broader question is put forth as whether the rise in urbanisation leads to water supply shortage in urban centres in East Sikkim district or not. For understanding this issue, one must understand water tariff structure and water supply policy in Sikkim. So far, no concrete policy is visible to implement the water tariff structure in Sikkim, especially in the urban centres of East Sikkim district. But, recently, the Government of Sikkim came up with an understanding of water quantity measurement ideas for conservation and to estimate the un-accounted water through volumetric water consumption tariff system. It is believed that the proposed volumetric consumption of water will be implemented soon in the state through the increasing block tariff. But, no scientific assessment has been conducted on whether the proposed model is appropriate or not in this small state.

CHAPTER III

OBJECTIVES, METHODOLOGY AND RESEARCH IMPLICATIONS

With the background and literature reviews discussed in chapter II, it is understood that the study on urbanisation is intertwined with water issues in the urban cities and towns. Even in the East Sikkim district, the urbanisation is very rapidly taking place. Many studies have been conducted by different scholars on urbanisation and water issues separately and independently. Whether the issue of water resources is really connected with the urbanisation process needs a careful analysis. Based on the research problem discussed, three major research questions have been put forth to capture the overall understanding of urbanisation and water resources management in this study.

3.1 RESEARCH QUESTIONS AND OBJECTIVES OF THE STUDY

From the background mentioned above, this study tries to explore some of the research questions as given below:

1. Is the ever growing urbanisation process proportionately supported by the required quality and quantity water supply in East Sikkim district?
2. Is the water problem negatively related with the income level in East Sikkim district?
3. Is the existing policy of domestic water management system effective in the wake of rapid upsurge of urbanisation in the East Sikkim district?

The specific objectives of the study are given below:

1. To assess the growth and trend of urbanisation in East Sikkim district.

2. To assess quantity and quality drinking water demand with the emergence of urbanisation in East Sikkim district.
3. To examine the existing domestic water policy in the East Sikkim district.

3.2 THE SOURCES OF DATA, SAMPLING AND METHODOLOGY

This section discusses methodology and methods employed in the study. Besides, this section covers the sources of relevant data used, areas of study undertaken and sampling techniques and area of the study. This study is supported by both secondary and primary data. To understand overall urbanisation process and trend in the study area, using secondary data, the descriptive statistics like percentage and share of the population and share of migrant population have been employed. Further, an urbanisation index has also been constructed to capture the trend of the urbanisation process. We have also collected information through primary field survey, conducted in the month of June-July 2018. To understand urbanisation, migration is taken as one of the important variables used in this study. The information pertaining to domestic water resources (in litres) could not be collected through secondary sources. Therefore, a field survey was carried out to generate the quantity of water consumption (in litres) to understand quantity water required in the domestic sector.

3.3 SECONDARY SOURCES AND TECHNIQUES EMPLOYED

The secondary data related to urban population and workers working in non-agricultural activities over the period from 1981 to 2015 were collected from the population census office located in Gangtok. The other sources of the secondary data have been gathered from the various government reports and the published annual data for the period from 1981 to 2015. The data related to river water quality were collected from the State

Pollution Control Board (SPCB), Govt. of Sikkim over the period from 2010 to 2015. The data on water infrastructure for water works on operation and maintenance expenditure from the period of 2004 to 2015 were collected from the handbooks of demand for grant in water under the Department of Water Security and Public Health Engineering Department (WS & PHED), Government of Sikkim. As the proposed study focuses on the urbanisation and water resources management in the East Sikkim district, using the information collected through secondary data, an urbanisation index and a river water quality index were constructed. For the construction of urbanisation index, we have used six indicators. They are: total urban population, total urban household, total main workers in non-agricultural activities, total educational institutions, total numbers of registered and functioning industrial unit and total registered vehicles in urban East Sikkim district. These indicators were incorporated arbitrarily based on their importance and relevance. The individual index values were normalized by using the following formula:

$$\text{Index} = \frac{\text{Actual value} - \text{Minimum value}}{\text{Maximum value} - \text{Minimum value}}$$

After getting individual index value, composite index was constructed to understand urbanisation index.

As of the data on river water quality, information collected by the state government (the State Pollution Control Board, Government of Sikkim, Gangtok) from nine different stations of the major rivers flowing from upstream, *Chungthang* under North Sikkim district which pass through the middle of the state (Sikkim) to downstream, *Melli* which falls under the state boundary of both Sikkim and West Bengal state have been used. The sketch of the river channel flowing through the state is given in Figure 4.4 in chapter IV. In order to see the difference in physio-chemical parameters of water— pH, conductivity, nitrate, biochemical oxygen demand (BOD), total coliform and faecal coliform, the information collected from the nine river stations were considered for the periods from 2010 to 2015. The monthly water quality data were also analysed, and the assessments have been made based on the comparison between the different parameters with their threshold values defined by the World Health Organization (WHO).

The Water Quality Index (WQI) is one of the most useful and efficient methods for analysing surface and ground water quality and its suitability for drinking (Seth et al. 2016). The WQI also provides the valuable information pertaining to the composite influence of different water quality parameters to the concerned citizens and policy makers (Akoteyon et al. 2011). In this study, we have used the weighted arithmetic index to construct WQI by using six water quality parameters mentioned above. The WQI is constructed by using the following formula:

$$\text{WQI} = \frac{\sum WiQi}{\sum Wi}$$

Where, W_i is the unit weight for each water quality parameters— pH, conductivity, nitrate, biochemical oxygen demand (BOD), total coliform and faecal coliform.

Again, Wi is calculated using the following equation:

$W_i = K/S_i$

Where, K is the constant proportionality and S_i is the standard permissible value set by World Health Organization (WHO) of the i^{th} parameter.

Further, the quality rating Q_i is calculated using the following equation:

$Q_i = V_i/S_i$

Where, V_i is estimated value of the i^{th} parameter at a given sampling point. The standard rating of water quality given by Brown et al. (1970) is depicted in chapter IV, and we have compared it with water quality of nine rivers stations located in Sikkim.

3.4PRIMARY SOURCES OF DATA, SAMPLING AND METHODOLOGY

As of the primary data, a well-structured questionnaire has been formulated, especially for the households who are currently residing in urban areas of East Sikkim district. The questionnaire covers the components of demographic characteristics, quantum of water supply consumed per day per head, amount of water supplied by the government agency. The field survey covered 355 households. We have used multi-stage sampling technique to identify the final household or respondents. In the first stage, we have identified the district having the highest percentage of population in Sikkim. Based on the criteria, defined by the population census of India 2011, we have selected three urban centres and one census town from East Sikkim district. The selected urban centres for the field survey are: Gangtok, Singtam, Rangpo and a census town i.e., Rhenok from East Sikkim district. Within the selected urban centres, we have selected the wards in each urban centres. Since Gangtok has got the highest percentage of population, followed by Rangpo, Singtam and Rhenok, we have used proportion of population to select sample size from urban centres of East Sikkim district. Accordingly, the total 355 sample respondents were decomposed as: 280 sample size from Gangtok, followed by 30 sample size from Rangpo, 25 sample size from Singtam and 20 from Rhenok. To identify the respondents, random sampling method was used. The respondents were interviewed at their respective homes, depending on their availability and suitability.

Starting from the first research objective and to quantify domestic water resource availability vis-à-vis urbanisation in the East Sikkim district, two types of inhabitants namely owner and renters residing in urban East Sikkim district have been surveyed. To understand migration trend, which indirectly captures population growth and urbanisation trend, we asked the respondents about their years of residency in the present place. Increasing migration basically adds to the population pressure, which in turn leads to increasing demand for water. Further, analysing the basic requirement of water in urban East Sikkim district, we asked the respondents about their water storage capacity (in litres). As socio-economic characteristics influence water consumption patterns the socio-economic variables have also been considered. The socio-economic variables such as the highest educational attainment by the family members, family size, per capita monthly family expenditure and hours of water supply, which influenced per capita water consumption have been included. Descriptive statistics have been employed to understand the per capita domestic water consumption. Usually, people belong to the higher income strata may likely to get more necessary amenities compared to lower income bracket. To understand the effect of income on water supply availability, we have taken the proxy of monthly expenditure as income level of the present household. Based on the convenience, we have categorized each household into five income groups: Lower income group (A), Lower middle income group (B), Middle income group (C), Middle higher income group (D) and Higher income group (E), in order to estimate per capita water consumption per day across income groups.

Further, to understand the per capita water consumption effect on the variables selected, we have used multiple linear regression model given below:

$Y_i = \beta_0+\beta_1 X_1 +\beta_2 X_2+ \beta_3 X_3 +\ldots\ldots\ldots. + U_i$

Where Y_i measures the i^{th} per capita water consumption per day (In litre)

β_0 measures the intercept term

β_i measures the slope coefficient values of i^{th} independent variables

X_i includes (X_1, X_2, X_3….) measures the i^{th} independent variables

U_i measures the i^{th} error terms in the model

A log transformation is being used in this exercise, in order to deal with outliers in the variables present in the regression analysis. To check multi-collinearity problem present in our study, we employed a set of variance inflation factors (VIF). We regress on each explanatory variable from selected parameters and calculated for VIFs is given in equation below:

$$\mathrm{VIF} = \frac{1}{1 - \mathrm{R}^2}$$

Our second objective intent to examine the economic analysis of demand for drinking water quality. We have analysed the cost estimation on water purification the household adopted for producing quality water, especially for drinking purposes. While surveying the respondents were asked about their spending power on water quality improvement. The proper way to clean drinking water is possible through either boiling or filtering the water. Therefore, there may present some variations in the methods adopted by households for cleaning drinking water. Based on this, we have collected the components related to cost of water purification device the household acquired at their respective houses. With presumption that there are households who do not use filter but do boil the water before drinking, we have kept fixed cost of boiling water is Rs 60 per person per annum. To estimate the average expenditure the households incurred for producing one litre of quality drinking water, we have simply taken the capital and maintenance cost of the filter the household incurred over the life time of the filter. Here, capital and operational and maintenance cost include investment on filter, interest charges and life span of the filter. To calculate the boiling cost for drinking, we have used Rs 60 as annual fixed charge for 730 litres (2 litres in 365 days is considered as minimum drinking water) for boiling cost per person per year in this study. We have also assumed that each individual required 2 litres of clean water for drinking purpose in a day. For estimating the unit cost (per liter of safe drinking water), we have adopted the methods used by Roy et al. (2004).

To understand the policy variable responsible for per capita cost on producing one litre of quality water, we have used the regression model. Since to avoid the outlier in the variables selected in the model, we have transformed the model from linear to log-log linear regression model. This regression analysis will help us to capture the in-build relationship between dependent and independent variables. The interpretation of the estimated mean value of the dependent variable gives the value of the independent variables.

As given in the third objective, the study tried to examine the existing policy on domestic water resource in East Sikkim district. We have used both the secondary and primary data to understand this objective. From secondary data sources, we are introspecting the various water policy measures adopted in India and its impact in the state of Sikkim. For understanding the possibility of switching from non-meter to meter water supply connection decision made by the water authority, we have carried out an experimental method to justify the public's choice preference. In this study, we have created three scenarios for water supply system; namely 1. Existing scenario or status-quo (Non-Volumetric), 2. Proposed (Volumetric) and 3. Alternative managed by private agency (Volumetric). By asking respondents three scenarios, we derive the individual households' preference for domestic water supply.

CHAPTER IV

URBANISATION VIS-À-VIS WATER RESOURCES MANAGEMENT

4.1 URBANISATION IN EAST SIKKIM DISTRICT

Sikkim, located on the foothills of the eastern Himalaya, merged with the Indian union on 16th May 1975. In terms of population, in 2011, it was estimated at 6.07 lakhs, considered to be the least populous state in the country. Large scale migration in Sikkim started from the 1930s till 1980s, especially during the British India and on the eve of the country's independence. However, after the merger, internal migrants increased manifold, much higher than that of the international migrants. In this manner, in the state of Sikkim, the migrant population (both internal and international) outnumbered the local population, estimated at 61 per cent of the total state's population in 1981 and marginally declined to 57 per cent in 1991 (Bhutia and Srivastava 2014, p. 2). The decadal growth rate of population, in 1981, it was around 51 per cent, the ever highest growth rate in the state's history. Thereafter, the ethnic violence in Bhutan in the early 1990s between the Nepali and the Dzongkha (Bhutanese) might have also added to the decadal growth of Sikkim's migrant population (Singh and Singha 2016, pp. 226-246). Urban centres are, generally, the preferred destinations for the migrants. Understandably, the East Sikkim district, especially the Gangtok (capital city of the state and East Sikkim district head quarter) and its surrounding towns have been the preferred destinations for the migrant population in Sikkim. For instance, 65.02 percent of the total migrant population of the state are found in East Sikkim district alone, mainly in Gangtok and its surrounding urban centres (Bhutia and Srivastava 2014, p. 3). In this manner, urbanisation pace in Sikkim has been very fast, especially in the East

Sikkim district. In simple parlance, the process of population shift from rural to urban centres, if not exclusively, is also considered as urbanisation. In this context, Pradhan (2004, p. 177) said, "rapid population growth is one of the main reasons for increasing the number of people on the move for livelihood, and migration has been a major factor of rapid population growth in urban areas in less developed countries". In quantitative term, the degree of urbanisation, especially in the East Sikkim district, the urban population has increased from 18 per cent in 1991 to 43 percent in 2011. Detail may be referred to Table 4.1

Table 4.1: Degree of Urbanisation (in %)

Year	1971	1981	1991	2001	2011
India	18.24	23.34	25.72	27.78	31.16
Sikkim	9.37	16.15	9.1	11.07	25.15
East Sikkim District	20.00	31.00	18.00	22.00	43.00

Source: Author's Estimation from: Registrar General of India, Census of India (1971, 1981, 1991, 2001 & 2011)

To understand urbanisation process in Sikkim scientifically, by employing secondary data available in the public domain, an urbanisation index is constructed in this section and the indicators/components used in constructing index are depicted in Table 4.2. While constructing the index, urban population growth and urban economic activities have also been considered and the same concept was also reflected in many other studies (e.g. Bhagat and Mohanty 2009; Bairoch and Goertz 1986, etc.). In this study, slightly different from the studies mentioned above, altogether six indicators have been used to construct the composite urbanisation index. The indicators included in index construction are as follows– 1) total urban population, 2) total number of urban households, 3) the main workers involved in non-agricultural activities, 4) total educational institute, 5) total number of registered and functioning industrial unit, and

6) total registered vehicles. To arrive at the individual index, the values of the indicators were normalized by using the following formula:

$$\text{Index} = \frac{\text{Actual value} - \text{Minimum value}}{\text{Maximum value} - \text{Minimum value}}$$

The year to year growth rate and exponential growth rate of urban population from 1981 to 2015 in East Sikkim district alone were found to be 4.07 per cent and 4.61 per cent respectively. The growth rate of registered vehicles in Sikkim has also increased significantly from 1981 to 2015 at the tune of 14.52 per cent (year to year growth) and its Compound Annual Growth Rate (CAGR) was found to be around 13 per cent during the same period. The growth rate (CAGR) of registered and functioning industrial units from 1981 to 2015 in East Sikkim district was found to be around 13.25 per cent. This reflects the urbanisation rate in the East Sikkim district and it can be considered as one of the most urbanised districts in the state.

Table 4.2: Indicators of Urbanisation in East Sikkim District (1981 to 2015)

Indicators	Year to Year growth rate	CAGR
Total urban population (TUP)	4.07	4.61
Total urban household (TUHH)	4.50	5.22
Total main worker in non-agricultural activities (TMWNAA)	3.79	4.33
Total educational institutes (TEI)	2.54	2.66
Total No. registered and functioning industrial units (TRI)	12.69	13.25
Total registered vehicles (TRV)*	14.52	12.70

Source: Author’s estimation
*Due to lack of data exclusively for East Sikkim District, it is taken for entire Sikkim

Table 4.3 given below depicts the construction of urbanisation index over the period from 1981 to 2015 in East Sikkim district. We have also estimated composite urbanisation index by adding altogether six indicators of urbanisation index from 1981 to 2015.

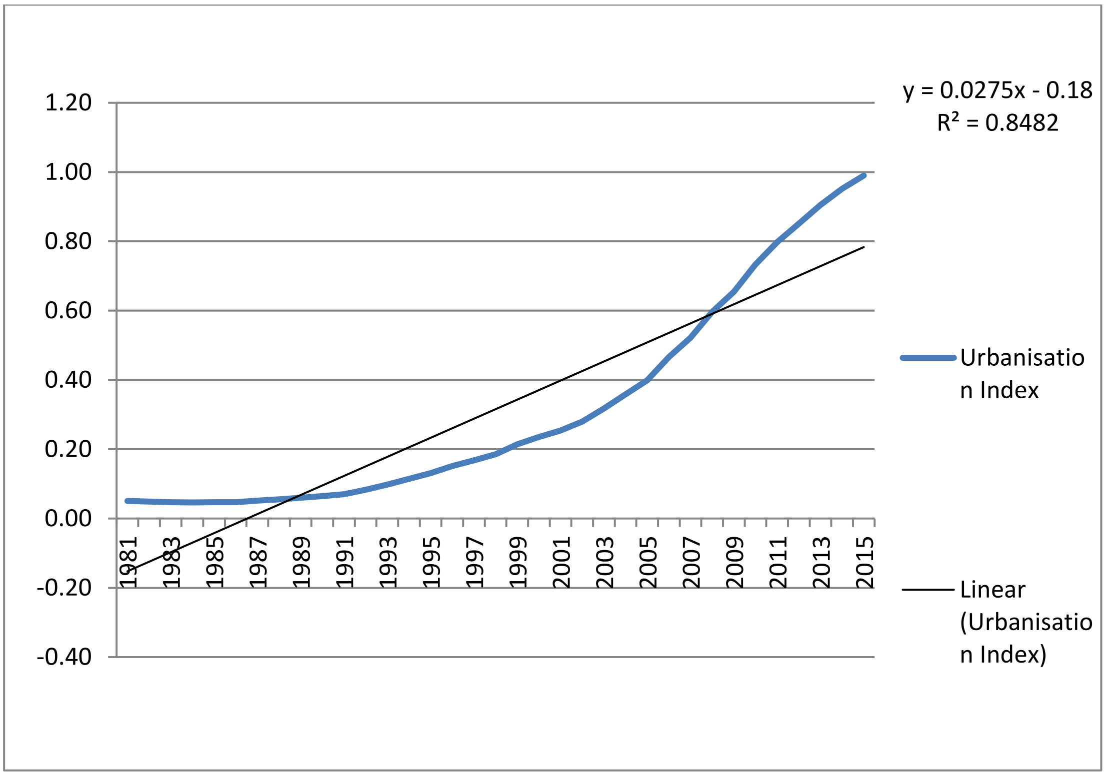
Table 4.3: Urbanisation index (UI) for East Sikkim district from 1981-2015

Year	TUP index	TUHH index	TMWNAA index	TRI index	TEI index	TRV index	COMPOSITE UI
1981	0.09	0.09	0.13	0.00	0.00	0.00	0.30
1982	0.08	0.08	0.11	0.00	0.02	0.00	0.29
1983	0.07	0.07	0.10	0.00	0.04	0.01	0.28
1984	0.06	0.06	0.09	0.00	0.06	0.01	0.28
1985	0.05	0.05	0.07	0.00	0.08	0.02	0.28
1986	0.04	0.04	0.06	0.00	0.11	0.03	0.28
1987	0.03	0.03	0.05	0.03	0.13	0.04	0.31
1988	0.02	0.02	0.04	0.04	0.15	0.05	0.33
1989	0.02	0.02	0.03	0.05	0.18	0.07	0.36
1990	0.01	0.01	0.02	0.05	0.20	0.10	0.38
1991	0.00	0.00	0.00	0.07	0.23	0.13	0.42
1992	0.01	0.01	0.01	0.07	0.25	0.14	0.50
1993	0.03	0.03	0.03	0.09	0.28	0.15	0.59
1994	0.04	0.04	0.04	0.10	0.31	0.16	0.69
1995	0.05	0.05	0.05	0.12	0.33	0.17	0.78
1996	0.07	0.07	0.07	0.15	0.36	0.18	0.91
1997	0.09	0.09	0.09	0.16	0.39	0.19	1.01
1998	0.10	0.11	0.10	0.17	0.42	0.21	1.11
1999	0.12	0.13	0.12	0.24	0.45	0.22	1.29
2000	0.14	0.15	0.14	0.26	0.49	0.24	1.41
2001	0.16	0.17	0.16	0.27	0.52	0.24	1.52
2002	0.20	0.20	0.20	0.27	0.55	0.26	1.68
2003	0.24	0.24	0.24	0.31	0.59	0.30	1.91
2004	0.28	0.28	0.28	0.33	0.62	0.36	2.15
2005	0.32	0.32	0.32	0.36	0.66	0.40	2.39
2006	0.37	0.37	0.37	0.52	0.70	0.46	2.80
2007	0.43	0.43	0.43	0.60	0.74	0.51	3.13
2008	0.49	0.48	0.49	0.80	0.78	0.54	3.58
2009	0.55	0.55	0.55	0.86	0.82	0.60	3.92
2010	0.62	0.62	0.62	0.98	0.86	0.70	4.40
2011	0.70	0.69	0.70	0.98	0.90	0.81	4.78
2012	0.77	0.77	0.77	0.99	0.95	0.86	5.11
2013	0.85	0.85	0.85	0.99	0.99	0.90	5.43
2014	0.92	0.92	0.92	1.00	1.00	0.95	5.71
2015	1.00	1.00	1.00	1.00	1.00	1.00	6.00

Source: Author’s estimate

Figure 4.1 depicts the trend line analysis of the urbanisation index, constructed by using the formula given in methodology section. The year to year growth rate of urbanisation is estimated at 9.77 percent over the period from 1981 to 2015.

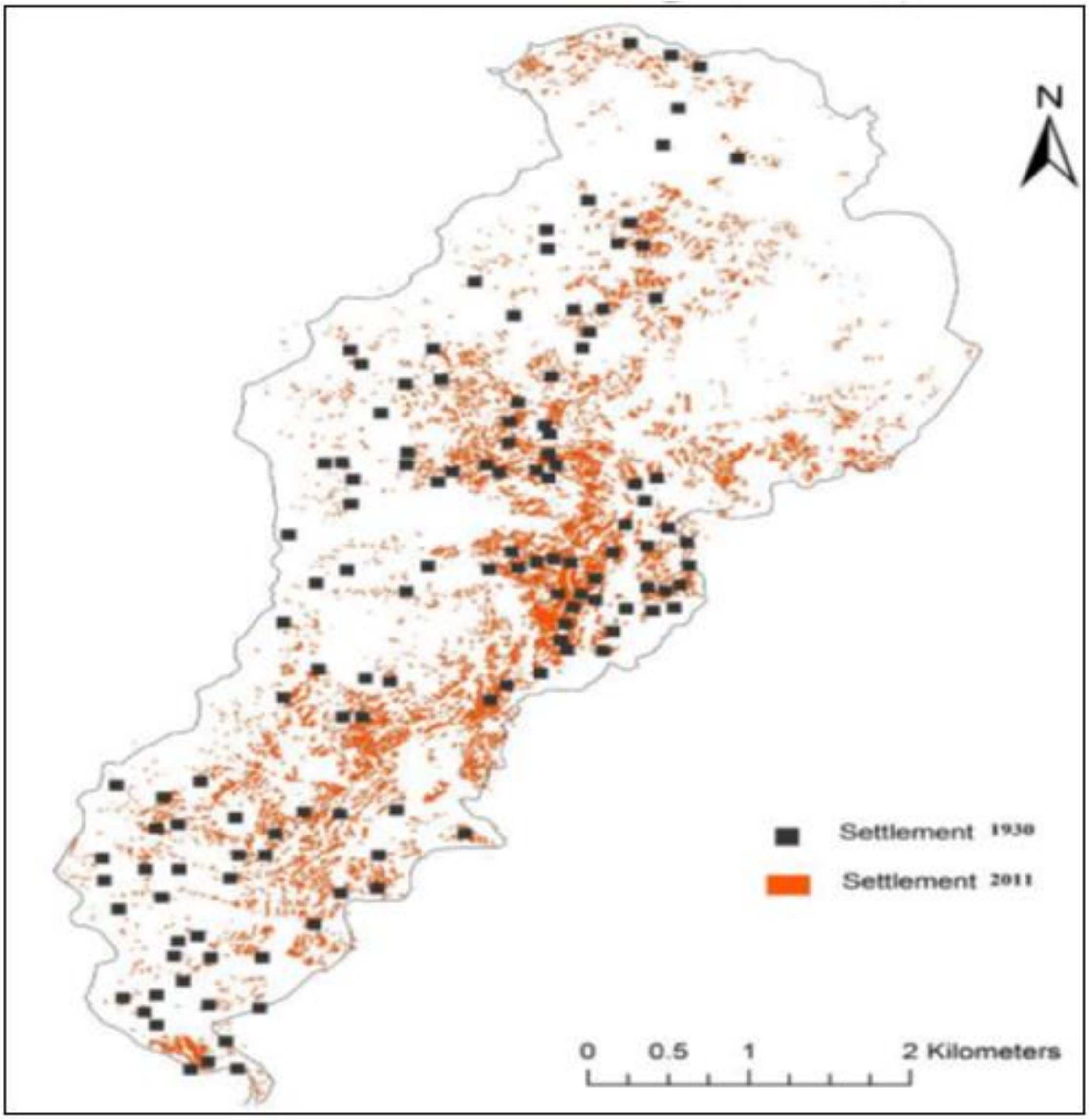
Figure 4.1 Growth Trend of Urbanisation in East Sikkim district (1981 to 2015)



Source: Author's estimate

There has been a dynamic shift in terms of demographic, land used and settlement patterns in Gangtok, Sikkim. A study conducted by Paul et al. (2016) by using remote sensing and geographic information system (GIS) technique witnessed a rapid transformation of settlement pattern in and around the Gangtok city. It is also understood that any change in land cover area reflects the environmental change. Therefore, there is a drastic change in the patterns of residential, industrial and commercial areas of Gangtok, which has reached new stage of development in terms of urban growth.

Figure 4.2: Expansion of Settlement Pattern in Gangtok (1930 and 2011)



Source: Paul et al. (2016)

4.2 SOURCES OF URBAN WATER SUPPLY

The state of Sikkim is endowed with rich water resources such as glaciers, rivers and natural springs. Around 84 glaciers, covering an area of about 440.30 sq. km (SER 2016) do provide major sources of water in Sikkim. Large numbers of natural springs are also present in the state of Sikkim, estimated at around 2000 natural springs (Sharma et al. 2013). In most parts of the rural Sikkim, springs provide main source of water and 80 percent of rural population depends on this water source for drinking as well as irrigation purposes (ibid 2013). Even in some parts of the urban areas in Sikkim get water from natural spring for various activities.

In Sikkim, water supply is based on gravity flow, which serves as a major source of domestic and drinking water to the inhabitants. Usually springs get recharged well in the monsoon season, serve as a source of domestic water supply for a quite large number of people and slowly getting dried at the end of the winter season. In the process, as water table of the springs rises during the rainy season it hits the rock surface and flows from it, which serves as potable water for more than 5 months in a year. In Sikkim, there are many perennial springs, which serve as drinking water source to people throughout the year. Water security and public health engineering department is the sole distributor of required water for the public, and the task of maintaining quality of water supplied to the residents in urban centres of Sikkim is also shouldered by this department. According to the census data available from the last two decades, 2001 to 2011, depicted in Table 4.4, it is seen that a considerable decline in the percentage of urban households access to safe drinking water in Sikkim, which includes tap water provided by the public health engineering department, Government of Sikkim. Hand pump and tube-well as a source of domestic water consumption used by inhabitant of Sikkim has declined from 97 percent to 92 percent in 2001 and 2011 respectively (Census 2011). On the other hand, there has been an increase in the percentage of household access to safe drinking water in rural Sikkim from 67 percent to 83 percent during the same period. The declined in urban residents accessed to safe drinking water may be associated with many other factors like increased in the population growth and reduction in the rainfall pattern over the periods. The percentage growth of urban population in Sikkim was 11 percent in 2001 and increased to 25 percent in 2011.

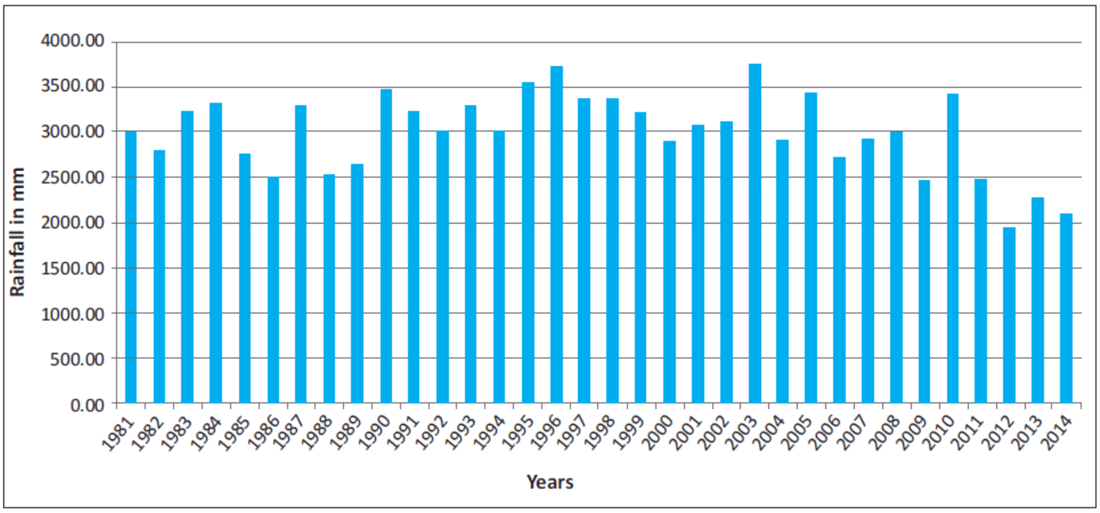
Table 4.4: Percentage of Household Access to Safe Drinking Water in Sikkim

Year	1981	1991	2001	2011
Total	30.3	73.1	70.7	85.3
Rural	21.7	70.8	67.0	82.7
Urban	71.9	92.8	97.1	92.2

Source: Registrar General of India, Census (1981, 1991, 2001 & 2011)

In Sikkim, there has been a clear evidence of declining rainfall pattern over the years probably be due to the climate change, of course, it requires scientific analysis.

Figure 4.3: Rainfall Pattern in Sikkim (1981 to 2014)



Source: Sikeniv.nic.in

For instance, the rainfall pattern over the period from 1981 to 2014 (refer to Fig. 4.3) is found to have slightly declined and perhaps, this may along with the growth in urban population, be the major factor for reducing access to safe drinking water for the residents over the year in Sikkim. If this trend continues, in future, there will be a shortage of water in urban areas to a great extent. On an average, the annual rainfall level till 2011 in the state was recorded at around 2500 mm to 3500 mm, but it has been declining since then and dropped below 2000 mm in 2012.

Table 4.5 presented below shows the percentage of drinking water sources in each district, which includes rural and urban areas. In 1998, the two districts of Sikkim namely East and North were found to have accessed to higher percentage of the urban tap water supply and lower percentage of natural spring and others water sources. As shown in Table 4.5, from 1998, the percentage of urban households access to safe drinking water was estimated at 90 percent in East Sikkim district (Gyatso and Bagdas 1998) and increased to 97 percent in 2001 (Census 2001). But, in 2011, there was a slight decline in percentage of access to safe drinking water, down by 4.9 percent.

Table 4.5: Percentage of Sources of Drinking Water in Sikkim (in 1998)

Source	EAST		WEST		SOUTH		NORTH	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Tap	74.8	89.9	85.7	76.4	78	61.6	63.6	91.4
Natural Spring	20.0	8.1	10.4	15.1	15.5	31.1	33.1	6.9
Others	5.2	1.9	3.9	8.5	6.5	7.3	3.2	1.6

Source: Gyatso and Bagdas (1998)

As happened elsewhere, following the rise of urbanisation the issue of water shortage in the Himalayan state of Sikkim is also felt. To what extent and in which manner the water issue is being experienced by the Sikkimese require a thorough analysis. Is this only a quantity issue or quality issue? It is also understood that the rise in population leads to water quality and quantity problems. In Sikkim also, with the rapid rise in construction activities and encroachment in the forest lands lead to rise in runoff water and population level due to the inability of concrete land to absorb rainwater and waste water flow into water system. Forest helps to store water and reduces pollutants and erosion. With rapid urban growth, tremendous pressure on land and water was felt. Financial constraint, inefficient delivery mechanism such as insufficient management and technical skills put extra burden on water quality that is being supplied to public. Population growth in cities is faster than the service delivery provision, decline in percentage of clean water and it results to low quality of life.

River is also one of the important sources of water supply to the public. In the less developing countries, river water is directly used for consumption purposes at household level. In Sikkim, the drinking water is not directly related to river water. If the rapid growth of urban towns leads to scarcity of water, then to manage water supply for the residents, river water can be considered as one of the sources of water supply. The quality of surface water, river water in this context, is a serious concern at present, due to urban sprawl, industrialisation and deforestation in the recent past. In order to attain sustainable development and to manage to provide safe drinking water, surface water quality and quantity must be monitored (Seth et al. 2016). Till very recently, around 80 percent of the India's population drink unsafe and polluted water. More than 2 million people die annually due to water-borne diseases (Kirch 2002). Sikkim has two important rivers namely— Teesta and Rangeet. These rivers along with their tributaries, from the left bank tributaries of Teesta are Lachung chu, Chakung chu, Dikchu, Rani Khola and Rangpo chu, and from the right bank tributaries lies Zemu chu and Rangyong chu. At Melli, Teesta merges with river Rangeet, which originated from Rathong glaciers. The major tributaries of Rangeet are the Rangbong, Relli, Rathong and Kalej (SERS 2016), and it provides drinking water to the people of East Sikkim. Today, most of the river water are getting polluted due to the anthropogenic activities, domestic wastes, weathering of rocks, etc., which in turn affect the physio-chemical and biological properties of water (Kulkarni and Pawar 2006; Lamtura et al. 2014; Patil et al. 2014; Scheili et al. 2016). The same is also happening in Sikkim and its water bodies. A study by Kirch (2002) tried to investigate the impact of urbanisation on water bodies, especially the river water, and found that development and growth of urbanisation negatively affect water quality, and poor management of urbanisation turns out to be the main problem of water shortage.

Limited study is found in this regard in Sikkim especially the carrying capacity of water resources and water quality monitoring in the urban centres and the rivers located in the urban centres. Therefore, this section attempts to assess water quality, including river water, which flow through the towns, in and around Gangtok. The water quality at the source, the glaciers in the up-stream Himalayan range, is generally considered as very good and clean, but urbanisation has greatly affected the downstream water quality. As of the data on the water quality, the rivers flowing from the upstream, Chungthang (North Sikkim district) to Melli, downstream is getting polluted as it moves down. Data on the water quality measuring parameters of the rivers flowing through the urban centres of East Sikkim district were obtained from the government publication as well as through the interview with official from the state pollution control board of Government of Sikkim GoS, Gangtok. Water samples were collected by the GoS (2016) from the nine river stations for the period from 2010 to 2015. For understanding water quality in this study areas, the physio-chemical parameters of water such as: pH, conductivity, nitrate, biochemical oxygen demand (BOD), total coliform and faecal coliform have been used. In this study we have taken six parameters of water quality. The definition of each parameters is explained as followed:

pH in as an indicator of the water quality as acidic or alkaline. According to World Health Organization set the limit value for pH 6.5 to 8.5 because the freshwater aquatic organism needs a pH in this range. If any change in this limit, then water become bitter taste causing corrosion, damaging mucous membrane, and also affecting aquatic life (Narashima Rao et al. 2011).

Conductivity measures of the ability of a solution such as water in a river to pass current. During the periods of low flow river water has greater influence on conductivity which is one of the indicators that polluting discharges have entered the water. Therefore, water with absolutely no impurities determine conductivity is very poorly performed.

Nitrate is produces with the help of blue-green algae. The legumes of blue green algae have the ability to covert nitrogen gas into nitrate and plants uses this to build protein. Nitrate is an indicator of water quality presences in water bodies. It has an adverse effect on health, if nitrate value increases above 45mg/l. In ground water, the presence of nitrate is very high due to high solubility capacity in water bodies (Nas and Ali, 2006). The WHO set permissible standard below 45 mg/l. The large amount of nitrate present in water causes "Blue-Baby disease in bottle fed infant" (Knobeloch et al. 2000).

Biochemical oxygen demand (BOD) measured the level of dissolved oxygen required by micro-organisms to decompose organic matter present in water bodies. This organic matter includes urban runoff which carries waste from streets and sidewalk, plant decay, waste generated from residential and industrial areas. If there is a large quantity of organic waste in the water supply, there will also be a lots of micro-organism present working to break down this waste. In this case, the demand for oxygen will also be high. So, the BOD level will be high. As the waste is break down, BOD levels will begin to decline. The WHO set permissible standard at 2 mg/l or less.

Coliform are known to be a group of bacteria (pathogenic organisms). It is an indicator of contamination of human or animal faecal waste in the water. The existing of it can causes various water borne diseases like diarrhea, typhoid and hepatitis (Theron and Cloete 2002; Elkp et al. 2003; Sood et al. 2008). The WHO set permissible limit 0 MPN/100 ml for drinking water. The central pollution control board (CPCB) of

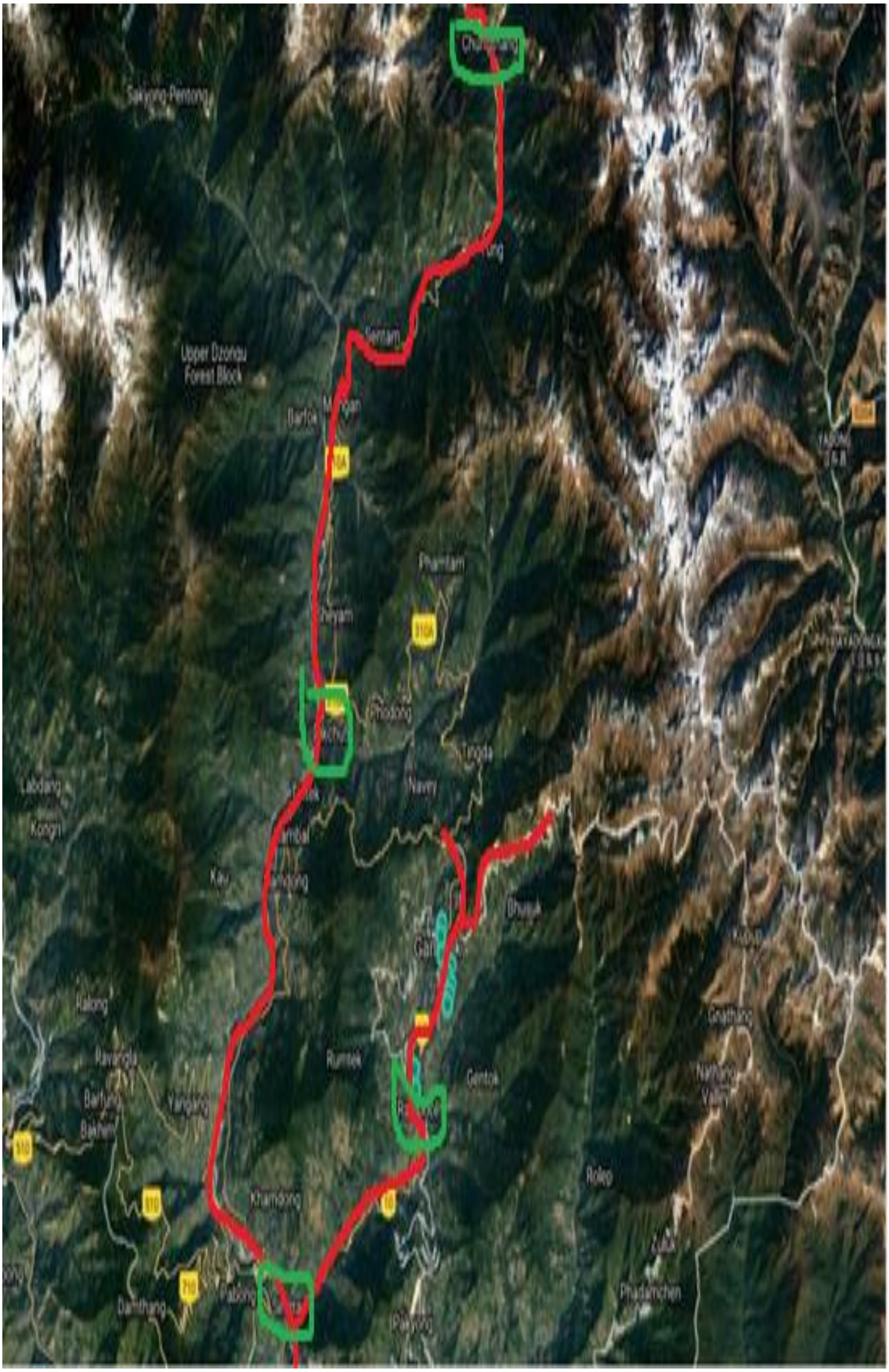
India has given the standard for the drinking water source without conventional treatment, total coliforms Organism MPN/100ml shall be 50 or less.

Faecal coliform refers to bacterial contamination of natural water. Usually, its present in the digestive tracks of warm blooded animals, including humans and are excreted in the feces. The improper channel of waste product of humans and animals can contribute to increase of faecal coliform in streams or rivers. The WHO set permissible limit 0 MPN/100 ml for drinking water.

The monthly water quality data were analysed, and the assessments have been followed by comparing different parameters with their threshold values defined by the World Health Organization (WHO). Due to shortage of time series data on river water quality, indicators prior to 2010, for understanding river quality, this study is limited to the period from 2010 to 2015. To understand, river water quality in Sikkim, we have constructed the water quality index (WQI). The WQI provides, the valuable information pertaining to the composite influence of different water quality parameters (Akoteyon et al. 2011).

The standard rating of water quality according to WQI (Brown et al. 1970) is given in Table 4.6 and compared it with water quality of nine stations located in Sikkim. Figure 4.4 shows the location of nine stations of river in Sikkim, which is the area of study. The marked green circles areas represent the location of river sites and red line represents the flow of rivers from upper-stream at Chungthang till downstream, located at Melli.

Figure 4.4: Study location of river site in Sikkim



Source: Google map of Sikkim.

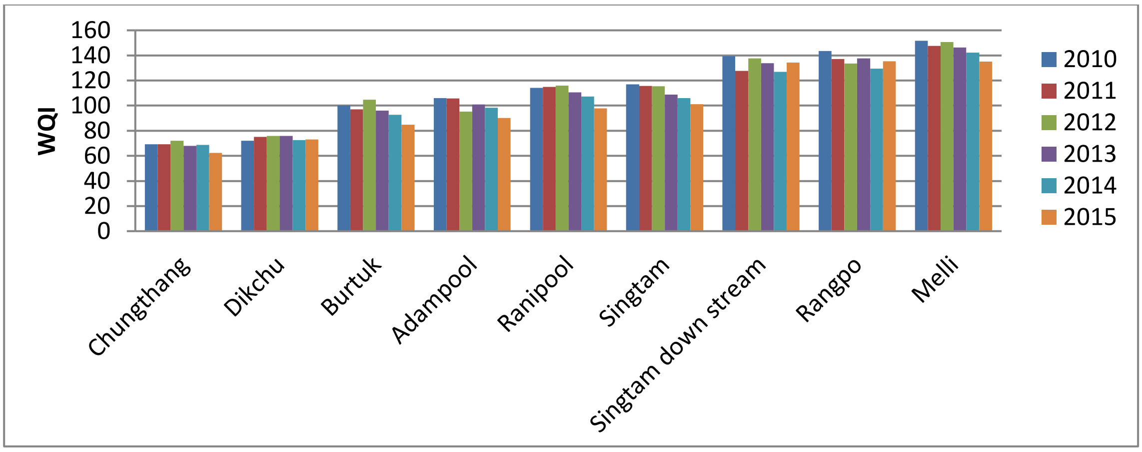
Table 4.6: Standard Rating of Water Quality Categories (in %)

WQI (Scale)	Rating
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
>100	Unsuitable water quality

Source: Brown et al. (1970)

Figure 4.5 depicts the water quality index (WQI) for the period from 2010 to 2015. Though the water quality rating in each site found to be low (lesser the WQI value better the performance) in up-stream stations like Chungthang and Dikchu. Its value is found to be higher than that of the standard norm of 50 per cent set by Brown et al. (1970). As we assess the river water quality, which is flowing all the way through the Gangtok city, at different stations from the up-stream river at Burtuk to down-stream at Melli, the water quality rating was found to be decreasing as it goes down from upstream to downwards (Fig. 4.5).

Figure 4.5: Water Quality Index in Nine River Locations (2010-2015)



Source: Author's estimation

The deterioration of river water quality has already crossed threshold value set by Brown et al. (1970) that is more than 50 percent indicating the unsustainable water quality. This is found in all the river location in the study area of Sikkim. Table 4.7, shows the mean value of each of the parameters.

Table 4.7: Descriptive Statistics of Water Quality Parameters (2010-2015)

Variable	Observation	Mean	Std. Dev.	Min	Max	WHO Standard
pH	54	6.37	0.18	6	6.5	6.5 – 8.5
Conductivity µmhos/ cm	54	275	11.93	250	300	< 800
Nitrate mg/l	54	2.47	0.28	2.2	3.2	< 45
Biochemical oxygen demand mg/l	54	3.43	0.70	2.15	4.5	< 2
Total coliform MNP/100ml	54	163.14	70.91	40	300	< 50
Fecal coliform MNP/100ml	54	59.04	39.47	23	170	<50

Source: Author's calculation

On an average, three water quality parameters are not up to the mark set by WHO. There is an increase in parameters of water quality, such as biochemical oxygen demand, total coliform and fecal coliform. The standard value of biochemical oxygen demand should be less than 2 mg/l, but in Sikkim, it is found that the value is greater than 3mg/l. Similarly, for the total coliform and fecal coliform have crossed the threshold value of less than 50 MNP/100 for drinking water measure set by WHO. Urbanisation process deteriorates river water quality, mainly attributed by industrial growth in urban areas.

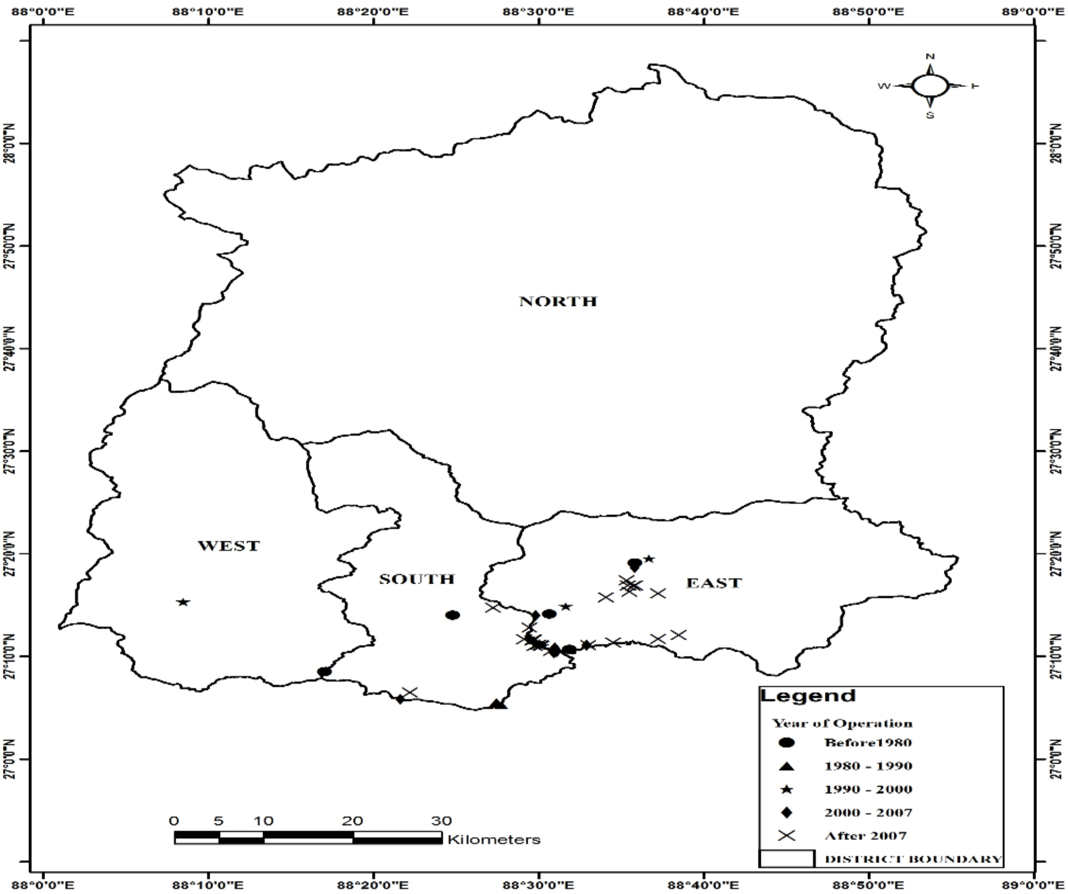
CHAPTER V

URBANISATION TREND AND DOMESTIC WATER RESOURCES MANAGEMENT: EVIDENCE FROM THE PRIMARY SURVEY

From the secondary data analysis made in the previous chapter (in Chapter IV) it is quite clear that the expansion of urban centres and urbanisation process is primarily driven not only by the growth of urban population and rural-urban migration, it is also contributed largely by the process of industrialisation. Further, it is also understood that the urbanisation pattern in the East Sikkim district has been a very rapid, and the year to year growth rate of urbanisation was found to be at the tune of 9.77 percent over the period from 1981 to 2015. At the same time, the percentage of the household access to safe drinking water in the district was found to be declining at the tune of 4.9 percent from 2001 to 2011. The shortage of domestic water resources was also found to be very apparent in the district. In short, as urbanisation rate increases the problem of domestic water resources aggravated. To corroborate the result given by the secondary data, this section/chapter analyses the primary data collected from the East Sikkim district. Since the rise in population in the urban centres is considered as one of the measures of urbanisation, the immigration or the migrant population in the district is also included as an important determinant of urbanisation.

Urbanisation, at the one side, rises economic activities basically through the growth of industrial activities and trade and business. On the other side, it decreases water quality and quantity. From the assessment on water quality measure analysed through river water in the East Sikkim district in the previous chapter it is understood that the quality of the river water was found to be declining due to the urbanisation and industrialisation in the district. Since water quality, especially the river water, is found to be deteriorating over the years there is a possibility of declining quality in other water sources as well where the people of the district are getting domestic water from. Therefore, this chapter tries to see the veracity of findings/results given by the secondary data in previous chapter. For convenient of the readers, the present chapter is divided into two sections as: 1) growth and trend of urbanisation and water sources available (in term of liter) for the urban household consumption in the East Sikkim district, and 2) demand for drinking water quality for the households.

Figure 5.1: Concentration and Year of Establishing Industries in Sikkim



Source: Singha, Sherpa and Jaman (Forthcoming)

Figure 5.1 shows the areas of concentration of industries and their establishment periods in the state of Sikkim. Most of the industries are found to be concentrated in the East

Sikkim district and it led to a large number of labour migration, increased migrant population in this district. Secondly, most of the industries concentrated in this district are also found to have established after 2007. Since the industrialisation, urbanisation and rise in population including migration have been taking place at the very rapid rate in the East Sikkim, the present study also incorporated the above-mentioned components. Field survey of this study is also conducted in the urban centres of the district where the industrial units are concentrated the most.

5.1 URBANISATION TREND IN EAST SIKKIM DISTRICT

To address the first research question, as whether the ever growing urbanisation proportionately supported by the required quality and quantity of water in the East Sikkim district or not, the present study conducted a primary survey on 355 households living in the urban centres of East Sikkim district. The selected urban centres in the district are: Gangtok, Singtam, Rangpo and Rhenock.

As mentioned above, migrant population forms a major portion of the population in East Sikkim district. In this study, the households moving from rural to urban within the district, inter-district migration (movement of the people from other districts to East Sikkim district), immigrant population (migrated from outside the states, including international immigrants) have been included to understand the migrant population over the years. Since the migrants primarily aim at the urban centres as their destination, this process ultimately adds up to the urban population over the years. Urban population includes both migrant population and early/original inhabitants. Original population in this study is defined as the people living in the survey areas (East Sikkim district) before 1948, country's independence in 1947.

Table 5.1: Percentage of Migrant and Original Households in East Sikkim District

Household Category	Number
Migrant households*	242 (68.16)
Original households**	113 (31.83)
Total	**355 (100)**

Source: Field survey
Note: Figures in the parenthesis represent the percentage of the total
*Migrant implies the household came in East Sikkim district after 1947
**Original households, living in the East Sikkim district before 1948

Table 5.1 depicts the share of sample households in the district between the original inhabitant (live on or before 1948) and the migrant households (migrated after 1947). Of the total 355 sample households, only 113 households turned out to be original inhabitants and 242 households are the migrant households, came after 1947. In percentage terms, they constitute 31.83 percent and 68.16 percent respectively. Before the state's merger with Indian union, from the period of 1948 to 1975, the households migrated to urban East Sikkim district, the survey areas were found to be only 21.

Table 5.2: Migration Growth Rate before and after Merger (in %) in East Sikkim

Before 1975	After 1975 to 2018
15.67	68.17

Source: Author's estimate

Table 5.2 depicts the growth rate of migration before and after merger in East Sikkim district and Table 5.3 depicts the growth rate of migrant households over the period from 1948 to 2018. On an average, the year-to-year growth rate of migrant households was estimated at 13.48 percent over the period from 1948 to 2018.

Table 5.3: Migrant Household(s) in Different Year (Number and Growth Rate) in East Sikkim District

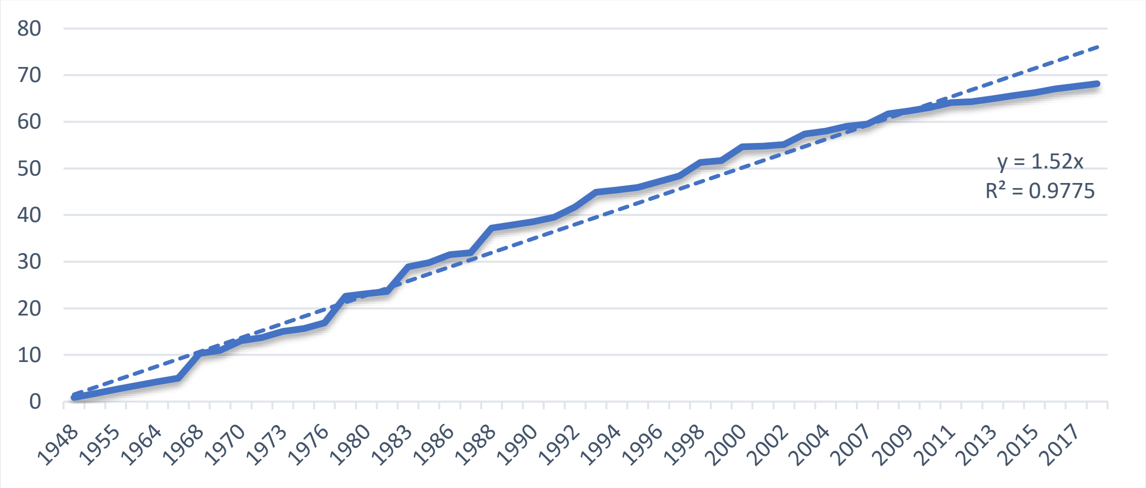
Year	Total Household	Total Migrant Household	Year-wise Migrant Household added	Migrant Growth Rate** (in %)
Base-Year*	113	-		--
1948	114	1	1	--

Year	Total Household	Total Migrant Household	Year-wise Migrant Household added	Migrant Growth Rate** (in %)
1950	115	2	1	100
1955	116	3	1	100
1958	117	4	1	50
1964	118	5	1	33
1965	119	6	1	25
1968	126	13	7	20
1969	127	14	1	117
1970	130	17	3	8
1972	131	18	1	21
1973	133	20	2	6
1975	134	21	1	11
1976	136	23	2	5
1978	146	33	10	10
1980	147	34	1	43
1982	148	35	1	3
1983	159	46	11	3
1985	161	48	2	31
1986	165	52	4	4
1987	166	53	1	8
1988	180	67	14	2
1989	182	69	2	26
1990	184	71	2	3
1991	187	74	3	3
1992	194	81	7	4
1993	205	92	11	9
1994	207	94	2	14
1995	209	96	2	2
1996	214	101	5	2
1997	219	106	5	5
1998	232	119	13	5
1999	234	121	2	12
2000	249	136	15	2
2001	250	137	1	12
2002	252	139	2	1
2003	265	152	13	1
2004	269	156	4	9
2006	276	163	7	3
2007	279	166	3	4
2008	295	182	16	2
2009	300	187	5	10
2010	306	193	6	3
2011	315	202	9	3

Year	Total Household	Total Migrant Household	Year-wise Migrant Household added	Migrant Growth Rate** (in %)
2012	317	204	2	5
2013	322	209	5	1
2014	329	216	7	2
2015	335	222	6	3
2016	343	230	8	3
2017	349	236	6	4
2018	355	242	6	3

Source: Author's estimation based on the Primary survey
* indicates the original household in the urban East Sikkim district before 1948
**Year to year growth rate (growth rate compared to previous year)

Figure 5.2: Urbanisation Growth trend in East Sikkim district



Source: Author's estimate based on Primary data

Using population growth as the migration rate, Figure 5.2 shows the growing trend of urbanisation in East Sikkim over the period from 1948 to 2018. On the eve of Sikkim merged with Indian union in 1975, the total migrant households in East Sikkim was very negligible (20 migrant households) and it has increased to more than four times till date. The finding from the primary survey data of this study in the context of growth rate of migrant households and population, which is further considered as "urbanisation" is truly supported by a study conducted by Bhutia and Srivastava (2014). Since the 1980s, following the setting up of many development activities (after the merger with India in 1975) many migrants have reached the urban centres of the state.

Of course, there is an issue of causal direction between the two (urbanisation and migration), which requires scientific investigation. There are number of factors which attract many migrants in Sikkim. To mention a few, the infrastructural development activities, good environmental, accommodative attitude of the people of Sikkim towards the visitors/migrants, North-east Industrial and Investment Promotion Policy 2007, etc. may be mentioned. Also, Sikkim being one of the most peaceful states in the country, in terms of law and order situation, migrants prefer to come to Sikkim.

From the primary data analysis, it is found that on an average, the year to year growth rate of migration in the study area was found to be 13.48 percent over the period from 1948 to 2018. At this rate of growth of migration, many issues are likely to face by the people in the state. One of the pertinent issues in this context is the domestic water resources management, and majority of the migrants generally target urban centres, of course, migration status in the rural areas in the present study district is not examined. Since rise in migration is also one of the major factors for increasing population, and in turn rise in demand for safe domestic water, the issue of it is directly related to the water demand/issue as well. In this study, we have tried to understand how the public are managing water when the growth pace of urbanisation in the East Sikkim district is very high.

Water plays an important role and it sustains life on the planet. Water is the backbone of an economy, and one cannot imagine growth of any sector in the economy without water. Sikkim lies in the Himalayan range, endowed with rich perennial flow of the glacier, river and natural springs. The main sources of water for the public in this study area is drawn from the tap water supplied by the government, privately managed tap water, spring (in local parlance *Dhara*), dug-wells, bore-well and rivers. Of the sources mentioned, the tap water is the main water supply source at households which comes through the network of the pipes and it is provided by the water security and public health engineering department (WS&PHED), Govt. of Sikkim. Figure 5.3, depicts the picture taken at the time of field survey in 2018, reflects the urban household water connection through pipe lines provided by the PHE department in East Sikkim district.

Figure 5.3: Household Water Connection through Pipelines Provided by the PHE Department

Source: Author’s collection at the time of field survey, Lall market, Gangtok.

Privately managed water supply in Sikkim is defined as “the public consciously decide to connect for private pipeline water source”, wherein households incur the cost of connection, maintenance and operation charges for regular water supply at domestic, industries or agriculture and services sectors. For the interest of the readers, it can be referred to Figure 5.4 as privately managed water connection and reservoir in the urban East Sikkim district.

Figure 5.4: Privately Managed Water Connection and Reservoir

Source: Source: Author's collection at the time of field survey at Upper Sichey.

Of course, people mostly depend on PHED supply water and private pipe line is taken as an alternative or stand-by to the former. In case of short-supply of tap water, the public will go for private pipeline water supply connections, spring or bore well water. Spring water is the natural and free flowing water on the land surface which comes through the overfilled of the aquifers. Well and bore-well water are the result of extraction of water through deep boring under the ground. River water is a natural stream of fresh water flowing from the glaciers, lake and other tributaries. In urban centres, water security and public health engineering department (WS & PHED), Govt. of Sikkim is the sole provider of tap water to the public. As per norm, under the supervision of WS & PHED, the water is filtered before distributing to the public.

5.2 WATER AVAILABILITY IN THE URBAN EAST SIKKIM DISTRICT

The main water supply sources in the study survey areas are primarily: 1) for the Gangtok Municipal Council area is from the river Ratey chu and the main water treatment plant is located at *selep tank,* installed at Gangtok, 2) for the Nagar Panchayat areas of Singtam, water source is located at Chalamthang (a sub-division of Pakyong), 3) for the Rangpo, water source location are at Dikling and Kamarey (a sub-division of Pakyong), and 4) for the water supply source of Rhenock are located at sudunglakhang (a sub-division of Rongli) and kopchey (a sub-division of Namchi).

5.3 SOCIO-ECONOMIC STATUS OF THE SURVEYED HOUSEHOLDS

Using the primary survey data, the descriptive statistics are presented in Table 5.4 and the different pictorial presentation are depicted in Figure 5.5, Figure 5.6 and Figure 5.7.

Table 5.4: Descriptive Statistics of the Domestic Households

Variables	Obs.	Mean	Min	Max	Std. Dev.
Family size (In number)	355	4.76	1	12	2.13
Hours of water supply (In a day)	355	2.95	1	5	1.55
Year of migration*	355	14.89	0	71	15.82
Highest educational attainment by family members (Years of schooling)	355	12.2	0	17	3.98
Family’s monthly expenditure** (In Rupees)	321	19900	3000	80000	10149

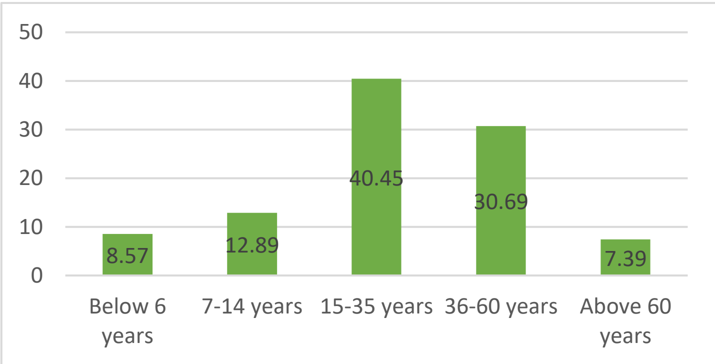
Source: Primary Field Survey

* In the year of migration, we have included both the original and migrated households.

** In the field survey, only 321 households (of the total 355 sample households) revealed their monthly expenditure that includes expenditure on food and non-food items

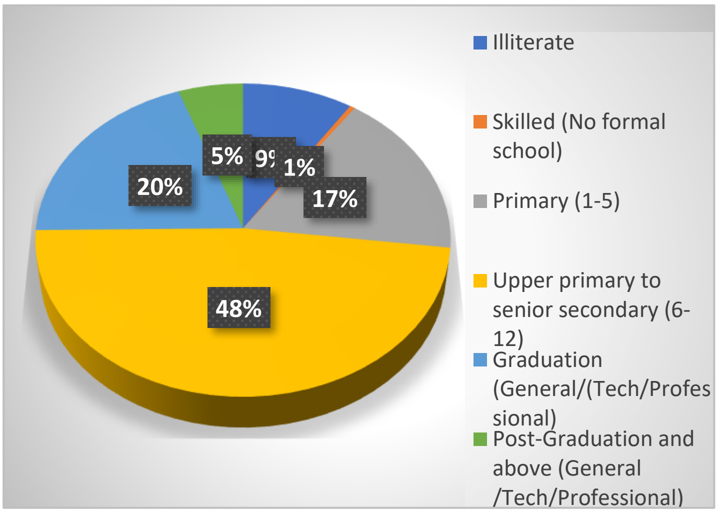
The average family size of the sample household is 5 members and the mean hours of water supply in the survey areas is 3 hours per day. The average period of the migrants staying in the survey areas (who have come to the urban East Sikkim district) irrespective of their origin is 15 years. The highest educational attainment by the members in the sample families is 12 years of schooling, which indicates upper primary to secondary education. The mean monthly expenditure of the family is Rs. 19900/- which includes both food and non-food items. The following section deals with the basic socio-economic status of the surveyed households, which include age composition of the family members, educational status, religious category, etc. It is done in keeping in the mind that the socio-economic characteristics of the households do influence their water consumption behavior.

Figure 5.5: Age Composition of the Respondents



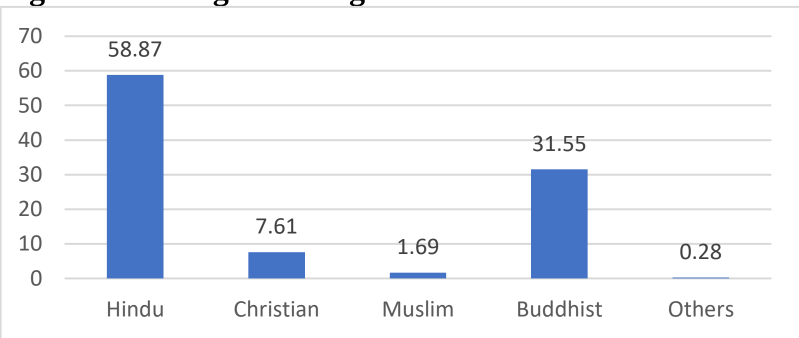
Of the total 355 sample households surveyed, 40.45 percent of them (members of the sample households) are belonged to age groups of 15-35 years, followed by 30.69 percent of persons belonged to age groups of 30-60 years. A total of 12.89 percent and 8.57 percent of persons are belonged to age groups of 7-14 years and below 6 years of age respectively. While, hardly around 7.35 percent of persons are found to be belonged to above 60 years of age groups.

Figure 5.6: Educational Attainment of the Household Members



As of the educational attainment, we have found that 48 percent of family members completed their upper primary to senior secondary education. Around 20 percent of the family members of the sample households have graduated from college and hardly 5 percent of the family members are found to be having post graduate and above qualification. Around 17 percent of family members are found to have studied till primary level and 9 percent of family members are found to be illiterate.

Figure 5.7: Religion Background of the Households



Within religious background, a total of 58.87 percent of households are found to be belonged to Hinduism. While, 31.55 percent and 7.61 percent of households are belonged to Buddhist and Christian community respectively. Around 1.69 percent 0.28 percent of households are belonged to Muslim and Others communities respectively.

Table 5.5: Occupational Structure of the Sample Households (in No.)

Occupational Structure	Family's main source of income	Subsidiary source of income
Agriculture	2 (0.56)	0
Govt. Employee	97 (27.37)	56 (15.77)
Private Employee	68 (19.15)	26 (7.32)
Self-Employee	32 (9.01)	11 (3.10)
Retired	29 (8.16)	1 (0.28)
Casual worker	4 (1.13)	0
Combination of farming, salaried and self-employed	1 (0.28)	0
Business	57 (16.05)	34 (9.58)
Others*	65 (18.31)	11 (3.10)
No Source	0	139 (60.85)
Total	355 (100)	355 (100)

Source: Author's estimate based on primary survey data
Note: Figures in the parenthesis represent the percentage of the total
* indicate the other occupation like driver, home guard, security guard, etc.

Table 5.5 indicates the occupational structure and the main source of income of head of the family members are represented in Table 5.5. We have found that 27.37 percent of the head of families are employed in govt. sector, 19.15 percent earning source is from private jobs (salaried). Around, 18.31 percent and 16.05 percent of head of families' sources of income are from others and business respectively. When we asked the households regarding whether they have subsidiaries sources of income, we found that 60.85 percent of households do not have any subsidiaries earning sources. But 15.77 percent of families do have the subsidiaries sources of income from govt. jobs, and 9.58 percent and 7.32 percent of households earning from business and private employee respectively.

Table 5.6: No. of households connected with different water supply sources

Sources	No. of Household
Tap water (Govt./PHED)	240(67.60)
Private Pipeline	50(14.08)
Both (Tap water & private pipeline)	58(16.34)
Spring	2(0.56)
Others*	5(1.41)
Total	**355(100)**

Source: Author's estimate based on primary survey data
Note: Figures in the parenthesis represent the percentage of the total
* includes purchasing water, well, & borrowing from/depend on neighbors.

Table 5.6 shows different water supply sources, the sample households connected for domestic purposes in the urban East Sikkim district. The main sources of domestic water supply for the households is from the PHED through pipe line. In term of number, it is 240 households out of 355 total sample sizes who depends solely on this source and in percentage term, it is 67.60 percent of the total sample households. On the other hand, 14.08 percent of households are having access to only private pipeline water supply (pipeline/tap managed by the private/individual) and 16.34 percent of households depends both on government tap (PHED) and private pipeline water supply, and remaining around 1.97 percent of sample households get water from spring and others sources at their door step. Altogether, we have found that tap water source is having the highest 98.02 percentage share of water supply (which includes both the government managed tap, private pipeline). Usually, in urban centres, the scope of having more than one sources of water supply is very limited and the same result was also found in our study as well.

According to the definition given by the Registrar General of India (2011), to measure a distance of the main water supply sources, the households receiving water can be classified into three categories: a). Within house, b). Shared but in the same building and c). Away from the premises. Therefore, we have used the same concept to understand the distance of main water supply the households connect water at their respective houses. We have found that 79 percent of households are having water supply within house across different water sources. The percentage of tap water source within house premises is 69 percent compared to other water supply sources and these figures are presented in the Table 5.7. The percentage of shared water connection in the same building/premise is the highest sources, which account for 68 percent.

Table 5.7: Types of distance of main water supply across different water sources

Premise	Tap water	Private pipeline	Both Tap and private water	Others*	Total
Within house	193 (68.92)	37 (13.21)	48 (17.42)	2 (0.71)	280 (78.87)
Share, but in same building	40 (67.79)	9 (15.30)	10 (16.95)	0 (0)	59 (16.62)
Away from premises	7 (43.75)	4 (25.00)	0 (0)	5 (31.25)	16 (4.51)
Total	240 (67.32)	50 (14.10)	5 (1.40)	7 (1.97)	355 (100)

Source: Author's estimate primary survey data
Note: Figures in the parenthesis represent the percentage of the total.
* includes spring, purchasing water, well, & borrowing from/depend on neighbors.

The daily water supply collections (in hours) in urban East Sikkim district varies from less than one hour to around four hours in different households and from different sources are presented in Table 5.8.

Table 5.8: No. of households getting hours of water across different sources

Hours water supply	Tap water (PHED)	Pvt. Pipeline	Both (Tap & Pvt. Pipeline)	Others*	Total
<1	70	3	13	1	87 (24.51)
1-2 hrs	76	3	9	3	91 (25.63)
2-3 hrs	37	4	6	0	47 (13.24)
3-4 hrs	20	4	3	0	27 (7.60)
>4 hrs	37	36	27	3	103 (28.73)
Total	240	50	58	7	355 (100)

Source: Author's estimate based on Primary survey data.
Note: Figures in the parenthesis represent the percentage of the total.
* includes spring, purchasing water, well, & borrowing from/depend on neighbors.

We have observed that 25 percent of the households receiving water from different sources are getting less than one hour of water supply in a day. At the same time, 29 percent of households getting more than four hours of water supply in a day. As urbanisation process increases at rapid pace the evidence of reducing hour of water supply is visible in the urban centres. But, merely reducing hour of water supply does not support the situation of shortage of water. There are various factors that caused to shortage of water. They are mainly, the nature of water use, the demand for water in other sectors, rapid population growth, etc. Connecting the urbanisation trend pattern with domestic water resources management in terms of percentage of households depending on different sources of water in East Sikkim district, the following Table 5.9, depicts the percentage change of urbanisation growth rate vis-à-vis the rate of change in different sources of water over the period from 1998 to 2018.

Table 5.9: Urbanisation vis-à-vis domestic water resources management (% of household depending on different sources of water) in urban East Sikkim district

	1998*	2018**	Change (%)
Urbanisation rate	51.29	68.17	16.88
Tap water	89.9	98.02	8.12
Spring	8.1	0.56	-7.54
Others	1.9	1.41	-0.49

Sources: Author's estimation.

Note: a) * indicate the data on the year 1998 especially for water, the households getting for drinking was taken from the Gyatso and Bagdas (1998)
b) ** For the year 2018, data was collected from primary field survey undertaken in the month of June-July 2018.

The percentage of urbanisation growth rate was 51.29 percent in 1998 and increased to 68.17 percent in 2018. These data are collected from primary field survey. Whereas, the domestic households accessing tap water supply increased from 89.9 percent to 98.02 percent in 1998 to 2018 respectively. But the domestic water sources drawing from other sources showed a consistent decline. For spring water supply, the percentage of household depending on it has decreased from 8.1 percent to 0.56 percent during the same period. We have found that, as urbanisation growth rate increases the tap water supply connection growth rate is at the increasing trend, but other water sources including spring for the domestic consumption started decreasing. In the study areas of urban East Sikkim district, we have found that the rate of change of urbanisation seems to be quite high, estimated at around 16.88 percent of urbanisation compared to the rate of change of tap water with 8.12 percent from the period of 1998 to 2018. Nevertheless, the household access to safe drinking water is still higher than that of the urbanisation rate.

To understand the concept of sustainability[4] of domestic water resources availability vis-à-vis urbanisation in East Sikkim district, we are considering the quantity of water consumption as a basic parameter in the study. The following sections will discuss the water use activities and water requirement in term of quantity of water consumption per person per day to capture the core context of sustainability of domestic water resources in the study area.

5.4 WATER USE ACTIVITIES AT HOUSEHOLD LEVEL

Water is used for various activities at the households, such as drinking and cooking, bathing and toilet, washing clothes and others (includes water use for gardening and washing vehicles) activities. Within these activities of water use at domestic households, the consumption of water used for bathing and toilet is the highest, followed by washing clothes and others activities. For the share of water consumption used for drinking and cooking purposes is very less (Shaban and Sharma 2007). Table 5.10 shows different sources of water consumption by households for different activities. We found that the households using 100 percentage of water from the tap connection do use for all purposes. Of the households depending on tap water, provided by the PHED, around 65 percent of water is used for drinking and cooking purpose, 64 percent for bathing and toilet, 62 percent for washing clothes and 63 percent for others activities that include washing car and gardening purposes. For those who depend on 100 percentage water from the private pipeline water, only 13 percent of households used for drinking and cooking and 14 percent for remaining other domestic activities. Around 4 percent of households use spring as an alternative/accessible source of water

[4] Sustainability is defined to ensure the high quality and quantity of water supply will be universally accessible to the public irrespective of their socio-economic conditions.

supply. Figure 5.8 shows some of the pictures of urban households using natural spring for different household activities in urban East Sikkim district.

Table 5.10: Share of Household using 100% of water sources for different activities

Activities	Tap water (PHED)	Private pipeline	Purchase	Spring	Others*
Drinking & cooking	232 (65.35)	46 (12.96)	1 (0.28)	11 (3.10)	3 (0.85)
Bathing & toilet	226 (63.66)	48 (13.52)	0 (0)	8 (2.25)	9 (2.54)
Washing clothes	221 (62.25)	48 (13.52)	0 (0)	17 (4.79)	8 (2.25)
Others**	224 (63.10)	48 (13.52)	0 (0)	16 (4.51)	10 (2.82)

Source: Author's estimate based on primary survey data
Note: Figures in parenthesis represent the percentage of the total
* includes well, borrowing from/depend on neighbors
** include the household's activities like car washing and water use for gardening.

Figure 5.8: Urban houses using natural spring as accessible source of water supply

Source: Field Survey at Bishal Goan, Gangtok.

The percentage share of household using 90 percent to 60 percent of water sources for different water activities depicted in Table 5.11 below. We have found that 3 percent of water is used for drinking and cooking, bathing and toilet, washing clothes and others activities of households depend on private pipeline water source compared to the rest of other water sources. This was mainly attributed with the fall in the household sample size as percentage share figure.

Table 5.11: Percentage share of Household using 90% to 60% of water sources for different activities

Activities	Tap water	Private pipeline	Spring	River	Others*
Drinking & Cooking	4 (1.13)	14 (3.94)	6 (1.69)	0 (0)	1 (0.28)
Bathing & Toilet	4 (1.13)	12 (3.38)	4 (1.13)	2 (0.56)	2 (0.56)
Washing Clothes	4 (1.13)	11 (3.10)	2 (0.56)	0 (0)	2 (0.56)
Others**	2 (0.56)	12 (3.38)	1 (0.28)	0 (0)	2 (0.56)

Source: Author's estimate based on primary survey data
Note: Figures in parenthesis represent the percentage term
* includes well, borrowing from/depend on neighbors
** include the household's activities like car washing and water use for gardening.

Table 5.12 shows that the households using 60-30 percent of water sources for different activities. We have found that household depends both tap and private pipeline water uses 5 percent for various household's water activities. We have also found that the household using water source from spring used is very minimum.

Table 5.12: Percentage share of Household using 60-30% of water sources for different activities

Activities	Tap water	Private pipeline	Spring
Drinking & Cooking	18 (5.07)	18 (5.07)	0 (0)
Bathing & Toilet	20 (5.63)	20 (5.63)	1 (0.28)
Washing Clothes	21 (5.92)	20 (5.63)	1 (0.28)

Others**	21 (5.92)	20 (5.63)	1 (0.28)

Source: Author's estimate based on primary survey data
Note: Figures in parenthesis represent percentage term
** include the household's activities like car washing and water use for gardening.

Table 5.13 shows the households depend on tap water provided by the PHED. Around 5 percent of water is used for drinking and cooking, bathing and toilet purposes, 4 percent of water is used for washing clothes and others activities compared to others water sources

Table 5.13: Percentage share of household using 30-5% of different water sources for different activities

Activities	Tap water	Private pipeline	Purchase	Spring	Others*
Drinking & Cooking	20 (5.63)	1 (0.28)	1 (0.28)	2 (0.56)	1 (0.28)
Bathing & Toilet	19 (5.35)	3 (0.85)	0 (0)	2 (0.56)	2 (0.56)
Washing Clothes	15 (4.23)	4 (1.13)	0 (0)	1 (0.28)	1 (0.28)
Others**	15 (4.23)	1 (0.28)	0 (0)	0 (0)	1 (0.28)

Source: Author's estimate based on primary survey data
Note: Figures in parenthesis represent the percentage term
* includes well, borrowing from/depend on neighbors
** includes the household activities like car washing and water use for gardening.

5.5 WATER REQUIREMENT IN URBAN CENTRES

The basic requirement of water is associated with the nature of water use, food habits, level of economic growth, culture and working conditions. According to the National commission for urbanisation 1988 in India suggested that 90-100 litres per capita per day is needed to lead a quality and healthy life (Sridhar and Reddy 2010). As per the norm set by the Bureau of Indian Standard (BIS), a minimum of water of 200 litres per person per day should be provided to high income group for domestic consumption in town and cities and 135 litres per person per day to the low-income group (Shaban and

Sharma 2007). The World Health Organization 2003 (Howard and Bartram 2003) has classified level of water access to the public as:

1. No access (consumption below 5 litres per capita per day)
2. Basic access (Average consumption of 20 litres per capita per day)
3. Intermediate access (Average consumption of 50 litres per capita per day)
4. Full access (Average consumption about 100 and above litres per capita per day)

To understand domestic consumption pattern of required water per capita per day in urban East Sikkim district, we have given range of water in term of litres is given in Table 5.14.

Table 5.14: Quantity of water consumption per person per day from different sources (in Litre)

	Tap water		Private pipeline		Both		Others*	
Water Consumption (in LPCD)	Obs.	Mean value	Obs.	Mean value	Obs.	Mean value	Obs.	Mean Value
3-20	34	12.44	2	12	6	16.39	4	7
21-30	14	27.59	2	24	6	29.46	1	30
31-40	15	36.16	-	-	-	-	1	33.33
41-50	8	46.94	-	-	3	40.89	-	-
51-60	7	54.88	2	60	2	54.20	-	-
Above 60	162	208.78	44	248.82	41	239.94	1	75

Source: Author's estimate primary survey data
* includes spring, purchasing water, well, & borrowing from/depend on neighbors.

From the primary survey presented in Table 5.14, we found in the urban East Sikkim district, out of 355 sample households, 248 households have about full access of water supply across different water sources, as per the norm set by the WHO. The mean value of water from tap is 208.78 litres, private pipeline is 248.82 litres and from both (tap and private pipeline) is 239.94 litres. We have also found that 107 households in our study area are getting water below the standard quantity set by the WHO i.e., 135 litres of water per person per day. In around, 30 percent of the households are having intermediate access to water consumption (in litres) per capita per day. Therefore, we can conclude that as urbanisation rate increases at 68.17 percent led to 70 percent of household accessing on an average the water consumption at above 60 litres per person per day in East Sikkim district in the year 2018.

As urbanisation increases, simultaneously there exists various dimensions that interplay with water consumption. The required quantity of water supply possibly depends on the income of the households. To understand the effect of income on the household water supply, while surveying, we asked respondents about their current expenses on food and non-food items. Based on this information provided by respondents on monthly expenditure on food and non-food, was considered the sum of the two expenditure components as a proxy for household income. From monthly consumption expenditure, we have categorised each household into five income groups: low income group (A), low-middle income group (B), middle income group (C), middle-higher income group (D) and higher income group (E).

Table 5.15: Income groups of the households based on monthly expenditure

Income groups	Monthly Household Expenditure
low income group (A)	Below Rs. 10000
low-middle income group (B)	Rs. 10000-20000
Middle income (C)	Rs. 20000-30000
Middle higher income (D)	Rs. 30000-40000
Higher income (E)	Above Rs. 40000

Source: Author’s estimate based on primary survey data

We have set the least expenditure the household incur i.e., below Rs. 10,000 as low income group. Similarly, for the rest of income categorization from total monthly expenditure is presented in Table 5.15. Within income categories, we have found that around 33 percent of household belong to low-middle income group, 10.98 percent of households belong to low income group and 5.35 percent of households are in higher income group, who use different water sources available for domestic consumption in the urban areas of East Sikkim district. From the primary survey, 9.57 percent of households did not reveal their total monthly expenditure (refer Table, 5.16).

Table 5.16: Frequency distribution of water sources across different income groups

Income range (In Rs.)	Tap water	Private pipeline	Both (Tap and private pipeline water)	Others *	Total frequency
Income not stated	26	5	3	0	34 (9.57)
Below 10000	26	5	5	3	39 (10.98)
10000-20000	79	13	21	4	117 (32.95)
20000-30000	62	14	14	0	90 (25.35)
30000-40000	33	12	10	0	56 (15.78)
Above 40000	13	1	5	0	19 (5.35)
Total	240	50	58	7	355 (100)

Source: Author's estimate Primary survey data
Note: Figures in the parenthesis represent percentage of the total
* includes purchasing water, well, & borrowing from/depend on neighbors.

When we compared the per capita water consumption (in term of litres) per day across the different income groups, it is revealed that these figures are above the recommended level or the norms set by the National Commission for Urbanisation. The commission has recommended per capita water supply of 90-100 litres per day, which is needed for domestic sector for healthy and quality of life to the public. As income increases, from low (Below Rs. 10, 000) to middle higher income (Rs. 30,000 - 40,000) groups, per capita water consumption increases from 115.68 litres to 230 litres per person per day. The estimate of per capita water consumption is depicted in Table 5.17.

Table 5.17: Per capita water consumption per day across income groups

Income range	Household Obs.	Total water consumed (in litres)	Per-capita water consumption (in litres)
Income not stated	34	24799	147.42
Below 10k	39	10227	115.68
10-20k	117	44325	123.07
20-30k	90	59414	186.35
30-40k	56	64541	230.43
Above 40k	19	11895	218.36

Source: Author's estimate based on primary household survey

5.6 REGRESSION ON PER CAPITA DOMESTIC WATER CONSUMPTION

In this section, we use an econometric analysis to understand the determinants for per capita domestic water consumption at the household level. Our basic model is represented in the following equation given as:

$$\log Yi = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \ldots\ldots\ldots\ldots + \beta_n \log X_n + €$$

Where, Yi is the measured dependent variable, β_0 denoted the intercept, which is a constant term, the β's measures each slope coefficients which represent the elasticity of dependent variable with respect to explanatory variables i.e., the percentage change in dependent variable for a given percentage change in explanatory variables and € denoted the random error terms in the model. From equation (1), we follow the ordinary least square methods to estimate the value of each β's parameter.

A multiple linear regression model is used to estimate the contribution of the various determining factors that a household demands/consumes water (in term of per capita water in litres) in a day. It also helps to check their level of significance. The explanatory variables in this model are— the hours of water supply, family size, highest educational attainment in the family (year of schooling), per capita monthly expenditure of the household measured in rupee term and types of residency which is captured in the binary form (renter or owner). The dependent variable in this study is the per capita water consumption. Table 5.18 shows the empirical finding of each slope coefficient of the variables. As we can see from OLS result, the selected parameters such as hours of water supply and types of residency variables are found to be statistically significant at 1 % level and highest educational attainment is significant at 5% level. Family size and per capita monthly expenditure of the family member's variables is significant at 10 % level. From the analysis, we have found the positive relationship between the dependent and independent variables for the selected parameters namely— hours of water supply, monthly expenditure of the households and highest educational attained by the family members. For family size, the relationship with per capital water consumption is negative in our study finding.

Table 5.18: Ordinary Least Square Result

Dependent variable: Log Per capita water consumption (in litres/day)	
Independent variables	Coefficient value
Log Hours of water supply	1.88 (0.041)***
Log Family size	-0.10 (0.057)*
Log Highest educational attainment by the member of Households	0.10 (0.053)**
Log Per capita monthly expenditure of the households	0.07 (0.043)*
Types of residency (owner=1; renter =0)	0.15 (0.046)***
Intercept term	1.55 (0.38)***
Number of observations	321
R squared	0.89

Source: Author's estimation based on household primary survey
Note: a). ***, ** and * indicates significance at 1%, 5% and 10% level respectively.
b). Standard errors are given in the parentheses.

The interpretation of this finding is that if one percent increase in hour of water supply at households, the per capita water consumption per day will goes up by 1.88 percent keeping others variables constant. On an average, an increase in one percent higher level of education attained by family members will led to increase in per capita water consumption by 0.10 percent. When the per capita monthly expenditure goes up by one percent then on an average the per capita water use per day will also increase by 0.07 percent, which indicates that the higher income will have higher per capita water consumption. Being owner category of the household, further, increase in per capita water consumption by 15 percent vis-à-vis renter type of households.

Usually, in the multiple linear regression model, we have more than two explanatory variables. Some of the selected variables in the model seem to be highly correlated with others variables. To check for the problem of multi-collinearity, we use set of variance inflation factors (VIF). We regress on each explanatory variable from selected parameters and calculation for VIFs is given in equation below:

$$\mathrm{VIF} = \frac{1}{1 - \mathrm{R}^2}$$

For any VIF < 5, then multi-collinearity is not severe in the study (Kacapyr 2015). We used stata12.0 software to calculate VIF for each regression by giving command vif (refer Table 5.19) that shows the calculated value of VIF for each explanatory variable. We found that all the selected explanatory variables are free from multi-collinearity problem. Therefore, the individual explanatory variables explained the model well in this study.

Table 5.19: Detecting Multi-collinearity Problem

Variables	VIF	1/VIF
Hours of water supply in a day	1.25	0.79993
Family size	1.63	0.61223
Highest education attained by the family member	1.17	0.85358
Per capita monthly expenditure of the households	1.53	0.65287
Types of residency	1.27	0.78935
Mean VIF	1.37	

Source: Author’s estimation based on primary survey data

5.7 SEASON FOR DETERIORATING DOMESTIC WATER QUALITY

To understand the impact of seasonality of deteriorating water quality, we have asked household respondents about the water quality issue during seasons-wise in the study areas. Most of the responses that we have received from households is that usually in the months of rainy season from May to July the household faced the deteriorating domestic water quality. Otherwise, the appearance of water seems to be clear and clean as reported by the respondent.

We have found that 84.51 percent of the households are having domestic water quality problem mostly during the rainy seasons starting from May to August and 8.74 percent of household are having water quality issues in winter season. Only 1.13 percent of household are having water quality throughout the year and 5.63 percent are not facing the water quality problems from various water sources available for the consumption (refer Table 5.20).

Table 5.20: Months having water quality problem at households

Months	Household responses
(December - January – February)	31 (8.74)
(May – June - July – August)	300 (84.51)
(January to December)	4 (1.13)
No water quality problem	20 (5.63)

Source: Author's estimate (primary field survey)
Note: Figures in the parenthesis are in percentage of total population size.

Larger numbers of households in our study are facing water quality issue but the question arises, how they are managing with drinking water quality issue at this juncture? In the next section, we intend to assess demand for drinking water quality in urban East Sikkim. Drinking water is the most important thing among the various water use activities the households. Drinking water should be free from any form of impurity or should have its acceptable standard in terms of physical, chemical or bacteriological parameters, so that it can be safely used for drinking purpose (Roy et al. 2004). To assess the quality of drinking water services in the absence of explicit market, then each household will be able to impose some amount of money for water quality services. The improvement in water quality helps the consumers in various way of reducing water bone diseases and improvement in health condition of an individual. Then there will be willingness to pay for such an improvement on water quality (Ibid 2004). The two most important factors that the households take into consideration are the ability of the households to spend. To examine the demand for domestic drinking water quality in the urban East Sikkim district, we are looking through the imposition of water charges and ability to pay across expenditure on water quality improvement. Across different income strata, we are looking at the purification methods adopted by households as well as the purification cost that households incurred for drinking water quality. Table 5.21 shows the socio-economic status of the surveyed households across income groups, including educational attainment vis-a-vis income level. The higher educational attainment level gives awareness related with the basic public service delivery. But, at the same time, average family size is also positively related with the monthly expenditure.

Table 5.21: Socio-Economic status of the households across income groups

Monthly expenditure	No. of house-hold size	Average household size	Average Highest educational attainment by the household members
Income not stated	34	5.35	12.58
Below 10k	39	3.69	12.23
10-20K	117	4.44	12.54
20-30k	90	4.77	12.81
30-40k	56	5.66	12.87
Above 40k	19	5.26	15.47
Total	355	4.86	12.47

Source: Author’s estimation based on primary survey data

In general, an average person requires 2 litres of water per day for drinking purpose (Roy et. al. 2004). In this study, it reveals that the households in urban East Sikkim district adopted two methods for water purification in order to produce the drinking water quality. One is the traditional method used by household i.e., to boil the drinking water and other method is to use modern technique to clean water using filter at the household level. Table 5.22 and Table 5.23 show different measures that the households follow for drinking water across sources and income groups. We have observed that 42.81 percent of households used the both methods for purification of water and 53.80 percent of household followed the traditional method for water purification. Only, 3.38 percent of households do not use any methods for water purification.

Table 5.22: Household following different techniques for purification of domestic drinking water

Sources	Only Boil	Only Filter	Boil & Filter	Consume as it is	Total
Tap water	130	21	82	7	240 (67.60)
Private pipeline	26	4	18	2	50 (14.08)
Tap and private pipeline	31	1	23	3	58 (16.34)
Others*	4	1	2	0	7 (1.97)
Total	191 (53.80)	27 (7.60)	125 (35.21)	12 (3.38)	355 (100)

Source: Author's estimate Primary survey data
Note: Figures given in the parentheses indicate percentage of the total.
* includes spring purchasing water, well, & borrowing from/depend on neighbors.

Table 5.23: Different measures adopted by households for safe drinking water across different income groups

Modes \ Income range	Not stated income	Below 10k	10-20k	20-30k	30-40k	Above 40k	Total
Only Boil	24	28	72	37	26	4	191
Only Filter	2	2	11	6	2	4	27
Boil & Filter	7	6	31	43	27	11	125
Consume as it is	1	3	3	4	1	0	12
Total	34	39	117	90	56	19	355

Source: Author's estimation based on primary survey data

5.8 COST ESTIMATION ON WATER PURIFICATION

In urban areas, people are becoming more conscious about the quality of water they drink. The demand for water quality increases as the level of educational standard increases. We found that more than half of the population from our sample household go for tradition approach for water purification i.e., boils the water before drinking. Around 343 households use both the filter and boiling methods for purification of drinking purposes. To estimate the average expenditure, the households incur for producing one litre of drinking water quality, we have simply taken the capital and maintenance cost of the filter the household used over the life time of the filter. Here, capital and operation and maintenance cost include investment on filter, interest charges and installation cost over the lifetime use of the filter. From the field survey, information have been gathered and collected from each of the household with regard to the cost pattern of the filters used by the households. For estimating the part of the unit cost, for capital investment, we have adopted the methods adopted by Roy et al. (2004).

From the analysis of data, we found that the different valuations of water quality the households incur which is starting from 0.08/litre to Rs. 2.30/ litre in ours study. We have calculated the average unit cost of drinking water represented in Table 5.24.

Table 5.24: Drinking Water Purification cost and Different Measures

Modes	No. of HHs	Average per unit filter cost (in Rs/Litre)
Only Boiling	191 (53.80)	0.07
Only Filter	27 (7.60)	0.77
Filter and Boiling	125 (35.21)	0.67
Non-of the above	12 (3.38)	0.00

Source: Author's estimation based on primary survey data

Note: a). Figures in the parenthesis indicate the percentage of Households using different mode of water purification.

b). Control for the family size of 4 members.

The household decision regarding purification technique adopted will depend on the ability of the household to pay. The perception about water quality purification technique will likely to change among households. The empirical analysis of this variation will help us to identify policy tools towards the water management. To understand this, we have considered the highest educational attainment among the family members as an indicator of access to relevant information available for the public regarding filter information for water purification. This indicator determines decision of the household adopting water filter by incurring extra cost on it. To identify the policy variables, we have employed the multiple linear regression model. From the households of 310 (out of the 355 sample households) who used at least one of the techniques to clean water before drinking, it is observed that each slope coefficient given in Table 5.25 shows a positive relation with the unit cost per litre of water in a day. We have found that the highest educational attained by the family members provide the necessary information about the water quality and at the same time pass the information about the use of the filter.

Table 5.25 Ordinary Least Square Result

Dependent variable: Log unit cost per litre of filter water	
Independent variables	Coefficient value
Log per capita monthly expenditure of the households	0.52 (0.11)***
Log highest educational attainment in the family	0.77 (0.31)***
Intercept term	-7.85 (1.10)***
Number of observations	310
R Square	0.10

Source: Author's estimation based on household primary survey.
*** indicate significance at 1% level and the Standard errors are given in the parentheses.

The monthly expenditure of the household plays an important role to understand the ability to pay for filter use. The interpretation of slope coefficient value explained that as one percent increase in monthly expenditure, on an average the unit cost of filter water goes up by 0.523 percent. Similarly, one percent increase in the educational attainment of the family members, on an average, the unit cost of filter water goes up by 0.767 percent.

From the analysis of primary data, we have found that there is season for deteriorating tap water quality supply, especially in the rainy season and not much quantity problem as urbanisation rises in East Sikkim district.

CHAPTER VI

URBAN DOMESTIC WATER SUPPLY POLICY IN EAST SIKKIM DISTRICT

6.1 INTRODUCTION

Urban water resources management and planning deal with the laws, institutions and policies that are framed by the government, private agency or local bodies. While planning for water resources management, the issue of environment is given special priority (Cosier and Shen 2009; Gupta 2001). In most of the countries, government agencies act as a regulators and distributors of water service delivery to the public. These features show a monopoly characteristics and essential nature of the water sector control by the government (Cosier and Shen 2009). Water users believe that water as an essential commodity for survival, merit good and it should be distributed freely. Over the years, in the world, the water supply volume showed a consistent pattern of underpricing to the public (Hirshleifer and Milliman 1967). This may be because of the rational reallocation of water supply, which had never been considered. With the growth of urbanisation, there is a need for economic optimization of water use today and tomorrow. The water allocations among different sectors such as domestic consumption, industries, agricultural use, etc. face a major challenge in distribution not only in the country but also globally (Kumar and Pandit 2016; Gupta 2001). The rapidly expanding cities requires more water for human use and the cities or urban centres require higher per capita water as compared to rural areas (Kumar and Pandit 2016). With these different scenario of water uses and needs, hardly we see any consensus among stakeholders on what needs to be done to meet the growing challenges of water policy in front.

Water being a state subject under the constitution of India or being a merit good, the government has the primary role and responsibility to use and control of water sector. At the national level, since the 1950s, various schemes and programmes have been implemented for drinking water supply. The first National Water Supply and Sanitation Programme was launched in 1954 for providing safe drinking water to urban and rural areas and the first National Water Policy came into existence in 1987 under the Ministry of Water Resources, Government of India. The 74th Constitutional Amendment Act was passed in 1992 to form urban local bodies (ULBs) consisting of Municipal Corporation, Municipal Council and Nagar Panchayats in urban areas (Hamid 2004). Subsequently, in 1993, the Accelerated Urban Water Supply Programme was launched in urban centres for providing safest and adequate water, for the population less than 20,000 as per census 1991 (GoI 1994). Under this scheme, matching grants was equally shared between state and central government. During the Eight Five Years Plan period (1992-1997), the problem of water supply sector was identified and various reforms were suggested. One reform agenda was placed, that is water was considered as “commodity”. Thereafter, privatization of water sector began and all local bodies were given responsibility for operation and maintenance of water works in the country. Under the Ninth Five Years Plan period (1997-2002), the major objective was to provide 100 percent water supply coverage both in urban and rural India. In 2002, the government of India has started Swajaldhara Pragramme for National Drinking Water Supply under the Rajiv Gandhi National Drinking Water Mission (RGNDWM). Under this programme, the Panchayat Raj Institutions (PRIs) and the local government bodies became the sole responsibility for water supply and management and sanitation schemes (Joshi 2004). But, still we find many lacunae for proper implementation of these various programmes in our country. The earlier two versions of the National Water Policy 1987 and 2002 and the recently implemented National Water policy 2012 in the country have made no such impact on improving Water Resources Management (Pandit and Biswas 2019). In Indian context, focus on water planning is based on quantity rather than quality of water, which is just opposite to the European countries that emphasized on water quality along with water quality (Ibid 2019).

The service delivery of water supply in Indian cities over the years is continuously inadequate and found to be unreliable quality. The sector suffers from chronic operational inefficiency due to lack of infrastructure development and expenditure on it. The problem further aggravated due to uneconomic tariff structure, low collection efficiency and high level of leakage of water from pipes lying on surface of the earth (Ibid 2011). Rapid urbanisation along with unplanned growth of cities and towns are adding more problems to the existing ones. With the increase in population, urbanisation and industrialisation together with spatial and temporal variations in water availability, the water quality problems led to the higher demand for water in any region. In Sikkim as well, the problem is being felt recently.

6.2 WATER POLICY IN URBAN EAST SIKKIM DISTRICT

There was no specific urban water policy as such in the state of Sikkim till very recently. In 2007, a general policy called the *State Water Policy* was framed on the line of National Water Policy of 1987, guided by the policies and programmes for water resources management and its development in the state (GoS 2009). The economic expansion process in the state leading to increasing demand for a diverse used of water requirement in various sectors namely, domestic, hydro power, industries, agriculture, production and recreation activities. Proper water policy management is the need of the hour. In Sikkim, the trend of rainfall pattern is also declining over the period from 2011 to 2014. The availability of water from rainfall showed inconsistent pattern. There are cases where the springs in some parts of the state are getting dried one after another, which further rose to the urgency to look into the water policy decisions.

The water resources management basically deals with two types of management namely the technical and efficient water managements. The technical management is defined as the water provided by the department through different channel of supply. It is related to maintenance of water supply network by government agency. An efficient management deals with how public are taking initiative to maximize the optimal use of water available. Water resources management deals with the various water extraction sources on the surface, such as the glacier, rivers and springs in Sikkim. The ample amount of rainfall will indicate the less insecurity of water in the state. But state of Sikkim has been witnessing a declining trend of rainfall in the recent past (SERS 2016). The population is unevenly distributed in the state of Sikkim, wherein the East district of Sikkim being the densely populated, relating with water management model, i.e., technical and efficient water management. The former management of water distribution in urban East Sikkim district covers 89.9 percent of families, having access to tap drinking water sources (Census 2011) and later water management covers 83.66 percent of domestic households as per primary survey conducted by this study in the month of June-July 2018 (Field survey 2018). As per Sikkim Water Supply and Water Tax Act 1986 says that:

> "The government may provide any area with a water supply to wholesome water for public, for commercial, domestic and other par-subject to availability of water. For the purpose of such supply the government shall cause to be constructed or maintained such water works as may be necessary and may erect stand pipes, wells or pumps for the use by public of area. The supply of water for domestic purposes under this Act means supply for any purpose except the following namely: a. for any trades, manufacture or business………" (GOS 1986, pp.1-2).

Further, the existing rules and regulations of Sikkim Water Supply Act 1990 regulated by the water security and public health engineering department (PHED), government of Sikkim mentions that the distribution network of water supply was carried by non-volumetric approach. This was done on the basis of number of taps used by domestic and commercial purposes. Table 6.1 depicts the water tariff based on non-volumetric distribution in Sikkim. The government of Sikkim hereby makes further rules to amend the Act of 1990 called the Sikkim Water Supply rules 2014. Under this amendment rules, the water supply services shall be rationalised with the introduction of volumetric tariff that will replace the tap-based tariff (GoS 2014). The past and present rules and regulations introduced by the government of Sikkim is executed by the PHED. Whether the equitable distribution of water required by public actually meet or not is one of the concerns with the upsurge of urbanisation.

Table 6.1: Non-volumetric Tariff as per No. of Taps

Sl. No.	Number of Taps	Domestic (in Rupees)	Commercial (in Rupees)
1	1-3 taps	90	180
2	4-7 taps	150	290
3	8-12 taps	250	390
4	Every tap in excess of 12	50	100

Source: Public Health Engineering Dept., Government of Sikkim (2014)

The existing tap-based tariff approach indicates the installation of number of taps charge the different rates of water supply for domestic and commercial activities. Table 6.1 indicates as the number of tap increases from the range of 1-3 taps to 4-7 taps, there are varied rates of tariff charged for domestic and commercial connections. The domestic households are paying rupees 90 as compared to commercial water connections which are paying double of the domestic connection. As the slab increased from 4-7 taps the commercial connection is paying rupee 290. Under state annual action plan (SAAP) report, the government has diagnosed service level gaps for the state as per information provided by the urban local bodies and concerned department of water supply under PHED. The universal coverage in water supply has been addressed by the state. According to the SAAP, the imbalance in the demand and supply is being addressed through ongoing schemes under Asian Development Bank (ADB). The recommendations given by the Ministry of Urban Development (MoUD) the water supply requirement for the Gangtok area can be met through metering works and replacement of smaller diameters pipeline called secondary feeder mains. With this suggestion, the government has amended the existing rules of Water Supply Act 1990 and called it as Water Supply Rules 2014. Based on this amended rule, the concerned department of water security and public health engineering department has given the volumetric tariff based rates for domestic water users in Sikkim. Till date, the water security and public health engineering department have not initiated the collection of water tariff based on volumetric approach. Table 6.2, present the volumetric tariff based on metered per kilo-litre. The main ideas behind the proposed implementation of volumetric tariff on water in urban Sikkim is to bring down the wastage of water and account for un-accounted water due to pipe lines break or pilferage.

Table 6.2: Volumetric Tariff based on Metered per kilo-litre (1000 litre)

Sl. no	Volumetric	Domestic (Rs./KL)	Commercial (Rs./KL)
1	First 20 KL	5	10
2	20-40 KL	8	13
3	40-60 KL	12	17
4	Every KL above 60 KL	20	20

Source: Public Health Engineering Dept., Government of Sikkim (2014)

Whether this initiative taken by government under PHE department will work out in the future for managing water supply and equitable water distribution to public is one of the important challenges for water policy in front. The government of Sikkim wants to switch from non-volumetric to volumetric water supply consumption pattern for public at large. But whether public at large are happy regarding the policy initiated by the state is a matter of investigation. To understand public choice regarding the decision made by the policy maker on water supply, we are focusing on the decision made by public on water supply policy services for domestic sector in urban East Sikkim district.

Table 6.3: Existing Fee for water service connection in Sikkim

Sl.no	Service	Fee (Rupees)
1	Cost of application form for new connection/shifting	25
2	New connection fee	600
3	Shifting charge of supply point /connection point	300
4	Re-connection fee	100
5	Fee for No objection certificate	60

Source: Public Health Engineering Department, Government of Sikkim

Table 6.3 represents the fee for water service connection. The initial cost of water supply connection come around rupee 685 (which includes cost of application, new connection fee and fee for no objection certificate). Despite this low fee structure, the coverage of water supply connection in Gangtok town status is 75 percent (SAAP 2016).

6.3 RESOURCES ALLOCATION FOR WATER SUPPLY IN SIKKIM

For meeting the ever increasing requirement of water in East Sikkim district, a Central programme called the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) along with the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) have been in place in Gangtok town. In the remaining urban centres, the water supply funding is done through various programme implemented by the central government as well as the state such as non-lapsable central pool of resources (NLCPR) from 1998-99 and development of North-Eastern Council (NEC) from 2003-04 (GoS 2015). During 1998, Sikkim was recognised as part of the North Eastern Region (NER) of the country and in the year 2002 fully integrated in the region. This amalgamation with the NER benefits the state of Sikkim for availing funding from NLCPR and NEC. There was the allocation of expenditure from the state plan as well as from the Central government for managing the water supply in Sikkim. The growth rate of annual state plan outlay/expenditure and revenue collection from water supply of Sikkim is depicted in Table 6.4.

Table 6.4 Growth rate of annual state plan outlay and revenue collection from water supply of Sikkim 2003-2012

Sl.no	Year	State plan outlay (Rupees in lakhs)	Growth rate State plan outlay (%)	Revenue collection (Rupees in lakhs)	Growth rate of Revenue collection (%)
1	2002-03	350	-	72.83	-
2	2003-04	950	171.43	74.25	1.95
3	2004-05	875	-7.9	95.38	28.46
4	2005-06	855	-2.29	100.56	5.43
5	2006-07	961	12.4	196.74	95.64
6	2007-08	1755	82.62	201.66	2.5
7	2008-09	1936.99	10.37	252.04	24.98
8	2009-10	2006.93	3.61	253.48	0.57

Sl.no	Year	State plan outlay (Rupees in lakhs)	Growth rate State plan outlay (%)	Revenue collection (Rupees in lakhs)	Growth rate of Revenue collection (%)
9	2010-11	1830.53	-8.79	254.21	0.29
10	2011-12	1540.99	-15.82	287.65	13.15
11	2012-13	3039.08	97.22	271.85	-5.49

Source: Author's computation from the Annual Report, 2012-13. WS&PHED, Government of Sikkim

The year to year growth rate of state plan outlay and revenue collection was 171.43 percent and 1.95 percent during 2003-04. On an average, the growth rate of state plan outlay was 34.28 percent and revenue collection were 16.57 percent over the period from 2003 to 2012. These figures indicate the state plan outlay is double times higher than the revenue collected from the water users of Sikkim from 2003 to 2012.

The water supply and sanitation expenditure of Sikkim data are summarised in Table 6.5, for the period from 1981 to 2015. The percentage of expenditure on water supply and sanitation to total expenditure in Sikkim is found to be less than 1 percent during the period from 2004 to 2015, while the state population is increasing every year at the tune of 1.22 percent (Census 2011). The per capita water user charge showed a consistent pattern of increasing trends of Rs. 218 to Rs. 647 from 2004 to 2015 (refer Table 6.5).

Table 6.5 Revenue expenditure on water supply and sanitation of Sikkim 1981-2015

Year	Water supply and sanitation expenditure (in Lakh)	Total expenditure (in Lakh)	% Water supply and sanitation expenditure to Total expenditure	Per capita user charge/Revenue (Rs)
1981-82	0	3173	0.00	0.00
1982-83	0	3546	0.00	0.00
1983-84	0	4928	0.00	0.00
1984-85	0	5857	0.00	0.00

Year	Water supply and sanitation expenditure (in Lakh)	Total expenditure (in Lakh)	% Water supply and sanitation expenditure to Total expenditure	Per capita user charge/Revenue (Rs)
1985-86	116	7758	1.50	0.00
1986-87	152	8126	1.87	42.39
1987-88	773	9846	7.85	210.23
1988-89	229	11316	2.02	60.74
1989-90	227	11527	1.97	58.72
1990-91	291	12815	2.27	73.41
1991-92	374	15509	2.41	92.01
1992-93	412	17973	2.29	98.51
1993-94	409	18891	2.17	95.04
1994-95	531	52642	1.01	119.91
1995-96	651	88119	0.74	142.87
1996-97	701	111886	0.63	149.51
1997-98	715	125810	0.57	148.20
1998-99	964	149560	0.64	194.19
1999-00	1089	150997	0.72	213.19
2000-01	1020	76331	1.34	194.06
2001-02	1046	166425	0.63	193.40
2002-03	1161	188262	0.62	212.07
2003-04	1288	118093	1.09	232.44
2004-05	1224	172349	0.71	218.23
2005-06	1400	176761	0.79	246.60
2006-07	1498	188756	0.79	260.68
2007-08	1775	234856	0.76	305.16
2008-09(RE)	2360	238075	0.99	400.84
2009-10(BE)	2073	256715	0.81	347.85
2010-11 (Accounts)	2484	290753	0.85	411.79
2011-12 (RE)	2219	355904	0.62	363.43
2012-13 (BE)	1651	357002	0.46	267.14

Year	Water supply and sanitation expenditure (in Lakh)	Total expenditure (in Lakh)	% Water supply and sanitation expenditure to Total expenditure	Per capita user charge/Revenue (Rs)
2013-14 (Accounts)	2219	345796	0.64	354.72
2014-15 (Accounts)	2837	373095	0.76	448.04
2015-16 (RE)	4149	431275	0.96	647.35

Source: Planning Commission, Hand book of statistics of Indian states, Reserve Bank of India. RE = Revised Estimate, BE = Budget Estimate.

The revenue collection of urban water in Sikkim is low as compared to the state plan outlay incurred under its provision. Per capita charge of water is increasing every year. This is reflected in the Table 6.5. In India's major cities as well, an appropriate price setting reform for the domestic water users is needed (Sauri 2013). This is because of the price charged from the urban water users are lower as compared to the cost incurred (Mathur and Thankur 2006). The price charged is 20 to 25 percent lower than that of the operation and maintenance costs (Ibid 2006). Even though, there is much difference between the revenue collection and state plan expenditure in water supply in the state of Sikkim. In nutshell, if price mechanism reforms happen, then that could lead to the proper management of resources allocation not only for revenue generation but also in terms of proper use of the available water resources (Sauri 2013). There is a negative relationship between the two, as higher price charge with lower water consumption and higher water security in future (Ibid 2013).

The water security and public health engineering department, government of Sikkim, demand No. 33 is related to the demand for grants on water supply programme in Sikkim. The Table 6.6 shows the maintenance and operation expenditure on water supply and sewage in East district of Sikkim.

Table 6.6: Maintenance and Operational Expenditure Water Supply in East Sikkim district 2004-2015 to 2015-2016

Year	Plan	Non-plan	Rs. (In Lakh)
2004-05	4900	15177	200.77
2005-06	7284	13660	209.44
2006-07	12400	12294	246.94
2007-08	13990	13475	274.65
2008-09	21398	14500	358.98
2009-10	6342	14700	210.42
2010-11	20000	16900	369.00
2011-12	23584	15400	389.84
2012-13	18261	16987	352.48
2013-14	18248	16262	345.1
2014-15	18248	17035	352.83
2015-16	12951	29610	425.61

Source: Handbook of Demand for grant in Water, PHE, Dept. Government of Sikkim

For efficient management of water supply to the general public, the government should collect at least the maintenance and operation expenditure on water works. From the given data on revenue collection on water supply of Sikkim represented in the Table 6.4 shows a lower and still unable to recover the maintenance and operation cost of water supply in East district of Sikkim. This reflects that the state of Sikkim needs a proper mechanism to look into an alternative to the system, to at least cover the maintenance costs. In this step, the policy makers have decided to account for water use through volumetric consumption and distribution of water to the different users. But, whether people are happy with the decision taken by water authority, especially on domestic water sector. To understand this paradigm on domestic water policy in East Sikkim district, we have conducted a choice based experiment for water service delivery, in the month of June-July, 2018. The primary survey was conducted for domestic sector based on the household preference for domestic water policy and we asked household respondents to select one scenario which they consider the best out of the three scenarios given to them. They are depicted in Table 6.7.

6.4: Policy Option

Any implementations of policy for welfare of masses needs thorough understanding of the public participation. To understand the domestic water supply policy in East Sikkim district, we have considered the public preference for water supply policy. Using the tools of choice based experimental methods, we have designed and developed the choice set, a set of attributes affecting water supply policy to reflect the true characteristic of water supply policy. To identify the attributes related to water supply policy, we have chosen four attributes (details given in Table 6.7), namely 1. Connection, 2. Water Supply Quantity/quality, 3. Governance and 4. Bill for water supply service.

Table 6.7: Three Scenario Open to the Water Users (Households)

SCENARIO	1	2	3
ATTRIBUTES	Existing System (Non-volumetric)	Proposed by the Government (Volumetric)	Alternative (Privatization)
CONNECTION	Without meter	Meter	Meter
SUPPLY/QUALITY	Limited supply, approx. 1-3 hrs/day.	Regular (Seemingly) [As per norm the supply of should be 24x7, but it is not happing in most of the cities in India at present]	Regular
GOVERNANCE	Government	Government	Private agency
RENT/BILL	Normal (Per connection)	block-wise per unit consumption	Higher than Government

Source: Primary Field Survey

In scenario 1, it basically portrays the existing system for water supply operating in urban East Sikkim district, wherein the status quo represented the connection of water supply at household is without meter system, quantity of water supply is limited to 1 to 3 hours per day and PHE department takes charge of distribution and maintenance of water supply work and households pay flat rate of tariff for water consumption per month.

In scenario 2, it is the proposed policy decision made by the policy maker (Government of Sikkim) for distributing water to the general public. This scenario is little different from scenario 1, wherein the meter system has been introduced by the PHE department to account for volumetric consumption of water supply and tariff for water consumption is based on the block-wise per unit consumption of water mentioned in Table 6.2. Further, the department has assured that the quantity of water supply will be on the regular basis i.e., 24x7 hours of water supply at domestic sector. Since, most of the developed cities and towns in India are already using the meter system of water supply for domestic consumption. But still, they are not getting water for 24x7 hours. So, this seems to be myth in the case of the urban East Sikkim district as well.

In scenario 3, we have included the privately managed water supply distribution for the general public as an alternative policy. Under this system, water is mainly governed by the private agencies for distribution and maintenance water works. In this system, water tariff charge will be higher than other previous two scenario (1 and 2).

When the experiment was conducted based on these three scenarios, we have found that there were mixed responses of the choice of scenario and it is represented in Table 6.8.

Table 6.8 Household's choice for water policy in Urban East Sikkim district

Choice of Scenario	Number of choices made by Households
Existing System (1)	180 (50.70)
Proposed by the Government (2)	82 (23.10)
Alternative (Private) (3)	93 (26.20)
Total	**355** **(100)**

Source: Author's estimate based on primary survey data
Note: Figures in parenthesis represented the percentage of the total.

The finding of households' choice based preference for water policy in urban East Sikkim district are found that 50.70 percent of households still prefer the existing system of water supply and followed by 26.2 percent of households prefer the privately managed water supply distribution. Around, 23.1 percent of households prefer the meter system at water supply consumption provided by PHE department. From the findings, we can conclude that most of households in urban East Sikkim district have the preference of existing water supply system (without meter) of water supply for domestic consumption.

In urban East Sikkim district, we have two types of classification of residency i.e., owner and renter of the households given in Table 6.9. Based on this classification, we have found that 52 percent of owner and 50 percent of the renter of households have the same existing system preference choice for domestic water policy. The remaining 23.81 percent of owner of the households have shown their preference for proposed meter system governed by PHE department and 24.49 percent households looks for private agency distribution for domestic water policy. In case of renter type of households, the preference choice of water policy for domestic sector is more or less same for owner type of households. There is not much difference in case for the preference choice of water policy which households actually demanding in the urban East Sikkim district.

Table 6.9 Classification of scenario based on types of residency in urban East Sikkim district

Scenario	Number of households (owner type)	Number of households (renter type)
Existing System	76 (51.7)	104 (50)
Proposed by the Government	35 (23.81)	47 (22.6)
Alternative (Private)	36 (24.49)	57 (27.4)
Total	147 (100)	208 (100)

Source: Author's estimate based on primary field survey;
Note: Figures in parenthesis represent percentage term of the total.

More or less the same preference choice between owner and renter types of the households indicate that people of urban East Sikkim district are happy with the existing water policy. Though some of the households have complained regarding the current water supply system, the urban East Sikkim district is still in the better position in regard to water supply provision, even if it is not compared to other districts of the state. For sustainable domestic water supply provision in the long run, it is required to improve infrastructure as well as knowledge of water recycling techniques and water saving technologies, which will be much helpful for the conservation and preservation of water resources in this hill state.

While surveying, we have put few questions regarding whether the households follow any water conservation technique or not. We have found that 310 households out of 355 total household do not adopt any water recycling technique. Only 45 households are found to be practicing the water recycling techniques at households. We have asked the few questions, whether the households adopt for water recycling techniques as: 1). after cleaning cloth, the water is used for bathroom purposes, 2). kitchen used water is for gardening, and 3). any others. Now, the questions regarding water saving technologies, such as installation of water harvesting system at building, we found that none of the urban East Sikkim district has installed rain water harvesting system at their respective building. Only 15.77 percent of households are using roof water harvesting practice.

Table 6.10 Number of households adopting water saving technologies

Water saving technologies	Response given in Yes
Shower head	84 (23.66)
Semi-Washing Machine	87 (24.51)
Rain Water Harvesting system installed at building	0 (0)
Roof Water Harvesting practice at household	56 (15.77)

Source: Author's estimate based on primary survey data
Note: Figures are in parenthesis shows the percentage term.

Table 6.10 shows a detail of the number of households adopting water saving technologies in urban East Sikkim district. Altogether 23.66 percent and 24.51 percent of household are using showerhead[5] and semi-washing machine respectively. None of the households in urban East Sikkim district used rain water harvesting system. This further indicates that urban East Sikkim district is in the better position when observing other major cities of the country, in term of domestic water supply. Figure 6.1 depicts the urban household practicing roof water harvesting and this figure was taken at the time of field survey in the study areas.

[5] Study done by Sharpe, W.E (1987) found that there was significant reduction in water usage corresponding to the installation of shower head as a water saving technology.

Figure 6.1 The household practicing roof water harvesting in urban East Sikkim district

Source: Picture taken at the time of field survey. The location is nearby Tathangchen area.

CHAPTER VII

CONCLUSIONS, SUMMARY AND RECOMMENDATIONS

7.1 INTRODUCTION

This chapter covers a brief summary of the analysis made in the previous chapters. Findings and discussion made above provide a set of recommendations. As we have understood that urban growth or the urbanisation process is a dynamic one, which connects and attracts the people towards urban centres. The urban centres of the East Sikkim district are relatively the preferred destinations not only for the migrants from outside state but also from the inter-district migrants of the state and rural-urban migrants of the same district. The degree of urbanisation in urban East Sikkim district is comparatively higher than that of the India's major cities, which accounts for 43 percent in East Sikkim District vis-a-vis 31 percent of all India level (Population Census 2011). At this degree of urbanisation, whether the urban dwellers face water shortage for domestic consumption is a subject of discussion. The present study is the modest attempt to assess the urbanisation and water resources management in the urban East Sikkim district. For this, we raised three major research questions, they are:

1. Is the ever growing urbanisation proportionately supported by the required quality and quantity water supply for the people of East Sikkim district?
2. Is the water problem negatively related with the income level in East Sikkim district?
3. Is the existing policy of domestic water management system effective in the wake of rapid upsurge of urbanisation in the East Sikkim district?

To answer these major research questions, we have employed both secondary and primary data. Using secondary data, growth trend of the population and urbanisation have been estimated. At the same time, river water quality is also measured in the study area. From primary data, per capita water consumption was measured and whether the availability of the water is related with the growth of income level is also assessed. Public choice of water distribution system was considered for the water supply policy in East Sikkim district.

7.2 SUMMARY OF THE STUDY

First, to defined the concept of urbanisation, we have simply constructed urbanisation index taking secondary data sources available for urban East Sikkim district. Therefore, we found that year to year growth rate of urbanisation was 9.77 percent over the period from 1981 to 2015 in the East Sikkim district. At the same time, the urban inhabitants of the state of Sikkim receive water from various sources like tap (both private and state managed), natural spring and others. However, there is no specific information about the quantity of water consumed by different sectors like agriculture, industrial and household sectors. Nevertheless, on an average, the per capita domestic water consumption in the East Sikkim district is found to be 235 litres.

As per the literature surveyed in the study, urbanisation is interlinked with migration. Therefore, from the primary data we have considered the years of migration of household as urbanisation and we found that growth rate of migration was 68.16 percent in the urban East Sikkim district. On an average, the year to year growth rate of migration was found to be 13.48 percent over the period from 1948 to 2018. To understand, how people at large managing water with the growth of urbanisation, through primary field survey, we found that 83.66 percent of the sample households got tap water connection (which includes both PHED tap and private pipeline connection), followed by private pipeline source exclusively in urban East Sikkim district. Since, migration is one of the major factors for increasing the demand for water, migrated populations have added in the total population. From the present analysis it is found that 247 households are having full access to domestic water supply (that is more than 100 LPCD) as per recommendation made by the WHO norms. The mean value of water from tap is 208.78 litres, private pipeline is 248.82 litres and from both (tap and private pipeline) is 239.94 litres. To understand the effect of urbanisation, the required quantity of water supply may depend on the household income. We have taken proxy of monthly expenditure, which includes food and non-food items of households to capture the household income. Based on consumption of monthly expenditure, we have divided the households into five categories: low income group (A), low-middle income group (B), middle income group (C), middle-higher income group (D) and higher income group (E). While comparing the households across income groups for water consumption in LPCD, from the estimated figures, as income level rises the level of access to water also rises. For instances, as income increases from low (Below Rs. 10, 000) to middle higher income (Rs. 30,000 - 40,000) groups, per capita water consumption also increases from 115.68 litres to 230 litres per person per day. It indicates that these figures are above the recommended quantity and standard set by the National Commission on Urbanisation. The commission has recommended per capita water supply of 90-100 litres per day, which is required at the domestic sector for healthy and quality life. This indicates that the urban households of East Sikkim district are still in the better position in terms of per capita water availability with the growth of urbanisation.

To understand the variables that influence the per capita water consumption, we have used multiple linear regression model (MLRM) and the finding from OLS estimators on per capita water consumed (dependent variable) by the household in a day is statistically significant at 1 percent level for the independent variables selected for the study are namely, hours of water supply and the types of residency. The highest educational attainment by the family members is one of the independent variables and it is also found to be statistically significant at 5 percent. We have found that family size and per capita monthly expenditure of the family member's variables is significant at 10 percent. We have also found that the positive relationship between per capita water consumption with hours of water supply, rise in educational attainment in the family, per capita monthly expenditure and the types of residency. On the other hand, as expected, there is a negative relationship between the per capita water availability with the family size. As family size increases there is a fall in per capita water consumption level. Some of the selected independent variables may be correlated. To check this, we have run test for multi-collinearity problem and the results from the variance inflation rate (VIF) shows that no multi-collinearity was present in the model for the selected variables. Therefore, the finding also shows that the signs of all variables selected for our study are appropriate.

While investigating the economic analysis on demand for drinking water quality, the household incur for producing quality of water supply in the study areas is estimated. To estimate the average expenditure per litre of clean drinking water the households incurred, willingness to pay money method was employed. In this case, we have looked into the purification cost that households incurred for producing potable water. The information collected on the purification cost involves the filter used in the household. We found that more than half of the sample used the traditional approach of safe drinking water i.e., boiling water before drinking. The per unit cost on drinking water quality the households incur from only boiling was estimated at Rs. 0.07 per litre, followed by filtering cost at Rs 0.77 per litre, and both the filter and boiling cost together estimated at an average of Rs 0.67 per litre.

The empirical analysis on willingness to pay money for producing quality of drinking water by households help us to identify the main policy instrument towards water quality management. To understand this, we have considered two major indicators namely: 1. Highest educational attained among the family members and 2. The monthly household expenditure. The first indicator i.e., highest educational attained among the family members as an indicator of access to relevant information available for the public regarding filter information for water purification. This indicator determines decision of the household adopting water filter by incurring extra cost in getting safe drinking water. Public at large may understand that as urban areas expand due to increase in population growth. In that case, the knowledge of education plays a vital role to get the most suitable information of filter use to provide the clean water for drinking purposes. To identity the policy variables, we have used OLS estimators to understand the variables from 310 households sample size who used at least one of the techniques to clean water before drinking. Therefore, the result shows that per capita monthly expenditure of the households and highest educational attainment in the family are statistically significant at 1 percent level. From these findings it is understood that as urbanisation rises in the East Sikkim district households do use filter to clean water at their respective places for drinking purposes.

In order to understand an appropriate policy on domestic water resources in the urban East Sikkim, it is very important to identify the existing policy. As per the information provided by the Govt. of Sikkim, there is no distinct urban water policy as such in place. Nevertheless, there is a rough draft called the State Water Policy 2007 in line with the national water policy of 1987, which gives direction in terms of formulating policies and programmes for water resources management in the state. For any policy to function smoothly it is very much necessary for a systematic infrastructural development. Similarly, in case of growth and development of water resources management, it needs a proper policy at state level. Looking at the spectrum of revenue collection from water supply distribution, it seems to be very low compared to its cost of management in the state. On an average, the growth rate of annual state plan expenditure on domestic water was 34.28 percent and revenue collected was 16.57 percent over the period from 2003 to 2012. This implies that expenditure was double times higher than that of the revenue generated from the water supply. This may be possibly due to inappropriate pricing policy of the state that led to fall in revenue generation. The present system of supplying water follows the rules and regulations of Sikkim Water Supply Act 1990, regulated by the water security and public health engineering department (PHED), Government of Sikkim, and the distribution network of water supply was carried through the non-volumetric approach. This was done on the basis of number of taps used by domestic and commercial purposes. The existence of tap based tariff approach indicates different rates for domestic and commercial connection. For the universal coverage of water supply in Sikkim, the government has further proposed to amend the existing water supply policy and switching over to metering system. The idea of implementation of volumetric consumption of water in urban Sikkim can somehow account for un-accounted or leakages in the water supply system. According to this volumetric consumption of water, the water pricing is based on the unit of water used and the govt. has introduced the four block pricing under this scheme. In the first block, for 20 kilo-litres, the charge proposed for domestic sector is

Rs. 5. As the slab of block increases, the charge also increases. Till date, the policy of volumetric consumption of water charge has not been implemented. In order to understand the effect of this water policy, we need to understand the people's choice regarding which policy works better for them. Based on this, we have tested an experimental analysis to understand the public choice regarding the decision they select for the water policy. We found that people are indifferent between the volumetric meter policy and existing water supply connection system. There is not much difference in case of the preference choice of water policy in the urban East Sikkim district.

In terms of domestic water resources via-a-vis urbanisation, the state of Sikkim is not at the cross road. Because, water recycling technique is not adopted, and households have no problem of water quantity in urban East Sikkim district. But, from primary data analysis, we have found that there is seasonal deterioration of tap water quality, especially in the rainy season. Still, people at large are happy with the existing water policy of the state. Nevertheless, deteriorating water quality and depleting water bodies in the state are the warning bells. Government must not be taken it lightly, must be conscious and ready for sustainable water development actions and plans.

7.3 RECOMMENDATIONS AND POLICY IMPLICATIONS

The state of Sikkim has a strict migration policy, but still the migrant population (both internal and international) are still increasing, outnumbered the local population. The decadal growth rate of population in 1981 in the state was around 51 percent, the ever highest rate in the state's history. The phenomenon of the rapid urbanisation is taking place in the state of Sikkim. At the same time, the state is doing much better in terms of growth in Gross State Domestic Product (GSDP) and per capita income of the state was Rs. 2.91 lakhs in 2016-17 current prices (GoS 2018). A strong policy on water resources management is very important to sustain further development in the state of

Sikkim. The state should also implement the proper allocation of water among different sectors. The annual budget for water sector should be enhanced. The water governing body should come up with the ideas to levy appropriate price for water for different sector and activities, so that the operational and maintenance expenditure on water works should be covered. Infrastructural development for water work is the basic requirements for proper delivery of basic water services with the growth of urbanisation.

With the rise in urbanisation the construction sector has also increased at the fast rate and this in turn leads to the proper arrangement of the domestic water connection network in the urban centres. Water harvesting policy must be framed and scientific water harvesting technique must be encouraged. For any proper implementation of the policy, public participation is needed and therefore, even for water conservation practices, public awareness is very important.

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APPENDIX

Sikkim University

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(The information sought through this questionnaire is purely for the purpose of PhD dissertation**)**

Urbanisation and Water Resources Management: A Study of East Sikkim District

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Interview Schedule for Households

<table>
<tr><th>Sl. No</th><th colspan="3">QUESTIONS
SOCIO-ECONOMIC STATUS OF DOMESTIC HOUSE:</th><th colspan="2">RESPONSE</th></tr>
<tr><td>1</td><td colspan="3">Respondent's Name:</td><td colspan="2"></td></tr>
<tr><td rowspan="2">2a</td><td colspan="3" rowspan="2">Family size (In number)</td><td colspan="2"></td></tr>
<tr><td>2b.
M –</td><td>2c.
F-</td></tr>
<tr><td>3</td><td colspan="3">Religion
(Hindu – 1, Christian – 2, Muslim – 3, Buddhist – 4, Others –5)</td><td colspan="2"></td></tr>
<tr><td>4</td><td colspan="3">Family's main source of income
(Agriculture- 1, Employee (Govt.) - 2, Employee (Pvt.) - 3, Self-Employee - 4, Retired - 5, Casual worker - 6, Combination of farming, salaried and self-employee - 7, Business – 8, Others – 9 (Specify))</td><td colspan="2"></td></tr>
<tr><td>5</td><td colspan="3">Subsidiaries source of Income (code same as given in Sl.No. 4)</td><td colspan="2"></td></tr>
<tr><td>6</td><td colspan="3">Caste (General – 1, Schedule Caste – 2, Schedule Tribe – 3, Other Backward Classes – 4, others –5)</td><td colspan="2"></td></tr>
<tr><td>7</td><td>Age – group of family members (In number)</td><td>8</td><td colspan="3">No. of the highest Educational qualification attained by the groups divided</td></tr>
</table>

	Below 6 years			8a. Primary (1-5)	
	7 – 14 years			8b. Upper primary to senior secondary (6-12)	
	15 – 35 years			8c.Graduation (General/(Tech/Professional)	
	36 – 60 years			8d. Post-Graduation and above (General /Tech/Professional)	
	Above 60 years			8e. Skilled (No formal school)	
				8f. Illiterate	

TYPE OF RESIDENT

9	Owner/land lord – 1, Renter/tenant – 0	
10	When did you come to Urban East Sikkim (In year) (in case of original inhabitant is from Urban East Sikkim – 0)	

WATER RELATED INFORMATION

11	Do you have water supply connection (No- 0, Govt.- 1, Private (Self-managed pipeline) –2 , Both Govt. & Pvt. 3, Can't say which type -4)	
12	Type of water taps connection (connection within the house – 1, share, but in the same building–2, Away from the premise – 3)	
13	How many hours of drinking/domestic purpose water you set per day? (< 1hr - 1; 1-2 hrs - 2; 2-3 hrs – 3; 3-4 hrs – 4 ; > 4 hrs or 24/7 – 5)	
14	What is your perception of water quality (Extremely bad – 1; Bad –2; Manageable–3)	
15	What precaution your family takes for drinking water (Straining – 1; Boil water– 2; Filter water – 3; use water filter and boil – 4; R.O Filter – 5; consume as it is – 6)	
16	If water filter is used, what is your annual expenditure on it [including start-up cost plus the installation cost & operational & maintenance] (in Rs.) (will calculate per capita expenditure using total exp/family size)	
17	Any water related disease/sickness reported in the family from the last one year (No – 0; Yes – 1 (e.g., Diarrheal, Dysentery, Typhoid fever, rashes/scabies); Don't know–2)	

18. Different usage of water in domestic sector

% share of water	Item	PHED	Private Pipeline	Purchased from the	Spring	River	others (Well, rain	Total

usag e				Marke t			water, etc.)	
18a	Drinking and Cooking							100
18b	Bathing & Toilet							100
18c	Washing clothes							100
18d	Others							100

19. Quantity of water Availability from different sources

19a	Water availability (per day in ltr.)							
19b	Regular – 1; Occasionally – 0							

19c	In which seasons or months you feel drinking water quality usually goes down (Please indicate the year from which you feel drinking water quality has deteriorated)											
	Jan	Feb	Mar	Apr	Ma y	Jun e	July	Aug	Sep t	Oct	N ov	Dec
20	In which months you face water shortage and how much litres of water your need at that time (Please indicate below in litres term)											

21	For how long you have been facing this problem? (Mention the year)	
22	If you face water problem/short supply, which alternative source(s) you look for: Bottle water – 1; Water tanker – 2; Spring – 3; Well – 4; River – 5; others (specify name) – 6	
23	What is your opinion/reasons for this shortage (if any) Poor management of department – 1; Population growth – 2; Natural factors (less recharge) – 3; Others (specify) – 4	
24	Do you follow the water recycling techniques at house? No – 0; After cleaning cloth, the water is used for bathroom purposes – 1; kitchen water is for gardening – 2; Others (specify name) – 3.	
24a	From which year you have been practicing it?	
25	Do you used the following (Any water saving technologies are used at household) (Shower – 1; Semi-washing-Machines – 2; Rain water harvesting system installed at building – 3)	

25a	From which year you have been practicing it?	

26	Per capita Household's monthly expenditure – (the standard measure of economic status)		
	26a. Food items (Rs)	26b.Non-Food items (Rs)	26c. Total (Rs)

27	Which of the scenario would you like to choose?		
SCENARIO	1	2	3
ATTRIBUTES	Existing System	Proposed by the Govt.	Alternative (Private)
CONNECTION	Without meter	Meter	Meter
SUPPLY/QUANTITY	Limited supply, approx. 1-3 hrs/day.	Regular (Seemingly) [As per norm the supply of should be 24x7, but it is not happing in most of the cities in India at present]	Regular
GOVERNANCE	Govt.	Govt.	Private agency
RENT/BILL	Normal (Per connection)	Normal (Per unit)	Higher than Govt.
28	Why you want to select this scenario?		

Urkund Analysis Result

Analysed Document: Lakpa Doma Sherpa PhD Thesis entitled Urbanisation and Water Resources Management A Study of East Sikkim District.docx (D64772009)

Submitted: 3/3/2020 1:09:00 PM

Submitted By: lakpaecodepartment@gmail.com

Significance: 1 %

Sources included in the report:

Chapter 1-4 Bib Final 16.9.docx (D56290734)
https://lawsisto.com/Read-State-Act/MTQxMQ==/THE-SIKKIM-WATER-SUPPLY-AND-WATER-TAXACT-1986

Instances where selected sources appear:

4