CHALLENGES AND OPPORTUNITIES FOR ACHIEVING THE DRINKING WATER GOAL OF THE MONGOLIAN SUSTAINABLE DEVELOPMENT VISION (MSDV) 2030.

Munkhzul Chimid-Ochir (2176336)

Master of Environmental Management Course

College of Humanities, Arts and Social Sciences

Flinders University

12 October 2018

Table of Contents

ABSTRACT 6

DECLARATION 7

ACKNOWLEDGEMENTS 8

1 INTRODUCTION 11

1.1 WATER AND SUSTAINABLE DEVELOPMENT 11

1.2 GLOBAL CHALLENGES OF POPULATION ACCESS TO SAFE DRINKING WATER 12

1.3 MONGOLIA, SUSTAINABLE DEVELOPMENT AND DRINKING WATER ACCESS (WITHIN THE CONTEXT OF THE MSDV 2030)15

1.4 RESEARCH QUESTION AND OBJECTIVES 17

2 METHODOLOGY 19

2.1 INTRODUCING THRESHOLD 21 (T21) MODEL 20

2.2 THRESHOLD 21 MONGOLIA MODEL AND ITS UTILISATION TO THE RESEARCH 22

3 LITERATURE REVIEW 24

3.1 GENERAL CONCEPTS 24

3.1.1 DRINKING WATER SUPPLY 24

3.1.2 SUSTAINABLE DEVELOPMENT 26

3. 2 WHY DRINKING WATER ACCESS IS AN INTEGRAL PART OF SUSTAINABLE DEVELOPMENT? 29

3.2.1 WATER AND SOCIETY–PUBLIC HEALTH 29

3.2.2 WATER AND SOCIETY–POVERTY 30

3.2.3 WATER AND ECONOMY 32

3.2.4 WATER AND NATURAL ENVIRONMENT 33

3.3 WHAT MAKES FAILURE FOR POPULATION ACCESS TO SAFE DRINKING WATER? 35

3.4 BASIS OF SUCCESSFUL APPROACH TO POPULATION ACCESS TO SAFE DRINKING WATER. 40

3.5 LITERATURE REVIEW IN THE MONGOLIAN CONTEXT 42

4 ANALYSIS OF CURRENT SITUATION AND FUNDAMENTAL CHALLENGES TO ATTAINING THE GOAL 45

4.1 EVALUATION OF THE CURRENT ACCESS TO DRINKING WATER BY THE POPULATION IN MONGOLIA 45

4.2 FUNDAMENTAL CHALLENGES TO ACHIEVING THE MSDV 2030 DRINKING WATER GOAL 47

4.2.1 WATER GOVERNANCE CHALLENGES 47

4.2.1.1 INSTITUTIONAL STRUCTURE AND ADMINISTRATIVE CAPACITY OF DRINKING WATER SUPPLY 47

4.2.1.2 DATA SCARCITY ON WATER 49
4.2.1.3 DRINKING WATER POLICY AND INVESTMENT PLANNING CHALLENGES 50
4.2.2 PHYSICAL WATER AVAILABILITY AND CLIMATE CHANGE RELATED CHALLENGES 52
4.2.3 CHALLENGES IDENTIFIED IN THE CASE OF ULAANBAATAR CITY 53

5 OPPORTUNITIES TO ACHIEVE THE MSDV 2030 DRINKING WATER GOAL AND ANALYSIS OF INVESTMENT ASSUMPTIONS. 56

5.1 OPPORTUNITIES TO ATTAIN THE MSDV 2030 DRINKING WATER GOAL. 56
5.1.1 IMPROVE WATER GOVERNANCE 56
5.1.2 ESTABLISH SCEINTIFIC WATER DATABASE 57
5.1.3 INCREASE INVESTMENT THROUGH PARTNERSHIPS IN WATER INFRASTRUCTURE SECTOR 58
5.2 ESTIMATION OF THE INVESTMENT REQUIRED TO ATTAIN THE PROPOSED GOAL 60
5.3 ANALYSIS OF INVESTMENT ASSUMPTIONS AND THE IMPACT ON SOCIO-ECONOMY AND ENVIRONMENTAL SECTOR USING THE T21 MONGOLIA MODEL. 69

6. CONCLUSION OF THE RESEARCH 84

6.1 MAIN FINDINGS OF THE RESEARCH 84
6.2 SIGNIFICANCE AND LIMITATIONS OF THE RESEARCH 88
6.3 RECOMMENDATION FOR FUTURE RESEARCH 88
6.4 CONCLUSION 89

APPENDIX 1. DRINKING WATER SUPPLY AND DEMAND RELATIONSHIP BY 29 RIVER BASINS. 91

APPENDIX 2. THE STATE BUDGET ALLOCATION IN MAJOR SECTORS IN MONGOLIA FROM 2015 TO 2018.92

REFERENCE LISTS 93

LIST OF TABLES

Table 2.1	Countries experiences that utilise the T21 model.	21
Table 3.1	Classification of improved and unimproved drinking water sources.	24
Table 5.1	The required total investment to achieve the 90 percent of the total population by 2030.	60
Table 5.2	Projected population for 2030 using regional data for Mongolia, (millions).	61
Table 5.3	The current drinking water supply proportion and proposed target by 2030.	62
Table 5.4	Required investment to cover 90 percent of the rural and urban population by using the capital cost per capita by Hutton and Varughese (2016).	63
Table 5.5	Required investment to achieve the 90 percent access to water for total population by the MCUD 2016 report.	64
Table 5.6	The State budget allocation in major sectors in Mongolia from 2015 to 2018, (%).	65
Table 5.7	Overall investment for the MCUD from 2015 to 2018.	66
Table 5.8	The current economic indicators and the MSDV 2030 policy document's proposed goals.	66
Table 5.9	The indicators to analyse the water infrastructure investment and their impact.	69

LIST OF FIGURES

Figure 1.1	Mongolia Watersheds.	15
Figure 4.1	Tuul River Basin in Mongolia.	48
Figure 5.1	Urban and rural population projection from 2015 to 2030 in Mongolia, (millions).	61
Figure 5.2	Mongolian state budget allocation in 2018.	65
Figure 5.3	The MCUD state budget growth projection and the total additional required investment each year by 2030, (million US$).	67
Figure 5.4	Simulation result of Assumption 1 by the indicator of life expectancy females, (ages).	71
Figure 5.5	Simulation result of Assumption 1 by the indicator of UB water recycling capacity, (million m3).	72
Figure 5.6	Simulation result of Assumption 2 by the indicator of life expectancy by females, (ages).	75
Figure 5.7	Simulation result of Assumption 2 by the indicator of life expectancy by males, (ages).	75
Figure 5.8	Simulation result of Assumption 2 by the indicator of infant mortality rate, (number of death in 1000 birth).	76
Figure 5.9	Simulation result of Assumption 2 by the indicator of the proportion of population below poverty line, (%).	77
Figure 5.10	Simulation result of Assumption 2 by the indicator of unemployment rate, (%).	78
Figure 5.11	Simulation result of Assumption 2 by the indicator of per capita CO2 emission, (Kg/ Person*Year).	78
Figure 5.12	Simulation result of Assumption 2 by the indicator of total BOD discharge, (thousand ton/year).	79
Figure 5.13	Simulation result of Assumption 2 by the indicator of real GDP, (trillion MN$/Year).	80
Figure 5.14	Simulation result of Assumption 2 by the indicator of revenue and grants, (trillion MN$/Year).	81
Figure 5.15	Simulation result of Assumption 2 by the indicator of Ulaanbaatar water recycling capacity, (million m3).	82

ABSTRACT

Regular access to safe drinking water is a basic human right and crucial to human well-being and sustainable development, therefore, the subject is always an essential part of the global development agenda. For instance, the United Nations adopted the 'Transforming our world: the 2030 Agenda for Sustainable Development' in 2015 and its goal 6 and target 6.1 plan to attain universal coverage of safe and quality of water for all human beings by 2030. However, governments in most of the developing countries struggle to achieve these crucial goals due to widespread water-related problems. The Government of Mongolia faces numerous encounters to reach a vital goal to advance the country's sustainability. Through the Mongolian Sustainable Development Vision (MSDV) 2030 policy document, the Government of Mongolia aims to increase the percentage of the population that has access to safe drinking water at 90 percent by 2030 through the. In this thesis, an analysis was made to highlight the underlying challenges and opportunities to achieve that goal. Mongolia's current situation of drinking water access was evaluated based on the standard international requirement as set out by the World Health Organisation. The analysis provided in this thesis explores possible opportunities, for instance, investment options and their impact on the socio-economic and environmental development of the country. This research used the Threshold 21 (T21) Mongolia macroeconomic modelling which is the most extensive database that the Government of Mongolia established and developed since 2012 with the support of the Millennium Institute of the United States and the United Nations Institute for Training and Research. The findings of this research using the T21 Mongolia model affirm the link between the drinking water supply and the sustainable development issues. The fundamental challenges are consistent with the literature, but more rigorous efforts are expected from the Government to reach the MSDV 2030 drinking water goal. Such efforts will offer integral and very positive benefits to the socio-economic and environmental development of the country.

Keywords: Sustainable development, MSDV 2030, drinking water supply, T21 model, water governance, partnership, investment

DECLARATION

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed: MUNKHZUL Chimid-Ochir

Date: 12 October 2018

ACKNOWLEDGEMENTS

Special gratitude goes to my supervisor Associate Professor Udoy Saikia, Director for the Applied Population Studies Programme, College of Humanities, Arts and Social Sciences at Flinders University for providing valuable guidance and comments as well as sharing his profound knowledge and expertise in this research field. I would specifically like to thank Dr Cecile Cutler for delivering constructive advice and encouragement throughout my research. I am thankful to Professor Weishuang Qu, Director of Modelling and Analysis at the Millennium Institute, Washington DC for the inspiration to use the T21 Mongolia model. I am grateful to Sanjjav Samdangeleg, Senior Officer, Ministry of Finance of Mongolia, for supporting the model utilisation and related data information. My appreciation extends to Dondmaa, Batchimeg, Oyunchimeg, Belegsaikhan, Ministry of Construction and Urban Development of Mongolia for sharing the updated national reports and related materials on drinking water supply issues. Moreover, sincere thanks to the Government of Australia for giving this scholarship opportunity to broaden my horizon. Thanks for all the outstanding support from both academic and non-academic programs.

Finally, I must express my heartfelt gratefulness to my beloved parents Chimid-Ochir, Darisuren, my son Munkhtushig, husband Jambaldorj and the rest of my family, as well as friends and colleagues for providing tremendous support and continuing motivation throughout my years of study. This thesis would not have been accomplished without their help. Thank you to all.

MUNKHZUL Chimid-Ochir

12 October 2018

This thesis is dedicated to my dad CHIMID-OCHIR Turbat,

Consulting Engineer of Mongolia,

my mum DARISUREN Damiran, Medical Doctor and

my son MUNKHTUSHIG Munkhzul.

ABBREVIATIONS

ADB	Asian Development Bank
CMO	City Mayor’s Office
GM	Government of Mongolia
GDPo	Green Development Policy
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
LDC	Least Developed Country
MA	Ministry of Agriculture
MCUD	Ministry of Construction and Urban Development
MDG	Millennium Development Goal
ME	Ministry of Energy
MEd	Ministry of Education
MED	Ministry of Economic Development
MET	Ministry of Environment and Tourism
MH	Ministry of Health
MI	Millennium Institute
MM	Ministry of Mining
MRT	Ministry of Road and Transportation
MSDV	Mongolian Sustainable Development Vision
NSO	National Statistic Office
RBM	River Basin Management
SDG	Sustainable Development Goal
T21	Threshold 21 model
UN	United Nations
UNDESA	United Nations Department of Economic and Social Affairs
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNICEF	United Nations Children’s Fund
USUG	Water Supply and Sewage Authority
WB	World Bank
WEF	World Economic Forum
WHO	World Health Organisation
WRG	Water Resources Group
WWDR	World Water Development Report

1 Introduction

1.1 Water and sustainable development

'We live in times of unprecedented global challenges as well as unprecedented opportunities' Ban Ki Moon, the former United Nation's Secretary General stated at the 71st United Nations General Assembly in 2016. A year earlier in September 2015, the global leaders adopted the historic landmark vision 'Transforming our world: the 2030 Agenda for Sustainable Development' in September 2015 to deal with current and future development obstacles. This Agenda is an action plan for people, the planet and prosperity. There are 17 Sustainable Development Goals (SDGs) and 169 targets which are identified as new global commitments for the next 15 years. Sustainable development is an intergenerational issue required to ensure current and future generation's commitment. The SDGs were followed by the Millennium Development Goals which were former development pledges made between 2000 and 2015. This set of SDGs is focused on the world's most demanding goals, for poverty, malnutrition, disease, housing and adequate water while fostering education, equality, human rights and environmental development. The targets have been created to eradicate all forms of poverty and hunger and they are planned to protect the earth from degradation, pollution and climate change. It is pledged to foster liberty and justice and stimulate cooperation and partnership. Accordingly, the goals are determined to ensure human well-being and an inclusive society. The underpinning of human well-being and socio-economic development, as well as the basis of sustainable development, is water. Indeed, water is a basic human right and the main source of every individual's prosperity. Water is the foundation of sustainable development of every country (Vojdani 2004; Wiek & Larson 2012). Also, the nexus between a country's development and its population's access to safe drinking water has long been recognised (World Bank 2004), therefore, safe and good quality of water has always been a significant part of the global development goals. In this regard SGD 6 and its target 6.1 is planned to achieve universal and equitable access to safe and affordable drinking water for all human beings. Therefore, the importance of achieving SDG 6.1 is an integral part of all other SDGs success.

Water is a basic human right that all governments must provide to their population. The dignity of human rights was proclaimed in the Universal Declaration of Human Rights by the United Nations General Assembly on 10th December 1948 (World Bank 2004). The Declaration also enshrined a gradual recognition of water as a rights issue (Rodriguez, Pruski & Singh 2016). It captured the attention of the world community. These topics have been positioned at the top of the global development agenda and comprised a prominent area of international and national discussions that generated extensive and complex debate. The emergence of water and human rights concepts was stated in the 1960s by the UN General's Comment No.15 of the International Covenant on Economic, Social and Cultural Rights and International Covenants on Civil and Political Rights (World Bank 2004). The General Comment No.15 is the section that highlights humans right to water. Then the UN Conference on the Human Environment held in Stockholm in 1972 and the UN Water Conference held in Argentina in 1977 were the first to declare that the basic human right is to have access to clean water and sanitation which is a commonly agreed principle (World Bank 2004). This declaration has been acknowledged in many international documents, conventions and charters. For example, the Convention on the Elimination of All Forms of Discrimination against Women and its article 14 highlights that Parties shall ensure to women the right to sufficient living conditions, especially in relation to water. Also, article 24 of the Convention on the Right of the Child urges that Parties must combat disease and hunger by the delivery of adequate healthy food and good quality of drinking water.

1.2 Global challenges of population access to safe drinking water

Although the human rights to water concept has been recognised as a primary focus of the global development agenda for many decades, the magnitude of the population drinking water issue makes it difficult to achieve proposed goals. There are over 2.1 billion people worldwide who lack safe drinking water (UN 2018; UN Water 2017; WHO & UNICEF 2017), over 2.3 billion people who lack sanitation facilities, 4.5 billion people need safely managed sanitation services and 892 million still use open defecation (WHO & UNICEF 2017). Approximately, 27 percent of the less developed countries' populations have access to soap and water for handwashing on their homes. Around 2 billion people are experiencing high water stress in over 40 countries (UN 2018; World Bank 2004). Roughly 70 percent of all countries are struggling with more than 70 percent of their population in serious water stress. According to the current worldwide prediction, one out of four people live in a country affected by serious freshwater scarcities (UN Water 2017). The relation among poverty and water scarcity is tight. Poverty is dominant in many water shortage areas where the poorer places of the developing world have insufficient drinking water (Jemmali 2017; World Bank 2004). The poor quality of drinking water and absence of adequate sanitation causes water-related diseases and subsequent epidemics become leading source of death in the developing world. Every

year around 842,000 people, including 340,000 children lose their life due to unsafe drinking water use (UN Water 2017).
Countries face enormous challenges in attaining SDG 6.1 by 2030. Because water is complex it links to almost everything in the world. There are three major factors within the water supply problem, population growth, water scarcity and lack of investment in the water infrastructure sector (Van der Bruggen, Borghgraef & Vinckier 2010). Also, poor governance is the fundamental problem globally of the population water supply issue (ADB 2013).

One of the main challenges is the overwhelming population growth and urbanisation that puts the urban drinking water supply in a critical situation. World population, which was 2.6 billion in the middle of the 20th Century has more than doubled to 7 billion now and it is expected to be around 11 billion by the 21st Century (UNDESA 2017). Not only population growth but also the basic demand is enormous, especially for drinking water resources. Around 29 percent of the global population lived in an urban area in 1950, the proportion reached to 50 percent by 2014, and it is predicted to get 60 percent by 2030 (UNDESA 2014). The urban population is estimated to be increasing by 5 million every month (Van der Bruggen, Borghgraef & Vinckier 2010). Urban population growth leads to more consumption of resources such as water, food, shelter and there are many other demands. Consequently, rapid population growth, urbanisation, the sharp increase in services in consumption, and services, as well as water resources depletion are the greatest global challenges that pose a risk for the subsistence of humankind.

Water is not only a basic human right but also a driving force of socio-economic development. Almost all socio-economic sectors such as agriculture, mining, and infrastructure, utilise water for their industrial development. The biggest water user is the agriculture sector which accounts for 69 percent of global freshwater extractions; industrial sectors, including electricity production reports for 19 percent and houses for 12 percent. It is estimated that around 45 percent of the global gross domestic product and 40 percent of worldwide grain production will be at risk by 2050 unless immediate actions to protect global water resources are taken (UN Water 2017). Unfortunately, water pollution of these economic sectors increases pressure on the drinking water distribution. All these water users pollute freshwater resources and discharge water back into water sources without adequate treatment which negatively affects the available drinking water and water ecosystems (UN Water 2017).

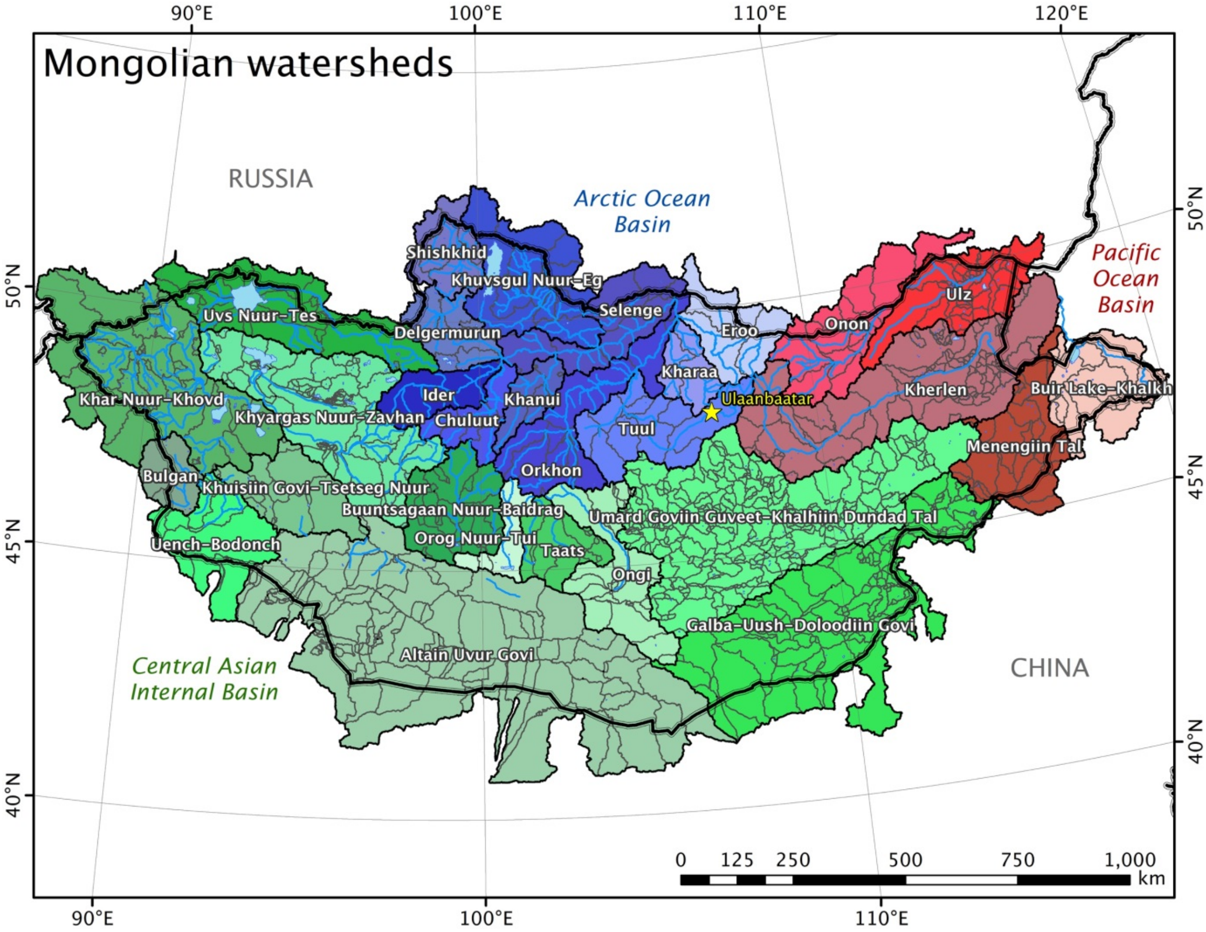
In addition, water resources are limited and becoming scarce everywhere, while the demand is increasing significantly due to population growth and economic development (Vojdani 2004). Groundwater depletion is substantial universally and per capita water availability is diverse due to geographic location. Concern about per capita water availability in Asia is considerable as Asia has the least compared to other regions. Asian per capita water availability is estimated at 3.92 1000 m^3/year, while Africa has 5.72, Europe 4.23, and North America 17.4 1000 m^3/year (Van der Bruggen, Borghgraef & Vinckier 2010). Furthermore, water scarcity is the most challenging issue in water supply, particularly in arid and semi-arid areas of the world (Kahil et al. 2016). Arid and semi-arid regions comprise one-third of the total land of the world (Vojdani 2004) and roughly 23 percent of the total Asian population inhabit these regions (Sivakumar, Das & Brunini 2005). In the region, water managers struggle to ensure equal distribution among water users. Meanwhile, countries are confronting massive threats associated with climate change such as droughts, floods, soil erosion desertification, and so on. All these factors decrease the availability of water resources.

According to the research conducted by the Asian Development Bank (ADB) in 2013, poor governance is the fundamental problem of water supply in worldwide. Poor governance can be characterised by the failure of an institutional set up and weak regulations and enforcement (Furlong 2012). Water is too complex to be governed by a single institution and sole regulation. Population drinking water supply requires many different rules from various levels of agencies in order to ensure its management and control, because water forms so many interconnected problems among the environment, social and economic sectors. The poor governance of the drinking water supply is associated with a low tariff for water supply and lack of investment in water infrastructure (Van der Bruggen, Borghgraef & Vinckier 2010; Wu, House & Peri 2016). As stated by Garrick, Whitten and Coggan (2013), water is considered as a public good which involves different groups, so to set the right tariff is difficult. This leads to complexity in water tariffs and water pricing. The lack of reliable data information on drinking water supply is part of poor water governance. Countries are at different stages in terms of available and reliable data for the SDG 6.1 and its monitoring and reporting mechanisms. There is a significant knowledge gap among countries to collect, monitor and report population drinking water access and related data information. Approximately 60 percent of all countries lack available data for at least four SDG 6 indicators, and just 6 percent of countries reported more than eight indicators. Therefore, lack of investment and a data scarce situation are closely related to the governance issue which is a crucial challenge to be solved to achieve the SDG 6.1. Overall, water resources and a safe drinking water supply for the population are rooted in all forms of development and poverty reduction, and sustaining economic growth in almost all economic sectors and maintaining ecosystems is essential.

1.3 Mongolia, sustainable development and drinking water access (within the context of the MSDV 2030)

Mongolia is a country that confronts all these population drinking water challenges. Mongolia is a landlocked country located in Central Asia. The total population is around 3.2 million in 2018 (NSO 2018). The total land area is 1.564 million square kilometres and population density is two people per square kilometre (NSO 2018). The recent report (MCUD, 2016), almost 50 percent of the total population live in urban areas, and the rest are rural dwellers. Water is an intrinsic part of Mongolian development. The ADB (2014) highlights that the sustainable development pathway for Mongolia depends on water resources availability, yet water scarcity in primary development areas is a major challenge to the country's further prosperity (ADB 2014). Water resources in Mongolia are limited and unevenly distributed within the country (Batnasan 2003). Abundant surface water resources are in the northern part of Mongolia, but most water resources are inaccessible to the major population centre Ulaanbaatar, or to mining, and industrial operations (ADB 2014). There are three major watershed basins: The Arctic Ocean Basin in the northern part of Mongolia but this water is carried downstream to the Baikal Lake to Russia; The Pacific Ocean Basin in the east, where the water flows to China; and The Central Asian Internal Drainage Basin in the south, which has no runoff surface water system (Figure 1.1) (Free 2015). Also, Mongolia is very sensitive to climate change due to its geographic location (GM 2012). Climate change and extreme weather events seriously affect the availability of water resources to the population as well as for socio-economic development.

Figure 1.1 Mongolian watersheds.



Source: Free, 2015.

The global SDGs are strongly embedded in Mongolian policies. The Parliament of Mongolia approved the Mongolia Sustainable Development Vision (MSDV) 2030 by its 19th resolution on 5th February 2016 (MF 2016). The policy aims to ensure Mongolian current and future sustainable development. The policy defined three major sets of sustainable development goals. One of the environmental sustainability goals of the policy is to increase the percentage of the population that has access to safe drinking water. The goal that focused on drinking water plans to achieve the supply of safe drinking water to 80 percent of the population by 2020, 85 percent by 2025 and 90 percent by 2030 (MF 2016). The current percentage of the population that have access to safe drinking water in Mongolia was estimated at 80.4 percent in 2015 (MCUD 2016). However, it should be highlighted that the research conducted by the United Nations Development Programme found that the National Statistical Office estimation of population with access to safe drinking water was unrealistically high in terms of Mongolia's total territory as well as the condition of its rural population (Dore & Nagpal 2006; Karthe et al. 2015; MED 2013; WRG 2014). With this data scarcity situation, it is uncertain whether the Government will be able to achieve the drinking water goal stated in the MSDV 2030 and ensure the country's sustainable development in the future. Thus, the research will explore this issue and related objectives in the framework of drinking water and sustainable development issues of Mongolia.

1.4 Research question and objectives

This research will investigate whether attaining the goal of the drinking water access to 90 percent of the population as stated in the MSDV 2030 is achievable in terms of the country's current situation. The current situation of the country will be assessed by its international requirements. At the international level, access to safe drinking water can be defined as an equitable and quality supply of water available at the rate of 20 litres daily per capita within a maximum 1 km distance (UN 2000). These international criteria for drinking water access will be the basis of evaluation of the current situation in Mongolia.

This study will pursue the following objectives to address the research question mentioned above:

- To identify the challenges and opportunities in achieving the drinking water goal stated in the MSDV 2030;
- To make an approximate estimation of investment required to achieve the goal;
- To find out the impact of increasing the investment on water infrastructure and its related policies on the country's sustainable development.

The research will also analyse a number of investment policy assumptions to achieve the goal by utilising the macroeconomic Threshold 21 model. The Threshold 21 model is a system dynamics based macroeconomic model for national development planning (MI 2018). The system dynamic is one of the system theories to understand nonlinear, circular or complex systems (Sterman 2000). This is a mathematical modelling method used to discuss interdependency and complexity of issues and problems. The model is a comprehensive planning tool that integrates economic, social and environmental aspects of the development framework. The T21 analysis considers medium to long-term planning. The model has been developed over the past 20 years from extensive research and application by the Millennium Institute. The model is widely used in both developed and developing countries' policy planning field. For instance, the Chinese Government used T21 to analyse opportunities to increase investment in the transport sector, and the National Environmental Agency of Italy used T21 for the Italian Government policy compliance with its Kyoto Protocol (MI 2018). According to the Mongolian Prime Minister's Office resolution, the Ministry of Finance has been developing T21 Mongolia model since 2012. Then in 2015 the model was expanded to analyse the Green Development Policy of the country and included four green economy sectors[1] which are water management, green energy, green building and waste management (MF & MI 2015).

The conclusion of the research will focus on water infrastructure development and its investment planning options to attain the goal. The research project will provide valuable approaches to achieve the MSDV 2030 drinking water goal of the country. The following methodologies were applied to conduct the research needed to achieve these objectives.

[1] Four green economic sectors- as a former officer of the MET, I was assigned to work with the T21 Mongolia project team on these sectors' development. Based on this knowledge and with support from the MF, the research utilised the T21 Mongolia model.

2 Methodology

The main methodology used in this research is based on qualitative and quantitate analysis using relevant literature and secondary data. The fundamental literature is found basically from three different sources, the first from academic databases, the second internet searches and lastly from other sources such as updated data from governmental officials through email and phone contact. The primary literature is focused on case studies that included population access to safe drinking water and sustainable development issues in developing and developed countries' experiences. These are all peer-reviewed journal articles from academic database sources, especially related to environmental studies such as ProQuest, Scopus, Science Direct, and SAGE Journals that are linked via open access to the Flinders University Library. The research methods of these data sources are various such as quantitative, qualitative and other methods, for comparative SWOT analysis, questionnaires, interviews and so on. For example, the case studies by Hutton and Varughese (2016), Zeneli (2016), Van der Bruggen, Borghgraef and Vinckier (2010), Osei et al. (2015), Norman et al. (2013), Rodriguez, Pruski and Singh (2016), Widmer et al. (2013), (Nickum 2012) and Malsy, Flörke and Borchardt (2017) have included extensive quantitative estimation, diverse modelling analysis and empirical researches. Qualitative methods based on substantial review of the relevant literature and empirical research was conducted by Naik (2017), Baer (2014), Jemmali (2017), Winkler (2018), Martínez-Santos (2017), Wiek and Larson (2012), Thomas (2004), Gawel and Bernsen (2011), Vojdani (2004) and Loucks (2000). While some researchers such as Kida et al. (2018), Batbayar et al. (2017), Nagara et al. (2015), Chung et al. (2009), Tortajada and Joshi (2014) and Batsuuri and Wang (2017) used sociological survey methods through sample collections, questionnaires and interviews. The research found a considerable amount of data information through internet sources from international and national organisations' websites. These reports and publications were used as a source of background information as well as to analyse not only the current situation but also future trends and projections for the research. For instance, it should be noted that the UN (2018) ''Sustainable Development Goal 6: Synthesis Report 2018 on Water and Sanitation'', the WHO & UNICEF (2017) ''Progress on Drinking Water, Sanitation and Hygiene 2017 update and SDG Baselines'' and Hutton and Varughese (2016) report ''The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation, and Hygiene'' supported by the World Bank were very useful to familiarise and explain th contextual setting of the work and its universal condition and the situation of the SDG 6.1 progress.

National data found by internet sources from the local organisations' websites, for instance, the ''Renewed 2015-2045 Population Projection'' from the National Statistic Office, law regulations and state budgets from the legal database www.legalinfo.mn that are run by the Government of Mongolia and other relevant data on Mongolian population drinking water access was taken from the Ministry of Construction and Urban Development (MCUD), and the Ministry of Environment and Tourism (MET)'s websites. Some information is based on direct contact with government officials[2]. For instance, Dondmaa, Senior Officer, Strategic Planning Department, MCUD, Batchimeg, Senior Officer and Oyunchimeg, Officer, both in charge of Drinking Water Supply and Sanitation Policy Regulation in the Department of Municipal Policy Regulation, MCUD and Belegsaikhan, Senior Officer, Department of Urban Construction and Land Use Policy have provided the estimations of the ''Mongolia SDG country costing summary report in 2016'' and the publication ''Mongolian population accessibility to drinking water supply and sanitation'' in 2014 and other updated data which were beneficial for estimating an approximate required investment to achieve the MSDV 2030 drinking water goal. Most of the data information and academic journal articles analysed in this research are recent dating from the 2000s to the current time to draw rational and reasonable results. The study is utilised and simulated data information from the T21 Mongolia model to include strategic investment planning for the MSDV 2030 drinking water goal.

2.1 Introducing Threshold 21 (T21) Model

The T21 model is system dynamic based macroeconomic modelling to support national development planning. The system dynamic is one of the system theories used to comprehend nonlinear, circular and complex systems (Sterman 2000). The model is used as a for comprehensive planning tool that integrates and understands the interdependency and complexity of issues and problems (Tong 2012). The significance of the T21 from other macroeconomic modelling is that the model utilises and simulates compound systems such as social, economic and environmental aspects of the development frameworks (Barney et al. 1995; MI 2018). The T21 analysis considers medium to long-term planning.

The Millennium Institute (MI) has developed and expanded the T21 model over the last 25 years (MI 2018). The primary goal of the MI is that to support strategic planning of developing and developed countries' sustainable development through comprehensive modelling and research tool

[2] Government officials- I have been employed as an officer of the Strategic Planning Department of the MET and they are my co-workers from the MCUD.

(MF & MI 2015; MI 2018). The MI has searched and studied hundreds of national development models and prioritised and compiled 50 models that considered as comprehensive as possible (MF & MI 2015). For instance, the Improved minimum standard model by the WB, Financial programming model by the International Monetary Fund, Green House Gas Emission model by the Intergovernmental Panel on Climate Change (IPCC), Energy demand and supply model by the Energy Authority of the United States, Population modelling for special groups by the United Nations Population Fund, Public Health models and Environmental monitoring models by the Dutch Environment and Public Health Institution, Meteorology and economic model by Yale University and Agriculture Production model by the Food and Agriculture Organisation and so on. Unfortunately, none of these models was long-term and dynamic that can comprehensively utilise all three aspects of sustainable development which are social, economic and environmental sectors and its strategic planning (MF & MI 2015). Most of these models analyse only social and economic sectors, but not environmental areas. Therefore, the MI is planned to develop long-term strategic modelling to support countries' sustainable development planning.

The first experimental version of the T21 model was developed by Robert Eberlein of the Massachusetts Institute of Technology and Harvard University (MF & MI 2015). The first version was developed as a gift from Professor Robert Eberlein to the MI. Since 1994, Weishuang Qu, Director of Modelling and Analysis of the MI and his team have been developing and expanding the T21 model for almost 25 years to advance the current T21 model version (MF & MI 2015). The model is widely used in both developed and developing countries' policy planning fields (MF & MI 2015; MI 2018; Tong 2012). The model is not an ultimate solution for strategic planning, but it provides feasible trends and projections for policy implications (Barney et al. 1995; MF & MI 2015; Tong 2012). The model requires improvement to provide a more advanced and comprehensive analysis of policy assumptions. The following countries (Table 2.1) are utilising the T21 model for various sector's strategic planning.

Table 2.1 Countries experiences that utilise the T21 model.

Countries	T21 added sectors and improvements	Period
Bangladesh	Health, nutrition and education	1994-1996
Tunis	Water sector improvement	1996-1997
Cambodia	Consequence of war	1997
Benin	Environmental indicators' improvement	1997
Italy	Improved Agriculture, nutrition and Greenhouse Gas Emission Inventory	1997
China	Transport policy planning	1999
Malawi	HIV, income distribution	1999
Mexico	T21 Mexico, not added new sectors	1999
USA	Forestry and energy sector planning	1999
Somali	Pastureland economy	2000
Ghana	T21 Ghana, not added new sector	2001
Guyana	Sugar and Aluminium and Copper Industry and their sectors' structure	2001
Bhutan	Water energy, National Happiness Index	2002
Indonesia	Highway, Dam construction, Illegal logging by region	2002
Mozambique	Small scale loan, Agriculture expansion, Mega projects, New Road, MDGs	2003
Papua Guinea	Environmental database	2004
USA	Demand based production	2004
Ghana	MDGs and its indicators	2004
Mali	Cotton manufacturing and Gold exploration	2005
Jamaica	Crime, Natural disaster	2006
Switzerland	HIV, Transport, Tourism and Telecommunication	2008
Economic Community of West African States (ECOWAS)	Income distribution and international trade	2010
Mongolia	Initial version of the T21 Mongolia model	2012

Source: T21 Mongolia Model: Technical Handbook, MF, 2015.

2.2 Threshold 21 Mongolia Model and its utilisation to the research

The T21 Mongolia modelling is the biggest macroeconomic database of the country that has been developed by the Government of Mongolia since 2012 (MF & MI 2015). The model is the main instrument used to analyse policy assumptions and implication for the national strategic planning and policy implementation in Mongolia. The initial version of the T21 Mongolia model was jointly developed by the Ministry of Finance of Mongolia and the Millennium Institute of Washington with support of the United Nations Development Program (UNDP) and United Nations Institute for Training and Research (UNITAR) in 2012 (MF & MI 2015). The Ministry of Finance is the authority mainly responsible for updating and continuing development of the model. Data information accumulated in the model is from all involved all ministries and related agencies in the country. The MET cooperated with the T21 Mongolia model team in 2015 to analyse the Green Development Policy (GDPo) that was approved by the Parliament in 2014. The primary goal of the GDPo is to ensure the country's sustainability and population well-being in the long run through inclusive economic growth based on the green development concept (GM 2014). The GDPo is the fundamental policy document of the MSDV 2030 strategy (MF 2016).

To analyse the GDPo, the T21 Mongolia model is expanded by the four green economy sectors (water management, green energy, green building and waste management). These sectors are added to the T21 Mongolia model's three major pillars i.e. social, economic and environment. Each sector is divided into sub-sectors and modules (MF & MI 2015). The social sector included 13 sub-modules including population, birth, death, primary education, high education, employment poverty and so on. The economic sector is divided into 16 sub-sectors and modules such as state budget income, state budget expenditure, investment, government's debts and loan, industries (agriculture, mining, livestock etc.), international trade and other relevant activities. The environmental sector included 7 sub-sectors and modules, for example, land, water recycling, water demand, energy demand and supply, natural gas production, greenhouse gas emission and ecological zone etc. Currently, the T21 Mongolia model includes 61 sectors and around 2,000 variables and more than 10,000 statistics of the country (MF & MI 2015).

This research analysis will utilise the latest version of the T21 Mongolia model. The research will approximate the required investment needed to accomplish the MSDV 2030 drinking water goal based on the related data information. Then, the research will analyse investment policy assumptions applied to achieve the goal by utilising the macroeconomic Threshold 21 model. The research will analyse two major investment policy assumptions; one is an increase in domestic funding; and the other is an increase in international investment in the water infrastructure sector in Mongolia. The following section reviews the literature underpinning the importance of investigating the ability of Mongolia to achieve its sustainable drinking water goal.

3 Literature review

The main objective of this literature review is to unfold the concept of the population's access to safe drinking water as an integral part of sustainable development and the nexus between access and development. The structure of this literature review is as follows: first, the review concentrates on the importance of drinking water supply as a basic human need; second, the reasons for failure and success of drinking water management are analysed. This objective will be discussed with examples and case studies. This review will guide further investigation of the research and define an important literature gap in the field of drinking water and sustainable development.

3.1 General Concepts

3.1.1 Drinking water supply

Researchers have defined the concept of the population's access to safe drinking water and sustainable development issues as well as their relationship which is complex and interdisciplinary (Jemmali 2017; Loucks 2000; UN 2018; Vojdani 2004; Winkler 2018). Academic sources highlight the main reason is water connects every aspect of human life and development (Martínez-Santos 2017; Naik 2017; Wiek & Larson 2012). As stated by the Asia Water Watch 2015 report by the ADB (2005) and Baer (2014) the definition from the WHO is commonly used in this research field. The WHO outlined that it is essential that population access to safely managed drinking water is equitable and a good quality supply of water is available at the rate of 20 litres daily per capita within a maximum 1 km distance (UN 2000). Baer (2014) claims that the origin of this definition is derived from the UN notion on human rights to water.

According to other academic explanations, there are three major components in the concept of the population's access to safe drinking water: access, safety, affordability of water supply service (Baer 2014; Van der Bruggen, Borghgraef & Vinckier 2010). As stated by Martínez-Santos (2017) and Baer (2014) access is measured by the rate of the population that are connected to an improved drinking water source on premises. The UN (2000) and Baer (2014) defined safely or adequate quality of water as assessed by the World Health Organisation's 'Guidelines for drinking water quality' as well as respective countries water quality standards. Baer (2014) and Gawel, Sigel and Bretschneider (2013) explain affordability is defined by the price per cubic metre of water in comparison between the average water bill and average monthly income. In addition, the UN Water (2017) accurately illustrates affordability should include the fact that payment for water services should not be a household barrier, regardless of the level of service.

The latest report of the UN (2018) identifies that for safely managed drinking water services people must practice improved water sources that meet the following three criteria: the accessibility of water on premises; water should be accessible whenever required and water should be free of contamination. It further explains that if any of these criteria are not met and around trip for water collection is less than 30 minutes, this classifies as a basic drinking water service. If the required water collection trip is over 30 minutes, it is then classified as a limited service. Commonly, the drinking water sources are divided into improved and unimproved (Hutton et al. 2004; Martínez-Santos 2017; WHO & UNICEF 2015). The classification is shown in Table 3.1. The latest UN (2018) estimation, over 2.1 billion people lack access to safely managed drinking water services, around 1.3 billion use basic services and approximately 263 million use limited services while at least 423 million still use unimproved sources and roughly 160 million use poor quality surface water.

Table 3.1 Classification of improved and unimproved drinking water sources.

Improved	**Unimproved**
Piped household connection	Unprotected borehole
Standpipe public tap	Unprotected spring
Protected borehole	Vendor-provided water
Protected spring	Surface water provided by tanker or truck
Collected or harvested rainwater	Bottled water
Water disinfected at the point of use	

Source: WHO & UNICEF, 2015.

On the other hand, some researchers argue that these terminologies are quite slippery, so that they need more clarification. Martínez-Santos (2017), Vojdani (2004) and Winkler (2018) claim that global data information often disregards essential aspects of drinking water supply issues. Rode (2014), supports the idea and argues that population access to water is evaluated solely by the number or percentage of people that are connected to improved water sources or types of facilities, but this does not accurately account for critical factors such as affordability, water quality (Martínez-Santos 2017), water source distance and time that people spend on accessibility (Van der Bruggen, Borghgraef & Vinckier 2010). Martínez-Santos (2017), Easterly (2009), Dar and Khan (2011) and Osei et al. (2015) affirm the argument that water affordability and quality is often ignored in the concept of the population access to drinking water.

Some researchers emphasise that there is lack of commonly agreed method to measure affordability and the term is the most complex part of the drinking water concept compared to other components (Baer 2014; Bartram 2007; Hutton 2012; Martínez-Santos 2017; Smets 2009). In this regard, several authors recommend that it is crucial to develop indicators to support more efficient and consistent monitoring of affordability in the future (Adank et al. 2016; Baer 2014; Bain et al. 2014; Bartram 2007). The UN report in 2015 estimated that around 85 percent of the rural population have access to improved drinking water sources. However, the number cannot assure all 85 percent of improved water sources are can meet adequate drinking water standards. This idea is also asserted by other researchers that studied the quality of drinking water (Abera, Bezabih & Hailu 2017; Anwar & Aggarwal 2014; Bahram, Hamid & Akram 2012). In addition, Martínez-Santos (2017) reminds us that safe water must be free of harmful microorganisms and toxic chemicals (Yunus et al. 2016).

Unfortunately, some improved water sources, such as boreholes and springs, are easily contaminated by poor hygiene and human or animal faeces in many rural areas worldwide (Abera, Bezabih & Hailu 2017; Bain et al. 2014; Kirby et al. 2016). For instance, Shaheed et al. (2014) examined improved water sources in Cambodian households, and found that more than half of the samples they tested were contaminated by harmful substances. Similar evidence was found by Adank et al. (2016) and Abera, Bezabih and Hailu (2017) in Ethopia, Rode (2014) in India, and Heitzinger et al. (2015) in Peru. These publications strongly emphasise that the current data evaluation of population access to safely managed drinking water is overstated and exaggerated. Therefore, more clarification and accurate data analysis are needed regarding drinking water access concepts.

3.1.2 Sustainable development

Contemporary academics highlight that sustainable development is a central concept of our era (Kates, Parris & Leiserowitz 2005; Sachs 2015; UN 2018; Vojdani 2004). The existing literature agrees that sustainable development is the main goal of humankind to ensure human well-being (Loucks 2000; Sachs 2015; UN 2018; Velis, Conti & Biermann 2017; WHO & UNICEF 2017). However, there are countless definitions and explanations about what constitutes sustainable development. For instance, there are the goals, indicators, guides, values and practices, and so on (Kates, Parris &

Leiserowitz 2005). Nonetheless, academic sources stress that the most widely accepted definition is the Brundtland Commission's seminal definition (Kates, Parris & Leiserowitz 2005; Loucks 2000). In 1987, then the Prime Minister of Norway, Gro Harlem Brundtland, led the World Commission on Environment and Development of the United Nations General Assembly which then became known as the 'Brundtland Commission'. The Commission followed the root of the 1972 Stockholm Conference on Humans and the Environment that first acknowledged the conflict between environment and development. According to the Brundtland Commission, sustainable development is the ability to make development which ensures that it meets the needs of the current generation without compromising the needs of future generations. Sachs (2015) supports this and states that this definition is surely the most widespread and frequently cited in the sustainable development research field.

Another commonly agreed concept of sustainable development is that this is the development approach that considers socially inclusive, environmentally friendly economic growth. Harmancioglu (2017), Sachs (2015), Stafford-Smith et al. (2017) and the (UN 2018) uphold the concept that sustainable development is a comprehensive and holistic integration of three components which are economic, social and environmental development. The last, but not least commonly agreed viewpoint is that of intergenerational equity: Loucks (2000), Wiek and Larson (2012) and (Winkler 2018) discussed that the concept of sustainable development refers not only to our immediate demands but also long-term future generations' demands. Loucks (2000) explains the reason for this and states that it is because population dynamics are a continuing process that require strategic planning in the short, medium and longer terms. From this intergenerational equity viewpoint, Loucks (2000) and Harmancioglu (2017) urge the understanding of a vital concept which is that of sustainable water management and sustainable population access to drinking water. They further claim sustainable water resource management is essential to satisfy the current and future demand without degradation of water resources. Likewise, the UNESCO (1999) defines that sustainable water resources management is a concept that highlights the needs to reflect long-term strategic planning for current as well as future use, while maintaining ecological and environmental integrity.

In the current literature, researchers refer to sustainable water resources management as the basis of water security which is required to ensure countries long-term water demand and supply management (Araral & Wang 2015; Ford & Andersen 2008; Naik 2017; Van der Bruggen, Borghgraef

& Vinckier 2010). With regard to the concept of sustainable population access to drinking water Araral and Wang (2015) and Naik (2017) state that it refers to safely managed water accessibility due to strategic planning. However, Loucks (2000) and Vojdani (2004) interestingly argue that water resources management cannot be sustainable because the future is uncertain and it is impossible to make decisions on behalf of our future generations. Nonetheless, many other researchers support the idea that the current policymakers should develop policies and plans to satisfy not only immediate demands, but also the next generation's needs.

From the above discussion, it can be seen that both concepts, population access to safely managed drinking water and sustainable development, are crucial areas that need further exploration in academic research fields. It seems even definitions, terminologies and their estimation and projections, especially concerning drinking water supply, are complex and challenging as often adequate water quantity and quality issues are disregarded, as well as time and distance of drinking water sources. These points are vital, but are highly difficult to evaluate, estimate and account. For example, it will be economically very costly to ensure water quality monitoring, especially in rural areas. Also, there are numerous parameters of water quality elements that cannot be fully controlled. Moreover, affordability is another barrier to evaluate as there is a lack of a commonly agreed method to measure it. Nonetheless, these burdens that are related to population drinking water access should not hinder the implementation of global and national targets. Van der Bruggen, Borghgraef and Vinckier (2010) rightfully state that all water-related challenges are preventable, reducible and manageable through appropriate actions. Regarding the concept of sustainable development, it is also a broad and interconnected notion that should account for the integration of economic, social and environmental development pillars. However, the intergenerational equity and sustainable population access to drinking water is an essential viewpoint that this research needs to address and follow for further exploration of achievement of opportunities of attaining the drinking water goal for Mongolia. Undeniably, the success of the drinking water goal should include an emphasis on long-term sustainable development planning for the present and future generations.

3. 2 Why drinking water access is an integral part of sustainable development?

3.2.1 Water and society–public health

Researchers and international organisations declare that the goal of sustainable development is to ensure human well-being through socio-economic and environmental development (Harmancioglu 2017; Osei et al. 2015; UN 2018). Researchers agree that the most important principal driver of ensuring sustainable development is considered to be water resources, which are more precious than any other resources and humankind's essential living source (Harmancioglu 2017; Jemmali 2017; Massoud et al. 2010 & Vojdani 2004). They further support that population health and poverty eradication are the primary focus to safeguard human well-being and water is the fundamental condition for this. Many agree that water is the foundation of an inclusive society, economic development and environmental protection (Gawel & Bernsen 2011; Sachs 2015; Stafford-Smith et al. 2017; UN 2018).

Other contemporary literature emphases that water is the most critical strategic resource of humankind's existence (Chen, & Wei 2014; Grey & Sadoff 2007; Li et al. 2014). Minerals, some renewable, wind, solar and other natural resources such as gas, oil, even forests and biodiversity do not count as being as strategic as water. The main reason that researchers strongly support population access to safe and good quality drinking water is that it is vital for human health (Martínez-Santos 2017; Massoud et al. 2010; Nickum 2012; Vlugman 2006). Some researchers support this idea and state that inadequate access to water and sanitation is a crucial part of the poverty and low development that affects many developing countries. With regard to this, Gleik, 2000 and Baer, 2014 warn that water-related diseases cause more death than all other forms of violence including war (Fragkou & McEvoy 2016). Baer (2014) estimates that around 14,000 to 30,000 people die daily from consuming dirty water. Rodriguez, Pruski and Singh (2016) state that people cannot live without water more than three consecutive days. Martínez-Santos (2017) urges that unsafe water is a trigger of a massive threat to public health and hygiene. The study further acknowledges patients who suffer from water-related diseases engage over 50 percent of hospital beds globally.

Poor quality of water directly generates many epidemics such as diarrhoea, cholera, dysentery, typhoid and polio (Chung et al. 2009; Gundry, Wright & Conroy 2004; Khan et al. 2013; UNEP 2010; WHO 2010; Widmer et al. 2013). If we take just one common water-borne disease, diarrhoea, this is caused by inadequate access to water and improper sanitation and poor household hygiene. There are many reports with abundant examples of this. For instance, Vlugman (2006) Environmental Health Advisor to the WHO estimates that over 2 million children die every year because of diarrheal diseases: that equals four children every minute, including 90 percent of children under five deaths. The report also further identifies that diarrhoea affects learning skills and intellectual development of children as well as reducing physical fitness and work productivity of adults.

However, this shocking number was estimated ten years ago; but the situation has not improved. The WHO & UNICEF (2017) finds that at least 2 billion people still use faecally infected drinking water sources. Widmer et al. (2013) argue that contaminated water causes over 500,000 diarrhoeal deaths every year. The UN (2018) emphasised that around 38 percent of developing countries' healthcare facilities lack improved water sources so that women and new-borns become infected from unsanitary rooms and services. Academic scholars contend that some improved water supplies, more specifically groundwater sources, are actually contaminated with toxic elements such as arsenic, lead, fluoride, nitrite and copper (Martínez-Santos 2017; Obeed Al-Azawi & Ward 2017). Chakraborti et al. (2015) investigated that Bangladesh is the foremost example of arsenic contaminated groundwater supplies so that waterborne arsenic that causes skin, lung and liver cancer is high in the country. Also, Saint-Jacques et al. (2014) estimates that there are around 20 million people who will continue to use drinking water with an arsenic content that exceeds 50 micrograms per litre which causes a dangerous situation. Many researchers who study water quality and population water access confirm that poor water quality and lack of drinking water access is directly linked to the poor standard of living that is poverty (Jemmali 2017; Naik 2017; World Bank 2004).

3.2.2 Water and society–poverty

Researchers and the UN Water (2017) uphold that water is the key to poverty elimination (Naik 2017; Vlugman 2006). Also, Naik (2017) and Vlugman (2006) claim that where there is lack of water there are poor and vulnerable communities. For instance, Naik (2017) argues that the lack of water availability is one of the reasons why Africa remains the most impoverished and most underdeveloped region of the world, while Jemmali (2017) adds that Africa has widespread water-borne diseases and the spread of other epidemics such as HIV and malaria. In fact, Africa is the continent with less than 50 percent of the total population living without improved water sources (UN 2018; WHO & UNICEF 2017).

The current literature insists that water also causes the increase of inequality and disparities among the population that exacerbates poverty (Fuller et al. 2016; Joshi et al. 2017; Osei et al. 2015; Perveen & James 2011; Rode 2014). More clearly, Nagara et al. (2015) and Joshi et al. (2017) argue that the different levels of drinking water accessibility, availability and affordability create inequality so that poverty increases. The WHO & UNICEF (2017) estimates that over 80 percent of the global population live in countries where the income disparities are widening. Jemmali (2017) believes that water supply coverage in the urban areas is much higher compared with the rural areas which are where most poverty occurs. It can be accurate since from the estimation of the WHO & UNICEF (2017) over 70 percent of the rural population still lack basic drinking water services. Although the important aspect of achieving SDG 6.1 is to eliminate inequalities in drinking water services the commitment requires a massive effort from all countries (UN 2018). Particularly, access to safe drinking water is critical component of gender issues, especially in relationship between human right to water and women and girls right in developing countries (Rebecca 2010). Increased water access to safe water empower women and girls (Fisher 2008; Saskia 2008). It provides numerous benefits such as sufficient maternal health, women avoid heavy loads of water, reduce cooking time, attendance of schooling, training and other activities. Thus, there is a strong link between women and water access.

Nonetheless, Jemmali (2017) states that water contributes to poverty reduction in several dimensions which enhance livelihood security, reduce vulnerability, improve health and increase economic opportunities and productivity. It can be seen from the work of authors discussed here that access to safe water for all the population is the key approach to poverty reduction. Another useful point stated by the UN (2018) concerns the mutual relationship between water and poverty. It is correctly noted that access to safe and adequate drinking water is essential to eliminate poverty: meanwhile, poverty also can be the cause of unsustainable use of water resources. This linkage is an important point to show these interconnections and close ties. On the other hand, some authors have converse explanations. For instance, Massoud et al. (2010), Vlugman (2006), and Tortajada and Joshi (2014) recommend that the importance of using improved water benefits: decrease of disease, for example, diarrhoeal diseases; avoided health welfare costs and time-saving associated with having water and sanitation facilities placed closer to home (Hutton & Varughese 2016). The time-saving is to gain high productivity and school attending, more leisure time and other benefits such as gender equality, convenience and well-being of population, especially women, all can be estimated in monetary terms that are of benefit to an economy (Hutton & Varughese 2016; Rebecca, 2010 and Vlugman 2006).

3.2.3 Water and economy

The World Bank (2016) defines water as an integral part of countries' economic growth and the achievement of the sustainable development. International reports and academic literature emphasises water expands economic opportunities (Baer 2014; Hutton 2012; UN 2018; UN Water 2015, 2018; WHO & UNICEF 2017; Wiek & Larson 2012) and confirm that countries' water sources are directly linked to economic development because water is the main function of the economy that connects to the population's standard of living. In 1998 the World Water Resources Report (UNESCO 1998) highlighted that water withdrawals were up to ten times greater in developed areas compared to some developing regions such as Africa and Asia. This statement certainly confirms that water is the primary resource for economic growth.

Likewise, other researchers confirmed that water is essential for development of all economic sectors such as food production, electricity generation, mining exploration, industrialisation and a source of other goods and services as well as most manufacturing products (Gawel & Bernsen 2011; Gu, Zhang & Pan 2017; Hutton 2012; UN 2018). The UN Water (2018) projected that water demand for rapid population growth and all economic sectors is expected to increase almost one-third by 2050. The UN Water (2018) defines agriculture as the largest water consumer which uses nearly 70 percent of all global water withdrawals and it comprises 30 percent of the worldwide employment which is a substantial economic opportunity for all countries and regions.

Also, Hutton and Varughese (2016) estimated that agricultural production would rise by 60 percent and intensify 15 percent of the increase in water withdrawals in order to feed 9 billion people worldwide by 2050. Moreover, researchers reveal that industrial and domestic water demand will increase significantly faster than agriculture although that will remain the most significant user overall (UN Water 2018). For instance, industrial water use rose from 20 percent to 24 percent in China which is the most populous country that comprises 21 percent of the global population (Gu, Zhang & Pan 2017). Other researchers (Lautze, Cai & Matchaya 2014; Rijsberman 2006) and the UN Water (2016) support the notion that water is a source of production and employment, gender equality and empowerment of the poor. Correspondingly, (UN Water 2016); UN Water (2018) urges that accessibility and availability of water creates the opportunity to unlock education, unemployment and improved health for women, children and families around the world and therefore enable the economy to grow.

Likewise, the World Economic Forum (WEF 2016) announced that water is one of the top five global risks regarding development influence. Also, Hutton and Varughese (2016) stresses the worldwide water crisis that leads to water scarcity, as well as climate change impacts on water sources, which could cost up to 6 percent of a country's GDP, intensifies migration and stimulates conflicts. It further asserts that heavy rainfall, and subsequent floods will severely impact the economy and similarly droughts generate population migration, food price surges, and possible violence among countries. The WEF (2016) warns that improved water supply infrastructure and boosting water efficiency will require high economic investment. Other researchers (Batbayar et al. 2017; Chung et al. 2009; Gu, Zhang & Pan 2017; Naik 2017) argue that water quality and insufficient water use from economic sectors impair development. Industrial water pollution and low water efficiency has become the bottleneck for many countries both developed and developing (Gu, Zhang & Pan 2017; Lu 2018). It is noted that during the 1960s, there has been severe over exploration of groundwater resources for intensive industrial development in China caused more than 60 meters of reduction of water level. Wang, MacLean and Adams (2005) claim that most industrial water discharge is untreated and only partially purified and it is estimated that 90 percent of water sources in Beijing were considered polluted at some stage in the 1990s. Gu, Zhang and Pan (2017) noted that the region continues to suffer from severe water pollution problems. It is said that this had become the most challenging constraint to China's sustainable development issue. Researchers (Adank et al. 2016; Chung et al. 2009; Martínez-Santos 2017; Naik 2017; Norman et al. 2013; Obeed Al-Azawi & Ward 2017; Tortajada & Joshi 2014; Widmer et al. 2013) revealed that this is a common problem for the sustainability of many countries.

3.2.4 Water and natural environment

The natural environment and all ecosystems are dependent on water (UN Water 2015, 2018). Water-related ecosystems, such as rivers, lakes, aquifers, glaciers and wetlands, as well as other environments including forests and grasslands are a critical part of sustaining biodiversity and the global freshwater water cycle (Gleeson et al. 2012; Oki & Kanae 2006; Rockström et al. 2009; Thomas 2004; Vitousek et al. 1997). Thomas (2004) asserts that water is vital for providing benefits and services to aquatic habitats, natural self-purification processes and climate resilience and others also further state that water ecosystems mitigate the effects of floods and droughts and can contribute as an alternative option to conventional water treatment. The UN Water (2018) highlights that the aquatic and terrestrial ecosystem purification process supplies water for drinking, industry and biodiversity habitat. It also enhances ecosystem services with significant contributions to the economy and society, so that further assists sustainable development.

On the other hand, Kremen (2005) considers that ecosystem functions are a significant influence on the quantity of available water in time and space. This further clarifies the main ecosystem function as being notably the soil-vegetation interface that is the crucial determinant of the providence of precipitation by infiltration from the land surface and groundwater recharge, surface runoff and soil moisture rehabilitation in plants and finally recycling water back to the atmosphere through evaporation. This process is a simple explanation of the interdependence of water and the natural environment. Generally, beyond dispute, freshwater sources ultimately depend on the continued healthy functioning of ecosystems. Unfortunately, the UN Water (2018) warns that earth ecosystems, particularly water-related ecosystems that sustain drinking water availability, are under increasing threat, as population growth is rapid, and the demand for water grows significantly.

Similarly, human dominance of earth's ecosystem is substantial and grows over time as stressed by researchers such as Rockström et al. (2009), and Vitousek et al. (1997). Therefore, anthropogenic climate change is evident, and it affects the degradation of aquatic-ecosystems (IPCC, 2007). According to the UN Water (2018), the current trends show that over two-thirds of forest, which is the primary recipient of freshwater and wetlands, have been degraded since the beginning of the 20^{th} Century. The report also considers that water pollution has worsened in most of the rivers in Africa, Latin America, and Asia. In this case, the appropriate management of the environment, especially water-related ecosystems are an essential approach to retain their benefits. This report further illustrates that maintaining a healthy ecosystem leads to improved water security for all. In other words, watershed management, protection, and conservation of freshwater sources are vital for achieving the SDGs.

Overall, per this literature review, it is clear from the work published by these scholars, water is inherently interconnected to society, economy and environment which are the main pillars of sustainable development. It is a crucial component of public health and ongoing poverty and it has great potential to eliminate this. No child or adult should die or get sick due to contaminated drinking water. Mothers and new-borns should not get infections from poor quality of water as they are the most vulnerable in the community, and no one should suffer poverty from the indignity of having a lack of access to drinking water. With regards to this, water is an essential element of humanity that no one can live without. Also, water is a vital factor in a variety of socio-economic and environmental purposes such as food production, industrial, and ecosystem protection. Demand for water is set to increase at all levels not only drinking water but also entire socio-economic sectors and environmental protection needs. Therefore, indisputably, water is extremely important to social development through improved public health and poverty eradication approaches and the promotion of economic growth and environmental protection. Today, more than ever, we should care for the water-related ecosystems and nature, instead of allowing their degradation and pollution. The most significant burden we must face is meeting this demand in a way that does not intensify negative impacts on ecosystems. Integrated and holistic freshwater management is vital for the provision coverage of the entire population's access to safely managed and basic drinking water. It is beyond dispute, the world will not be able to meet the sustainable development of the 21st Century–human development, liveable cities, climate change, food and energy security without improving water resources management and ensuring access to reliable water for all humanity.

3.3 What makes failure for population access to safe drinking water?

According to the literature reviewed here, researchers have articulated physical scarcity of water (Gawel & Bernsen 2011; Jemmali 2017; Kahil et al. 2016; Nagara et al. 2015; Naik 2017; Ragab & Prudhomme 2002; Rodriguez, Pruski & Singh 2016; Wang et al. 2008; Wiek & Larson 2012) and economic scarcity for water infrastructure (Araral & Wang 2015; Baer 2014; de Andrade et al. 2011; Rode 2014; Van der Bruggen, Borghgraef & Vinckier 2010; Vlugman 2006; Vojdani 2004; Whittington 2003) to be the two leading causes of failure of drinking water access. Cirilo (2008) claims that natural water scarcity is a critical question everywhere that should be addressed to overcome the global development burden. Naik (2017) states that where there is a lack of sufficient water whereas Jaeger et al. (2013) indicates that it can be the condition where there is a lack of water supply access. Jaeger et al. (2013) explain that water shortage or deficit refers to an insufficient water quantity for a particular procedure but deficit also signifies water scarcity depending on the value placed by society in the particular process: this means that deficit can occur without water scarcity. Others (Jemmali 2017; Kahil et al. 2016; Nagara et al. 2015; Ragab &

Prudhomme 2002) support the notion that water stress is a broader term of ability or absence to meet human and ecological demand.

The water crisis is a dangerous or critical situation of water scarcity that requires serious attention (Jemmali 2017; Nagara et al. 2015). From these terminology definitions, water scarcity, especially physical scarcity can be the causes and effects of a failure of drinking water access. Many studies show that only 3 percent of water is freshwater, while the remaining 97 percent of water is saline. Roughly 79 percent of this 3 percent is glaciers, 20 percent is in the form of groundwater, and only 1 percent is easily accessible surface water (Vojdani 2004). Due to such insufficient freshwater resources, almost every country faces a water scarcity problem and the related consequences. As noted earlier one-third of the global land area is arid and semi-arid (Malagnoux 2007). In fact, Central and West Asia and North Africa are known as the driest regions of the world (Nagara et al. 2015). Over 70 percent of Northeast Brazil is characterised as semi-arid. Cyprus, the Mediterranean Island is another example of a semi-arid country (Ford & Andersen 2008). In these regions, water availability is below 1,000 m^3 per capita which is in the water-scarce category according to the estimation of Rijsberman (2006). Falkenmark (1989), classified that any country with water availability below 1,700 m^3 per capita is suffering water shortage pressure, and those below 1,000 m^3 per capita are facing water scarcity.

Moreover, Wiek and Larson (2012) debate that increasing demand, climate change, pollution and aquatic ecosystem degradation make things worse by affecting water scarcity and the water crisis. The UN Water (2009) forecasts global population growth of around 80 million people a year increases annual freshwater demand by about 64 million m^3. Veiga and Magrini (2013) warned that the rapid population growth which aligns with intensive economic development in Asia and Africa will cause a severe water supply and demand gap. It is important to note that the populations of these two continents are projected to reach 62 percent of the total global population. Araral (2010), Batsuuri and Wang (2017); Kahil et al. (2016) and Ragab and Prudhomme (2002) add the point that climate change, especially global warming and related droughts are putting water resources under challenge and leading to future changes and variability as well as greater uncertainties. Ragab and Prudhomme (2002) argue that there has been a significant reduction in precipitation in the Mediterranean region, Southern Africa and Australia in the past century. Rodriguez, Pruski and Singh (2016) provide more information on the need to pay attention to address temperature rise occurring through climate change impact. However, Kahil et al. (2016) identifies that the serious effects of climate change are not only temperature increase but also variations of precipitation, evaporation, runoff, soil moisture and hydrologic and the hydrogeological regime. Batsuuri and Wang (2017) confirmed the idea and stated climate change is one of the factors to influence physical water scarcity that increases the pressure of population access on available drinking water resources. Araral (2010) claims another reason that impacts on freshwater availability is pollution from economic sectors. Most water from municipal, industrial, mining and agriculture sources discharge water without treatment to water bodies (Gu, Zhang & Pan 2017; Lu 2018) which also reduces freshwater availability through ecosystem degradation (Wiek & Larson 2012).

Conversely, others argue that there are abundant water resources existing on earth (de Andrade et al. 2011; Debaere 2014; Naik 2017; Zeneli 2016) because although a small proportion of water is drinkable, almost 70 percent of the earth is covered with water (Debaere 2014): this idea leads to the notion that there are trillions of tons of water which are potable per capita. Meanwhile, Naik (2017) claims Africa is not the continent of water scarcity; instead, it is the region of abundant water resources. There are large rivers such as the Zambezi, Nile and Congo and Lake Victoria, which is the second largest lake in the world. The region also comprises vast groundwater resources. Researchers, for instance, Debaere (2014) and Zeneli (2016) defined that the problem for this region is possibly the uneven distribution of water resources in comparison with population density and socio-economic development. The estimation by Zeneli (2016) confirms that there are nine countries: the US, Russia, China, India, Canada, Colombia, Brazil, Colombia and the Congo which 'own' around 60 percent of available water resources, while the US has just 8 percent of the global population and approximately 15 percent of the drinking water supply. In fact, Naik (2017) also supports this point and states that the Congo River basin covers around 30 percent of the total water resources of the African continent and is inhabited by only 10 percent of its population.

In addition, Nagara et al. (2015) point out that China alone comprises over 20 percent of the world's population whereas it has just 7 percent of the global drinking water supply. There are more examples existing around the world such as Brazil (de Andrade et al. 2011), Iraq (Obeed Al-Azawi & Ward 2017), Mongolia (ADB 2014), China (Nagara et al. 2015), Cyprus (Ford & Andersen 2008) etc. Moreover, several other researchers such as (Young & Haveman 1985), Gleick (2009), Nagara et al. (2015), de Andrade et al. (2011) and Ford and Andersen (2008) are convinced that even if there is a small amount of water which is not saline and accessible, there is more fresh water available through water recycling, harvesting, virtual water trading, desalination and trans-basin infrastructure for example. Unfortunately, despite water harvesting and water recycling, other water infrastructures require vast amounts of investment and financing from nations and international bodies as analysed by several researchers de Andrade et al. (2011), Mukherjee, Chindarkar and Grönwall (2015) and Nagara et al. (2015). Therefore, there are various alternatives and options identified to change our impressions on water scarcity and water crisis situations. Although these arguments are valid from the viewpoint of water being an abundant resource, many countries still face water crises and scarcity due to uneven water resources distribution, growing population and demand from expanding economic sectors and their pollution, as well as climate change risks causing failure of drinking water availability. Thus, physical water scarcity certainly affects lack of population access to adequate water that impacts on other emerging reasons for the failure of the drinking water supply.

Researchers emphasise that another reason causing the critical water supply condition is economic scarcity i.e. investment issues for water infrastructure (Araral 2010; Baer 2014; de Andrade et al. 2011; Rode 2014; Van der Bruggen, Borghgraef & Vinckier 2010; Vlugman 2006; Vojdani 2004; Whittington 2003). Countries, especially in the developing world, face numerous development barriers such as rapid population growth, widespread poverty and starvation, plus unprecedented drinking water challenges and related economic difficulties that require immense financial resources. Researchers admit that theoretically and practically, drinking water infrastructure requires a considerable amount of financial capacity and investment for construction, operation and ongoing maintenance (Baer 2014; de Andrade et al. 2011; Gawel & Bernsen 2011; Wang et al. 2008).

The UN (2018) agencies agree that financial requirements to establish an adequate provision for population drinking water always remain high. Tecco (2008) claims that countries pay less attention to water infrastructure compared with its importance in public health and human well-being as well as development opportunities. Morris (2017) supports the idea and states that nations' underinvestment and low financial capacity applied to water facilities' maintenance causes the sector to be in a dangerously risky condition. This study uses the example of Michigan State administration which admitted there was a high lead concentration in drinking water caused by corrosion of pipes in 2005. Later, it was revealed that the pipes were installed decades ago. This situation is confirmed by de Andrade et al. (2011) who noted that drinking water pipes around the world are outdated regarding their design and the majority are due for replacement which is costly.

The study estimates that leakages can easily lose around 40-60 percent of distributed water. Morris (2017) also stresses that this is a typical example that can occur everywhere around the world.

However, Rode (2014) argues that local governments contribute almost 80 percent of the financial and operational costs and over 90 percent of the water systems. Although local authorities cover and are responsible for the most substantial proportion of money compared to other sources, foreign assistance, loans, grants, international and national private investors play an important role in the sector's development. Notably, the UN (2018) considers that the World Bank and the Asian Development Bank provide the most extensive international assistance to the water infrastructure sector in many countries. Inherently, these foreign financial sources often support the more expensive part of the industry such as technology innovation of wastewater treatment plants, water recycling technologies, dams and reservoirs, desalination and water transfer projects that increase the population's drinking water availability. Hutton and Varughese (2016) argue that the current financial resources are inadequate to achieve SDG 6.1. Further, they stress that attaining SDG 6.1 and SDG 6.2 requires more investment than other sectors, such as energy, construction and tourism. It is estimated that around US$114 billion annually is needed which is a massive effort from national and international agencies. This estimation is not included in basic water distribution services and institutional capacity and human resources development. Additionally, water treatment plants require a further US$ 4.2 billion every year so that the total cost required by developing countries is US$ 26.8 billion annually as estimated by Haller, Hutton and Bartram (2007).

On the other hand, Gawel and Bernsen (2011), Mukherjee, Chindarkar and Grönwall (2015) and Whittington (2003), assert that the main reason for lack of financing in the water sector is mainly due to the perception of water as a public good. Water is mostly free with a low or slow revenue stream so that its lack of economic value leads to insufficient funding in the sector. Whereas, other researchers Haller, Hutton and Bartram (2007) and Van der Bruggen, Borghgraef and Vinckier (2010) contend that another common problem is that developing countries face a lack of financial sourcing schemes to implement water infrastructure. Consequently, Furlong (2012) agrees that the weak and inconsistent financial mechanism causes poor accountability of water infrastructure maintenance. Despite these investment-related reasons, Haller, Hutton and Bartram (2007) and Hutton (2012) claim that all governments of developing countries must acknowledge that water infrastructure investments are often cost-beneficial due to reduced population healthcare costs and time-saving due to secure access to water which enables the population to become more productive. They projected that, in the case of developing countries, each US$1 water infrastructure investment returns an estimated US$5-46, which is a significant saving. It shows water infrastructure investment and its return is high compared to initial spending and the clear financial source is beneficial to include in the water infrastructure planning. Clearly, from the current academic literature, economic scarcity is another bottleneck for the drinking water sector that is closely tied to governance issues.

3.4 Basis of successful approach to population access to safe drinking water

Many academic researchers support the notion that good governance is the key to a successful drinking water supply sector (Araral & Wang 2015; Baer 2014; de Andrade et al. 2011; Ford & Andersen 2008; Gawel & Bernsen 2011; Kahil et al. 2016; Loucks 2000; Norman et al. 2013; Thomas 2004; Tortajada & Joshi 2014; Wiek & Larson 2012). The principal approach to improving population access to safe drinking water is good water governance, proper planning based on reliable data, stakeholder cooperation, and coordination (Berkes 2009; Furlong 2012; Gawel & Bernsen 2011; Kahil et al. 2016; Van der Bruggen, Borghgraef & Vinckier 2010; Vojdani 2004; Wiek & Larson 2012). As water is a public good Gawel and Bernsen (2011), it is too complicated to be governed by a single institution (Berkes 2009). Likewise, some authors illustrate that the main cause of lack of water supply is water governance mismanagement which results in an uneven distribution of water in time and space (Kahil et al. 2016). Furlong (2012) supports this idea and states that good water governance and water management are essential in water infrastructure development. As stated by Berkes (2009) the foundation of good water governance is cooperation and coordination of all stakeholders. Araral and Wang (2015), Berkes (2009), Wiek and Larson (2012) and Rode (2014) confirm this idea and state that the effective approach to good water governance is co-management which means integrated management based on partnerships, reliable data, information and knowledge sharing within the process. The integrated management approach focuses on sharing power and responsibility between state and local water institutions (Berkes 2009). The main benefit of this approach is an enhancement of stakeholders' coordination. This approach can enhance not only state capacity but also local water authorities as well as other stakeholder groups.

The co-management approach will also improve data and information on population access to safe drinking water. Kahil et al. (2016), Rode (2014) and Vojdani (2004) suggest that every water governance institution should learn how to manage existing water resources and plan better for the future. This point is fundamental to increase current water use efficiency, but the essential approach here is, as Van der Bruggen, Borghgraef and Vinckier (2010) assert, that the correct estimation of existing water resources is undertaken and recent and future demand information is vital to good water governance. To confirm the idea Araral (2010) and Wang et al. (2008) argue that appropriate management also establishes a rigorous database for practical planning. Good drinking water governance should have long-term strategic policies and future implementation planning.

In other words, Kahil et al. (2016) illustrate that feasible drinking water policy planning derives from a reliable supply and demand data monitoring system. For instance, Chen, Maksimovic and Voulvoulis (2011) recommend Singapore as an excellent role model of integrated urban water management planning, and their experience is applicable elsewhere. Singapore has moved from being a water scarce country to a water exporter. In Singapore, water security has become everyone's business not only the government's responsibility. Singapore has achieved significant success not just regarding drinking water coverage but also the whole country's water security management. Tortajada and Joshi (2014) and Otaki, Otaki and Sakura (2007) emphasise that the success of Singapore's 100 percent drinking water provision is the Government's strong leadership skill through an integrated regulatory framework, reliable data, information and monitoring for sound-based strategic planning, policies and programmes and their implementation, cooperative public, private partnerships in water service delivery, and stakeholder participation at all levels.

Furthermore, Chen, Maksimovic and Voulvoulis (2011) consider the country has good experience in water infrastructure investment planning. They further claim that the secret of drinking water planning in Singapore is based on reliable water resources and hydrological data. Singapore lacked sufficient current freshwater resources for demand so water governance focused on improvement of existing drinking water management and increased investment on water recycling and water reuse as well as water harvesting. Thus, good governance based on a reliable database and its planning and stakeholders' cooperation and coordination are keys to successful governance of population access to improved drinking water supply. On the other hand, Araral (2010), Araral and Yu (2013), Araral and Wu (2016), and Araral and Wang (2015), raise the debate that there is still a lack of empirical studies to show how water governance improves water sector performance. Also, there is a lack of indicators on how to measure governance performance. In addition, there is lack of consensus definition about good governance. Araral and Wang (2015) argue that empirical studies on water governance are still quite limited compared with claims of its importance. Although there are some uncertainties about what is precisely good water governance, strong government leadership role incorporating feasible long-term investment planning, based on valid and reliable data, is the basis of an efficient approach to achieving not only global SDG 6.1, but also MSDV 2030's drinking water goal. These points are all valid when considering the case of Mongolia.

3.5 Literature review in the Mongolian context

There is a lack of academic material about Mongolian drinking water governance and the linkages to sustainable development issues in the recent literature. One of the gender-related issues of water access to women and their role of rural water access in Mongolia is still absent in the academic literature. Researchers have however studied population, drinking water quality, surface and groundwater resources, the connections to climate change and mining development as well as analysis of integrated water resources management in Mongolia. They emphasised clearly the importance of water resources for Mongolian development, but there is a lack of studies which suggest the way out of the water-related challenges and opportunities for the country to manage water wisely. For instance, Uddin et al. (2014) finds that water supply in the Ger[3] area of the capital city Ulaanbaatar, is not connected to the public water supply system: water from kiosks is inadequate due to the insufficient collection, transportation and storage in the peri-urban Ger area. The study revealed that 36 to 56 percent of drinking water was unsafe and exposed to biological contamination which causes diarrhoea, dysentery and hepatitis A. Gawel, Sigel and Bretschneider (2013) also confirm this and claim that in the Ger area in Ulaanbaatar, people use water from self-built private wells that are adjacent to contaminated unsealed pit latrines with have huge negative impacts on the environment and public health.

Other researchers Hofmann et al. (2010), Nriagu et al. (2013), Pfeiffer et al. (2015), Olkhanud (2012) and Tsutsumida et al. (2015) found that in many rural areas, especially in the Gobi region, people are using drinking water which is exposed to excessive levels of arsenic. Their findings are based on analysis of human urine, hair and nails samples. Arsenic concentration is of both natural and industrial origin in Mongolia (Pfeiffer et al. 2015). Hofmann et al. (2010) recommends that enhancing the monitoring system, mitigating mining dump areas and searching for another safe drinking water sources are the strategic approaches needed to avoid further contamination of arsenic. This approach is an undeniable argument, but limited studies have proposed how to improve the situation. Even though, several articles mentioned that there is an urgent need to

[3] Gers have been a distinctive feature of life in Central Asia for at least three thousand years. A Ger is our traditional home and is around shaped dwelling that has been used since the Mongols started nomadic life with animal husbandry. Ger is portable, easily assembled and disassembled, and the most natural dwelling on earth. Ideally suited to Mongolian's nomadic lifestyle. Source: https://www.ottsworld.com/blogs/mongolian-gers/: https://www.discovermongolia.mn/mongolian-traditional-dwelling/.

develop and implement a water safety plan (Nriagu et al. 2013; Olkhanud 2012; Uddin et al. 2014) again it is still not clear what the plan refers to and the relevant actions needed to implement improved access to drinking water for the population.

Researchers noted that another pollution source that reduces drinking water availability is the mining industry of the country (Bulag 2010; Ganbold & Ali 2017; Moran 2013; Reeves 2011). Karthe et al. (2017) consider that mining is not only an essential pillar of Mongolian development but simultaneously a significant water user and polluter. McIntyre et al. (2016), clearly state that while being the most rapidly developing primary sector of the country Mongolian mining has lost its water management capability due to groundwater overexploitation and direct discharging of polluted water to surface sources. Pollution from mining activities influences the country's transboundary issues. Most rivers in Mongolia flow into the River Selenge which is the largest sub-basin, in fact makes up over 60 percent of inflow of Lake Baikal (Törnqvist et al. 2014). Lake Baikal is the deepest and largest freshwater reservoir in the world and is in eastern Russia, one of Mongolia's neighbouring countries. According to Thorslund et al. (2012) and Malsy, Flörke and Borchardt (2017) analysis of the River Selenga is considered to be one of the areas most impacted by contaminated heavy metal loads in the world. This further defines mining in Mongolia as the main source of this water contamination.

Some researchers (Batbayar et al. 2017; Karthe et al. 2017; Kida et al. 2018) recently confirmed the that the Tuul and Selenga River Basin is contaminated by various heavy metals such as colloidal aluminium, iron, cadmium and lead due to the various mining explorations for coal, gold, copper, molybdenum and wolfram that are in the upper streams of the Tuul River Basin. Mining water pollution therefore affects the country's valuable groundwater resources as well. Hofmann, Watson and Scharaw (2015) illustrate that the groundwater quality of the country is increasingly threatened by mining expansion, urbanisation and intensified land use change for agriculture. Their analysis further highlights the fact that groundwater concentrations of heavy metals, primarily arsenic, lead, nickel, zinc, manganese, and iron exceeded Mongolian drinking water guidelines. These results were found downstream of mining areas in Darkhan, the second largest city in Mongolia.

Another group of researchers discussed the country's decentralised water management – that is Integrated Water Resources Management (IWRM) and its implementation challenges. The IWRM incorporates the concept of river basin management (RBM). Horlemann and Dombrowsky (2012) argue that the country's 29 river basin management attempt has existed on paper, but is not clear regarding institutional structure and capacity and capability to carry of the required work. Grit et al. (2015) argue that the country's IWRM is aligned with the World Bank, 2004 and the Dublin Principles in 1992 which recommended management of water at the lowest appropriate level. They argue that the IWRM is the most suitable approach to enhance coordination, while Moss (2004) says that it is challenging to balance stakeholder's interests with actual need. In addition, Horlemann and Dombrowsky (2012) assume that the IWRM and its lack of coordination are even greater in Mongolia because developing countries often lack necessary financial, institutional and human resources to implement this successfully.

Moreover, the ADB (2014) and WRG (2014) emphasised that the country is facing difficulties to implement IWRM due to the insufficient state budget to establish River Basin Administrations (RBAs) as well as a rural professional capacity to operate the institutions. Another challenge associated with the IWRM is that river basins lie across trans-provincial borders, so that creates another spatial and decision-making problem. Although there have been numerous challenges to the implementation of IWRM in the country, it was legalised by the Water Law 2004 and then renewed in 2012. The IWRM is based at the lower administration levels gaining more decision-making power that may be beneficial to managing water. Also, there is an opportunity to empower local Governments and their self-financing approach due to local water governance initiatives such as water use payments and water efficiency and other water sources protection actions (Houdret, Dombrowsky & Horlemann 2014). The Government needs to focus on skilled staff capacity building and financing mechanisms at the local RBAs level. In this case the IWRM, the way to manage water with a sustainable and holistic approach, may be implemented successfully in Mongolia. Therefore, the current literature about drinking water in Mongolia can be divided into water quality and its related pollution, mining impact and the assessment of the country's integrated water resources management. Despite the drinking water quality, little research has been done to analyse safe water access and its coverage for the country's population. Although some literature emphasised the importance of water resources for Mongolian development there is a gap in the recent literature that discussed and analysed the MSDV's drinking water goal and its challenges and opportunities to achieve it. Therefore, this research project may be the first to analyse and investigate the opportunities to meet the drinking water target of the SDG in Mongolia. Further, the research can be used as an example to examine other developing countries drinking water goals in line with the global SDG 6.1.

4 Analysis of the current situation and fundamental challenges to attaining the goal

This analysis chapter consist of two components, the first is to evaluate the current situation of the population access to safe drinking water, and second to define fundamental challenges the government faces in achieving the MSDV 2030 drinking water goal in Mongolia. The current situation is examined applying the international requirements for safe drinking water access. As noted earlier (section 1.4) the World Health Organisation defined the population access to safe drinking water as an equitable and adequate quality of water source availability that is daily 20 litres per capita daily within the maximum distance of 1 km (UN 2000). The research identified that the current situation of Mongolia's drinking water supply cannot meet these international requirements, whereas the main challenges are defined based on the national circumstances. The challenges are related to poor governance, lack of water-related data, insufficient investment in the sector and water scarcity as well as climate change impacts on water resources availability. This chapter also identified priority challenges in the case of the capital city Ulaanbaatar. The city Government faces rapid population growth, lack of water resources availability and water infrastructure investment problems.

4.1 Evaluation of the current access to drinking water by the population in Mongolia

According to the international requirements for population access to safely managed drinking water as defined by the WHO, the current situation of water supply coverage in Mongolia is inadequate and insufficient making it impossible to attain the MSDV 2030 water goals under these conditions. There have been several reasons identified as to why the country cannot meet these international criteria. Mongolia's access to drinking water is significantly varied due to the variety of their locations, across major cities, smaller urban centres and rural areas, so fair and equitable access to water cannot be ensured. Water supply networks are found in the main cities, but outside the cities and small urban areas water is available from kiosks that are connected to the central water supply network or from water tankers (MCUD 2014). The rural population is heavily dependent on wells, springs, rivers, lakes and ponds for their water supply many these sources are unimproved (MCUD 2014, 2016). In the 1970s construction of many boreholes was started in rural areas. Unfortunately, due to the market economy transition in the 1990s, many boreholes were found to be now broken down and out of operation (Davaasuren & Basandorj 2017; MCUD 2014). Nowadays, water supply networks are old and need replacement to ensure good quality water. The percentage of people with basic drinking water access is therefore significantly different between rural and urban areas. For instance, in rural areas many people still use unimproved drinking water sources with Bayan-Olgii province at around 58 percent, Arkhangai at 52.3 percent, and Khovd at 54.3 percent (MCUD 2014). On the other hand, in the urban area roughly 94 percent of people have access to basic drinking water services (WHO & UNICEF 2017). Moreover, in other rural areas, for instance, Dundgobi, Sukhbaatar, Tov, Uburkhangai, Dornogobi, Bayarkhongor, Bulgan and Gobi-Altai provinces people need to spend an average of 1 kilometre of travelling to get water. In the Gobi area people collect water from an average 20 km of distance and spend approximately 2 hours to reach it (MCUD 2014). Therefore, the Government needs to reduce this disparity by supplying at least basic water services, such as constructing boreholes for rural area dwellers, so people can reach water within 30 minutes. Furthermore, even in urban areas, the disparities in water access among Ger and apartment households is extremely high (Dore & Nagpal 2006; WRG 2014). In Ger areas, some people use around 8 to 10 litres of water daily due to lack of water availability in water kiosks (MCUD 2014, 2016). More than 50 percent of Ger households live in poverty which means they are unable to afford water (Oyunchimeg 2016). Conversely, people in apartments have access to water in their premises and consequently use approximately 120-230 litres of water daily (MCUD 2016; Oyunchimeg 2016). These numbers clearly show the disparity between Ger and apartment households' drinking water access. Likewise, the water tariff discrepancy is also enormous. Ger households pay almost twice the amount of money per litre of water than apartment families. The water tariff for the Ger district is 1 MN$ per litre, while it is only 0.6 MN$ for apartment people (Oyunchimeg 2016). Therefore, the country cannot qualify for the international requirement of equitable access to water among the population.

The next reason for the drinking water supply being inadequate as per the international standard is quality issues of the country's drinking water. The rural population uses large amounts of surface water and highly mineralised groundwater for their household use, while in cities industrial wastewater discharge affects the drinking water quality (MCUD 2014). There are many cases of the high content of total dissolved solids: hardness, arsenic and other hazardous and toxic elements being identified in drinking water sources (Gawel, Sigel & Bretschneider 2013; Pfeiffer et al. 2015). There are also a few cases of bacteriological contamination revealed in the urban water supply (Nriagu et al. 2013). In addition, insufficient wastewater treatment and poor quality of industrial water discharge that contains heavy metals and persistent organic pollutants and nutrients seriously affects the drinking water sources (MCUD 2014). Davaasuren and Basandorj (2017) stressed that the majority of water softening systems that are installed at boreholes are out of operation due to lack of maintenance. In rural areas, unprotected boreholes, wells and springs and other drinking water sources can easily be polluted by livestock waste. Hence, the current situation of population access to safe drinking water is insufficient and inadequate which makes huge difficulties to achieve the goal. The country faces more challenges that were identified throughout the research and are presented in the next section.

4.2 Fundamental challenges to achieving the MSDV 2030 drinking water goal

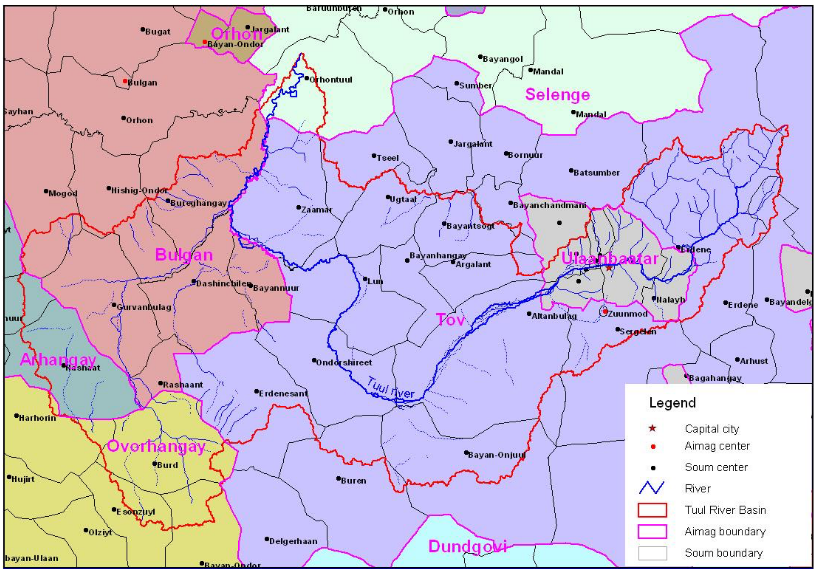
There have been some core challenges identified that halt the attainment of the MSDV 2030 drinking water goal. These challenges are weak water governance, lack of a water-related database and investment planning to implement policies and regulations, and water scarcity and climate change impact on water resources availability in Mongolia. International reports suggested Mongolia needs to work towards addressing water-related challenges to ensure the country's sustainable development (ADB 2013, 2014; MCUD 2016; WRG 2014). The challenges focus on addressing the underlying critical causes of problems (WRG 2014). The ADB (2013) state that challenges provide opportunities to resolve problems, thus, this research recognises the key challenges and barriers to achieving this goal, then defines possible opportunities to succeed in it. The country's water sector faces the following fundamental challenges to improve the current situation of the population water supply and to achieve the proposed MSDV 2030 drinking water goal.

4.2.1 Water governance challenges

4.2.1.1 Institutional structure and administrative capacity of drinking water supply

According to the WRG (2014), water governance and water management in Mongolia are weak and inadequate. Water-related institutions in Mongolia are unstable and it changes frequently from election to next election (Janchivdorj 2012). There are unclear institutional responsibilities and a lack of coordination between public institutions and other stakeholder groups. Administratively, the country is divided into 21 provinces and one municipality. Provinces are sub-divided into 321 districts. The capital city is divided into nine districts and 132 sub-districts. In water management perspective, Mongolia is divided into 29 river basins. The Ministry of Water Economy was established between 1938 and 1986. During this period, this Ministry was solely responsible for water issues (Janchivdorj 2012). Then, during 1990s market economy transition, many organisations were privatised and water institutions were divided into several agencies. The current water-related institutional structure is divided between five Ministries in Mongolia (Oyunchimeg 2016). The Ministry of Construction and Urban Development (MCUD) has an overall responsibility for population water supply issues, while the Ministry of Health is in charge of water hygiene, the Ministry of Environment is responsible for water source protection and conservation and so on. The Water Authority under the Ministry of Environment was established in 2004 and abolished in 2012 due to a new government structure. Under the renewed Water Law in 2012, the country is divided into 29 river basins so there are 29 basin authorities, and these have responsibilities for water supply at the river basin level (MET 2013). The Water Law states the river basin authorities are responsibly for integrated water resources management planning and its implementation which is the basis of sustainable water management planning including the drinking water supply (MET 2013). Regrettably, as stated by the ADB (2014), recently established basin authorities face considerable challenges such as a lack of professional staff at the local level, a lack of administrative facilities, a lack of financial resources and mechanisms, and lack of databases and groundwater monitoring systems. The territory of a river basin is dissimilar to the administrative unit boundaries which establishes overlapping responsibilities to manage drinking water issues. For instance, the Tuul River Basin is the biggest among other basins and it is the main basin that services the population of the capital city Ulaanbaatar (Figure 4.1) (ADB 2014). The territory of the basin covers one city and five provinces and it supplies 65.5 percent of the total area of Ulaanbaatar, 38.8 percent of Tov province, 20.8 percent of Bulgan, 6 percent of Uvurhangai, 4.4 percent of Arhangia and 2.2 percent of Selenge. In addition, there are environmental agencies that operate under the MET and public utility service offices under the MCUD at the local level. These agencies river basin authorities, environmental agencies and public utility service offices are all in charge of drinking water supply issues at the local level which causes overlapping responsibilities and insufficient cooperation and coordination. The Government needs to clearly define and separate their responsibilities.

Figure 4.1 Tuul River Basin in Mongolia



Source: Institute of Geoecology, 2018.

Moreover, the Water Supply and Sewage Authority (USUG) is responsible for water allocation to the city population and other industries (MCUD 2016). There is also the Public Utility service council to set the appropriate water price, and overall stakeholder coordination has been operational since 2014 (MCUD 2016; Oyunchimeg 2016). Thus, the water-related institutional structure in Mongolia is immense and complex. This institutional complexity leads to a lack of coordination, unclear responsibilities, inconsistent policies and their unpredictable enforcement. The situation also causes a lack of administrative capacity to manage the drinking water supply adequately. This challenge directly links to the next barriers which are lack of reliable data on water and inappropriate investment and financial planning problems to implement policies and regulations.

4.2.1.2 Data scarcity on water

The poor water governance causes a lack of water-related information and an inadequate database. Data on water is unreliable and inconsistent in Mongolia. Many academic sources (ADB 2014; Dore & Nagpal 2006; Karthe et al. 2015; WRG 2014), particularly Karthe et al. (2015) highlight that Mongolia is a country with a lack of reliable and sufficient data, especially in the water sector. The lack of coordination between ministries and agencies results in each of them working towards their own agenda, and protecting their data information, which hinders the integrative planning. For instance, the Tuul River Basin Management Plan which covers the area where the capital city Ulaanbaatar is located, is unsupported by other institutions except MET (WRG 2014). The alleged current percentage of population with access to safe drinking water is unrealistically high and inconsistent (ADB 2014; Dore & Nagpal 2006; Karthe et al. 2015; WRG 2014). The Fifth National

Report of the MDG stated that the current population with access to safe drinking water was 72.6 percent of the total population in 2013 (MF 2013). Even the report itself highlights that the country-specific statistical estimation methods for drinking water coverage may vary from the global drinking water estimation method, so the data for 2013, which indicated 72.6 percent of population coverage, is likely to be much higher than the real situation. Moreover, the latest report by the MCUD in 2016 states the current percentage of the population with access to safe drinking water was at 80.4 percent in 2015. The proportion is inconsistent with the MSDV 2030 drinking water goal. It seems the MSDV 2030 plan to achieve 80 percent of population access by 2020 had already been attained. This muddled situation confirms that the country has a lack of integrated planning due to insufficient and unreliable data information. Furthermore, it is unlikely that such a high proportion of population will have adequate access to safe water. As discussed in section 4.1, the current situation of population access to safe drinking water cannot meet international requirements due to lack of equity issues and poor quality of water throughout the country. Another explanation is the rural population's lifestyle. The rural population comprise almost 40 percent of the country's total, they have a nomadic lifestyle which means they are scattered over the country's vast territory. This rural lifestyle makes it impossible to connect people to a water supply using piped networks in rural areas. Therefore, obtaining reliable data information on the population water supply issues is one of the primary challenges the country should deal with to achieve the MSDV 2030 drinking water goal.

4.2.1.3 Drinking water policy and investment planning challenges

There are several drinking water-related policies, laws and regulations in Mongolia, but the enforcement of these is slow and insufficient. In addition, there is a lack of investment planning and funding mechanisms to implement these strategies and actions. The primary policy document of the country is the MSDV 2030 that was developed in line with the global SDGs. The Parliament of Mongolia approved the MSDV 2030 in 2016. The vision of the policy is that 'By 2030, Mongolia aspires to be amongst leading middle-income countries based on per capita income. It hopes to be a multi-sector stable economy, and a society dominated by middle and upper-middle income classes, which would preserve ecological balance, and have stable and democratic governance' (MF 2016, p. 9). The policy proposed primary goals and objectives to achieve the vision by 2030. One of the environmental sustainability goals of the policy is to increase the percentage of the population that has access to safe drinking water. However, it should be noted that the policy document does not included an action plan or an investment and funding mechanism, to achieve these proposed goals, not only the drinking water goal but also implementation of the whole policy.

The next document discussed here is the Law on Water which was renewed in 2012. The law has redefined the water pollution limits and fees, which is crucial in improving drinking water quality control and monitoring. The law is the basis of market-based instruments through water use permits and licences (WRG 2014). The market-based instrument is the policy tool that provides incentives or economic leverage to increase water-related revenues and funding (Carter 2018). The comprehensive implementation of this approach requires further elaborations of several regulations and guidelines on water use permits and licences for the country's industrial water supply issue which can then support and allow an increase in the population with access to safe water sources (ADB 2014; WRG 2014). However, these guidelines and regulations are not fully developed by the state government authorities such as the MCUD and MET which is slowing the implementation of the law and its subsequent enforcement (ADB 2014; WRG 2014).

The next regulation on population drinking water supply is the Law on Use of Water Supply and Sewage Systems in Urban and Settlement Areas that was adopted by the Parliament in 2011. The law regulates the utilisation of water supply and services and their tariffs, protection of drinking water sources, regulation of wastewater discharge, ownership of related constructions and water recycling issues (Oyunchimeg 2016). It has defined duties and responsibilities for national and local level water supply, and guidelines for associated permits and licences for the population's drinking water and other water supply constructions. The law is the primary instrument to set the appropriate water tariffs, increase water supply revenue, and support water infrastructure development. The law and related regulations enabled an increase in the revenue from MN$ 235.6 million as of 2002 to MN$ 5.3 billion in 2013 (Oyunchimeg 2016). However, the Water Supply and Sewage Authority (USUG) of Ulaanbaatar is in inherited debt due to low water service charges (WRG 2014). The USUG business model is not financially secure and it is unable to finance the required water infrastructure investments and its revenues from service operations are not able to cover even the operating costs. In addition, the law is the principal instrument available to increase water recycling and water re-use measures throughout the country (Oyunchimeg 2016). Unfortunately, the enforcement of this aspect of the law is insufficient as the recycling water quality standard is still not developed, so water recycling is very low, especially as the country is required to promote abundant surface water recycling practices.

The next crucial policy related to drinking water supply is the National Water Program (NWP) approved by the Parliament in 2010 (MET 2010). The action plan of this program was also approved by the Government and was planned to be implemented in two phases, from 2010 to 2015 and from 2016 to 2021. The program defined six strategic objectives and 98 actions designed to be implemented (MET 2010). Almost one-third of the measures are related to the drinking water supply issue (Oyunchimeg 2016). For instance, to expand hydrological surveys, to improve the drinking water supply in Ulaanbaatar, to establish expansion of the central wastewater treatment plant, to renew water supply network standards and engineering drawings, to develop the water supply networks for the provincial centres and so on. It seems a massive amount of investment is required to implement the program in line with a number of academic sources which highlight how water infrastructure demands a massive amount of funding for its construction and maintenance. Unfortunately, again there is a lack of investment and financial planning that has estimated the required investment and the allocation to particular actions (Oyunchimeg 2016). There is therefore a gap between implementation planning and its financial source mechanisms. There is a lack of information about financing and investment planning to implement these measures and projects indicated in the NWP. Based on the analysis, water governance, a lack of a database on water, and inconsistent investment and financial planning to implement policies are the primary challenges that the country needs to address to effectively achieve the MSDV 2030 water supply goal. In spite of these management challenges, there are other challenges such as water scarcity and climate change which are adversely affecting the population's access to safe drinking water.

4.2.2 Physical water availability and climate change related challenges

The Mongolian sustainable development pathway depends on water resource availability, however the influence of climate change is one of the major challenges to ensuring the country's sustainability and human well-being (ADB 2014). Climate change and subsequent water scarcity is a crucial challenge which must be overcome and to achieve the MSDV 2030 drinking water target. Generally, Mongolia has sufficient water by volume and quality to supply its population and socio-economic sectors' development (MET 2013; WRG 2014) (see Appendix 1. Drinking water supply and demand relationship by 29 River Basins). However, on a local scale, severe water scarcity challenges the equitable and safe access of the population to water (ADB 2014; WRG 2014) because water resources in Mongolia are limited and disproportionately distributed throughout the country (MET 2013). Vast surface water resources are available in the northern region of the country, while most water resources are inaccessible to the major population centres and mining and industrial development areas. For example, the Southern Gobi Desert area occupies more than 40 percent of the total land (Dore & Nagpal 2006), however the region is facing serious water scarcity challenges due to a lack of surface water resources availability (ADB 2014; MET 2013). The desert region is an area of strategic mining development deposits of the country as it is rich in mineral resources (ADB 2014; Dore & Nagpal 2006; Moran 2013). Large mines have started developing in the area along with planned value-added industrial development. The mining water use in this region is likely to increase from 40 million m^3/year in 2015 to 83 million m^3/year by 2025 (ADB 2014). In spite of this expansion, the current mining development is already putting pressure on the region's drinking water availability. Therefore, conflict exists between mining activities and local communities and herders, because both are entirely dependent on groundwater resources which are valuable resources for the country (ADB 2014; Ganbold & Ali 2017; WRG 2014). These deep groundwater resources are vulnerable and made up of fossil water aged from 10,000 to 35,000 years old (Janchivdorj 2012). This groundwater resource not only receives a very small recharge, its shallow aquafer recharge level is only around 0.5 mm/year in the region (Janchivdorj 2012).

Moreover, climate change negatively affects water resources and groundwater availability (MET 2014). Mongolia is very sensitive to climate change due to its geographic location, fragile ecosystems and environment and weather dependent socio–economic circumstances (GM 2012). For instance, the agriculture and livestock sector, which comprises almost 30 percent of the total Gross Domestic Product (GDP), is extremely vulnerable to climate change. According to the impact risk index of climate change, Mongolia is ranked number eight out of ten of the most vulnerable countries (MET 2014). The annual mean temperature has increased by 2.14C between 1940 and 2008 which is three times greater than the global average 0.74C from 1906 to 2006 (MET 2014). Climate change affects not only drinking water availability but also socio-economic development. Climate change in Mongolia is observed in increased drought, desertification and severe winters and water scarcity (MET 2014). The extreme weather events such as thunder, snowfall, hail, dust storms and floods have increased, and socio-economic losses associated with these events have roughly doubled in the last 20 years (GM 2012). Hundreds of springs, ponds and lakes have dried out, and decline of the snow caps of high mountains and thawing of permafrost has been observed which has an enormous negative impact on drinking water sources and their availability.

4.2.3 Challenges identified in the case of Ulaanbaatar city

Van der Bruggen, Borghgraef and Vinckier (2010) state that the three major challenges that have influence on the condition of urban drinking water supply condition in most developing countries are population growth, water scarcity and lack of investment. These factors are all relevant in the case of the Mongolian capital city Ulaanbaatar's drinking water case in Mongolia. Population growth in Ulaanbaatar is rapid and intensive: the total population in Ulaanbaatar was around 1.4 million in 2015 which had doubled from 1996 (NSO 2018). The reason for the rapid urbanisation is the rural population migration to the city (MCUD 2016). Population growth in Ulaanbaatar requires more human consumption such as water, food, housing and other demands. Also, it expands the Ger districts in Ulaanbaatar. The Ger districts are slum areas of the city, and over half of the households are poor (MCUD 2016). The slum district's water supply issues and urban population growth put pressure on the current city Government's water supply planning. Currently, there are 159 borehole wells, three pumps, ten water reservoirs and a 570 km long water supply network in Ulaanbaatar. The water supply system in the city was initially established in 1959 (Davaasuren & Basandorj 2017). Ulaanbaatar drinking water takes comes from more than 30 metres below the surface and it relies on fully on groundwater extraction from the Tuul River. The latest report from WHO & UNICEF (2017), Mongolia reported that Ulaanbaatar, including other urban areas' basic water coverage, has reached 94 percent of people, but safely managed supply services with improved water network connections are only around 35 percent and 6 percent of city people are still using unimproved drinking water sources. These data show that the city Government is required to supply an additional 55 percent of the city's population to achieve the MSDV 2030 drinking water goal i.e. to provide 90 percent by 2030. Also, it is important to include that the population is projected to double by 2030 from the 2015 figure (NSO 2018). Urban population growth is therefore one of the foremost challenges that the city faces to achieve the proposed target.

Water scarcity is a real problem in Ulaanbaatar (MCUD 2016; MET 2013; WRG 2014). It was estimated that Ulaanbaatar's future water demand will exceed the current water supply capacity before 2021 (WRG 2014). In fact, the medium-water demand scenario of the WRG projection model shows the city's demand will surpass the maximum available resources within seven years in 2026 (WRG 2014). This estimation is based on the Tuul River Basin Integrated Water Management Plan from 2013 and the New Ulaanbaatar City Master Plan in 2013. In addition, the current water resources are vulnerable to the Ger district's inappropriate sanitation and other industrial wastewater pollution (MCUD 2016). The wastewater treatment plants are outdated, especially the central wastewater treatment plant which is operating at excess capacity in terms of quantity and quality (MCUD 2016). The city managers are having a huge challenge to find alternative water sources (Oyunchimeg 2016).

The city is also struggling with water infrastructure investment issues similar to that at the national level. Water is a public good which involves different groups and setting the right tariff is difficult (Coggan & Whitten 2005). In this regard, the water tariff is often low which causes minimal revenue available to undertake the sector's development (Hepburn 2010). Thus, water infrastructure lacks sufficient investment for construction, operation and maintenance. In Ulaanbaatar, the renovation of the central wastewater treatment plant alone needs US$ 500 million (MF 2018a), which is around ten times higher than whole urban construction and development sector's state budget in 2018. The MCUD sector's state budget in 2018 was US$ 50.5 million (GM 2018). Therefore, the city government has massive investment pressure to achieve the MSDV 2030 water supply target.

Overall it is clear that there are considerable challenges for the country, and its capital city to achieve the MSDV 2030 drinking water goal. It is very important for the country and its future development that the goal is achieved. Socio-economic and industrial development cannot be achieved without an adequate and reliable water supply therefore Mongolia must deal with these ongoing challenges.

5 Opportunities to achieve the MSDV 2030 drinking water goal and analysis of investment assumptions

5.1 Opportunities to attain the MSDV 2030 drinking water goal

There are three major opportunities which exist to improve water governance, establish a science based water database and increase investment in the water infrastructure available for the country to achieve the MSDV 2030 drinking water goal to have 90 percent of the total population of Mongolia with access to a safe water supply. However, an achievement of this magnitude requires a massive effort and firm commitment from the government to increase the investment to water infrastructure. The primary focus of the Government of Mongolia is to improve water governance through the co-management and cooperation approach (ADB 2014; Houdret, Dombrowsky & Horlemann 2014; WRG 2014). Good water governance and its key focus provide the opportunity to advance water-related data monitoring in order to advance water infrastructure and its investment planning, prioritise appropriate measures, allow equal water resources distribution to stakeholders and many other aspects of water access. It is vital to increase investment in the water infrastructure sector by expanding national and international cooperation and introducing financial mechanisms to develop the required infrastructure (Berkes 2009; Hofmann, Watson & Scharaw 2015; Karthe et al. 2015; Malsy, Flörke & Borchardt 2017). Addressing these crucial opportunities in the future will enable the Government to provide a solid basis for achieving the proposed drinking water goal by 2030.

5.1.1 Improve water governance

The underlying opportunity for achieving a successful drinking water supply is cooperation based on the future transparent and accountable governance in Mongolia (ADB 2014; MCUD 2018; WRG 2014). Governance in Mongolia, especially water-related institutions and their stable organisation, combined with consistent policies with strict implementation and enforcement is crucial in the water sector development of the country.

The transparent, accountable and cooperative management approach advances the leadership role through a medium to long-term planning framework and rationally prioritised actions which are the best available to manage not only the drinking water issues but also the whole water sector's maturity. For instance, Japan is one of the best examples in Asia of having advanced water management. The reasons behind the good water governance in Japan is a strict implementation of water regulations at the national and local level (Otaki, Otaki & Sakura 2007). The reasons for the strict enforcement of water regulation is that water-related authorities have clear responsibilities and duties. Also, the Government of Japan ensures coordination and other stakeholders' involvement in the decision-making process based on the concept of co-management and cooperation. This governance approach enables control of water infrastructure development and investment planning (Noda 2018). The local water authorities also must play a vital role in performing their responsibilities and duties. Japanese water supply governance considers that to supply too much water is not the right approach and instead to focus on an equal and high quality of distribution. The Government also addressed the issue of data monitoring to assist the efficient allocation of the water supply. The average per capita daily water supply was 106 litres in Japan at the beginning of the 21th century. This approach also increases water revenue and infrastructure investment due to its water savings and the improved health condition of the population (Noda 2018; Otaki, Otaki & Sakura 2007). The Government of Mongolia should use this model to address cooperation and coordination as well as identifying precise responsibilities among the water-related institutions in order to empower water regulations to advance water governance in Mongolia. Particularly, in the framework of reducing complexity of water-related institutional structure and clarifying local responsibilities of drinking water issues for river basin authorities, environmental agencies and public utility offices as discussed earlier in the section 4.2.1.1, the Government of Mongolia must urgently improve the water governance mechanisms by using the opportunities based on cooperation, transparency and accountability of water-related institutions to achieve the MSDV 2030.

5.1.2 Establish sceintific water database

The next valuable opportunity available to the Government is to improve their water-related database based on scientific research and careful planning (Karthe et al. 2015; Thomas 2004; WRG 2014). The foundation of sustainable water resources management and proper strategic planning is to develop a plan to consider immediate demand as well as for future needs and this plan must be constructed from reliable data (Loucks 2000; Vojdani 2004). The primary approach to ensure a sustainable water supply plan is to implement periodic improvements to achieve the maximum benefits from the resources which need to be properly managed and used (Chen, Z & Wei 2014; Loucks 2000). Scientific knowledge is a significant contributor to strategic planning, optimal solution and appropriate decision in the environmental field as well as the development of the water sector.

This approach is the basis of policy changes and priorities in water infrastructure funding allocation (Morris 2017; Vojdani 2004).

Population access to safe drinking water is one of the development areas that requires the involvement of many groups and institutions with nested interests in enhancing their initiatives or agendas. By responding to these stakeholders' interests and any possible conflicts can be decreased and rationalised by use of the science-based database (Karthe et al. 2015). In addition, available water resources and drinking water sources, as well as their exploration and exploitation require solid scientific research in order to facilitate appropriate planning. For instance, science-based knowledge of the current water supply and demand gap are crucial for water infrastructure planning (Morris 2017). If the existing water supply is enough, the nations should focus on the expansion of the water supply network to provide to cover for a larger population. However, if the water supply is not enough countries should improve the water management system, water conservation, water recycling or water harvesting infrastructure. The WRG (2014) highlight that the existing data is not being shared adequately among institutions to enable them to evaluate and analyse available resources and its management. Moreover, there is a lack of a mechanism that verifies the current data available in Mongolia so a sound and quality assured database must be the primary focus of the Government (Dore & Nagpal 2006; Reeves 2011; WRG 2014). Therefore, the Government of Mongolia should focus on establishing a scientific and reliable water supply database to share with relevant institutions to enable better water infrastructure and related investment planning to be efficiently developed.

5.1.3 Increase investment through partnerships in water infrastructure sector

The foremost opportunity to accelerate the achievement of the MSDV 2030 drinking water goal is to increase investment in the water infrastructure sector through expansion of cooperation and partnerships and to introduce economic instruments at the national and international level (Hutton & Varughese 2016; MCUD 2018). The United Nations and other international organisations, as well as academic literature strongly suggest that partnerships for the implementation of the SDGs are the key to achieving the global commitments (Hutton & Varughese 2016; UN Water 2018; WHO & UNICEF 2017; Wiek & Larson 2012; Wu, House & Peri 2016). Also, partnerships provide fundamental opportunities for generating knowledge, building trust, solving conflicts and social learning progress, and for experiencing and practicing sharing opportunities (Berkes 2009). The UN Water (2018) and Wu, House and Peri (2016) encourage water partnership among international institutions, Governments and water-related NGOs. They recommend that the population water supply issue is the foundation of ensuring sustainable development so that water is the global primacy concern. Countries and Governments should acknowledge that investments for water infrastructure are cost-beneficial (Haller, Hutton & Bartram 2007; Hutton & Varughese 2016). The accessibility of safe drinking water improves human well-being and increases productivity and pleasure time through decreased public health cost and time-saving processes. Haller, Hutton and Bartram (2007), estimated that every single dollar of water investment returns roughly US$ 5 to 45 which is substantial revenue.

Governments should also encourage public-private partnerships (PPP) on water infrastructure to improve the quality of the drinking water supply. Most poor quality of water in Mongolia is due to industrial developments in rural as well as in urban areas. This approach to supporting the PPPs should disseminate awareness that a clean water supply is not only the Government's responsibility but it is a duty of all other stakeholders, including the private sector and communities in general. An excellent example of this would be China, where water infrastructure investment has been significantly increased since 1990 by introducing PPP (Wu, House & Peri 2016). The PPP in China is the collaboration of two or more private sectors and Government that based on various financial mechanisms and their agreements or contracts. China supported 237 projects in water supply and sanitation during the period of the 2000 to 2008 which increased the population's access to water by 38 percent. It also increased water resources efficiency by around 40 percent (Wu, House & Peri 2016). Mongolia can learn from this example.

However, the Government of Mongolia should be cautious PPP on ownership of drinking water sources that can cause unequal accessibility of water supply for poor and vulnerable groups and communities. Many developing countries such as Bolivia (Bakker 2008), Tanzania (Rebecca 2010) and India (Karn & Harada 2002) have had faced numerous problems and difficulties due to the privatisation of drinking water sources. For instance, only 2% of slum families rely on own tap connection, and almost 74% of them had to purchase from vendors by 2.25 Indian rupees per 1000 litres (Karn & Harada 2002). Water is considerably expensive for slum households which have no income sources. With regards to this, partnership relies on privatisation and ownership of water sources should have conducted under careful and detailed assessment before proceed and encourage them in Mongolia.

Moreover, it is crucial to develop and introduce a financial mechanism and valuation of water resources in the water supply sector in order to set the right incentives to increase water infrastructure investment (WRG 2014). Under the Water Law in 2012, Mongolia introduced several economic instruments including a water usage fee, wastewater and water service charge, but there is a lack clear guidance and enforcement of how to implement these mechanisms so that water sector revenue is very low and cannot support water infrastructure investment. For instance, the charges for wastewater and polluters are not implemented yet due as there is a lack of development and approval of a wastewater standard. The current wastewater payment is based on the industrial norm, but not based on the actual amount of wastewater discharge so that its revenue is considerably low. However, the water service charge and water usage charge are based on water use, but the enforcement is weak and insufficient. For example, mining companies pay for water usage by their maximum allowed water use as compared to a fixed water use amount that is stated in their licence. But their actual water use is often much greater than this normative water use so that water use charge is low and the water resource is undervalued and the suppliers are unable to increase their revenue. This inadequate water use charge is hindering private companies' initiatives to reduce water use, increase water efficiency and introduce new technologies.

These approaches to water economics and incentives, and valuation of water resources, open remarkable opportunities to increase investment in the water sector field in Mongolia. Therefore, the Government of Mongolia is in urgent need to complete, implement, and enforce these incentive mechanisms to grow investment and expand national and international cooperation for sustainable use of water resources and advanced water efficiency technologies to support water infrastructure to fully develop access for the population safe and quality of drinking water.

5.2 Estimation of the investment required to attain the proposed goal

As the investment in water infrastructure is the key opportunity, this research has estimated the approximate funding required to achieve the MSDV 2030 drinking water goal to provide access to 90 percent of total people by 2030. According to the analysis the Government of Mongolia will require to invest a total of US$ 1260,5 million (1,260 billion) by 2030 and it equals US$ 115 million is additionally required to the state budget from 2019 to 2030 to achieve the goal. This figure comprises of US$ 460.5 million to supply basic services to the rural population and safely managed services in urban areas, plus US$ 800 million to plan and undertake the upgrade of the Central Wastewater Treatment Plant (CWWTP) in Ulaanbaatar and Wastewater Treatment Plants (WWTPs) in 21 provinces. This can be achieved with the support of the Chinese Government's soft loan, the financial assistance of the Asian Development Bank and the Government of South Korea. The required total investment to achieve the 90 percent of total population coverage to supply drinking water goal by 2030 is presented in Table 5.1.

Table 5.1 The required total investment to achieve the 90 percent of the total population by 2030.

No	Required investment	Cost, million US$	Comment
1	Required investment to build and maintain drinking water supply coverage with different service levels until 2030	460,5	The estimation shown in Table 5.5.
2	The CWWTP project	500,0	The MF of Mongolia plans to sign an agreement with the Chinese Government for a soft loan in the near future, possibly in 2018.
3	Sub WWTPs in 21 provinces	300,0	The MF of Mongolia plans to develop an agreement with the ADB and Korean Government to support these projects.
	Total	1260,5	The required additional investment to achieve the MSDV 2030 drinking water goal 90 percent of the total population coverage.

Source: MCUD, 2018 and MF, 2018a.

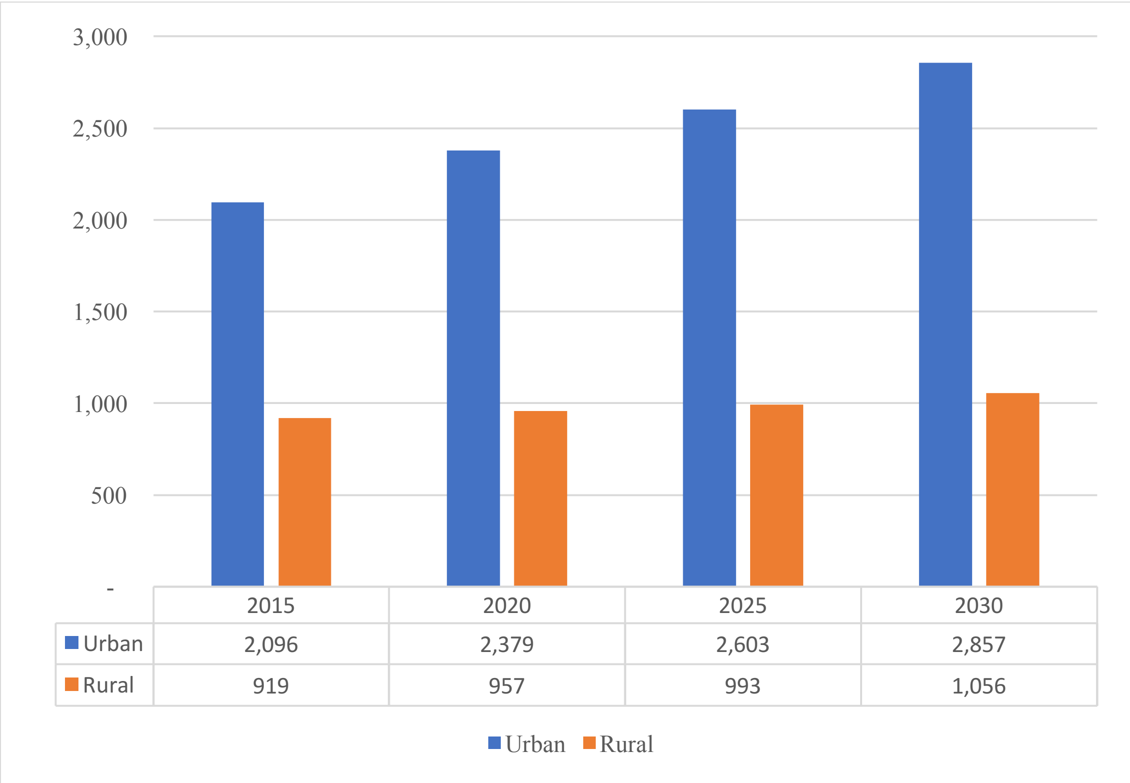
In order to estimate the total investment amount, the rural and urban population number must be calculated so that the number of people needing water can be assessed. Since there was a lack of data information about the rural and urban population numbers, this needs be evaluated in the following way. The NSO database was used for the regional centres' population numbers in 2015 (NSO 2017, 2018), then the annual average growth rate is used to estimate the rural and urban population numbers separately as well as its projection (NSO 2017). The total number of rural and urban population projections to 2030 is compared with the latest NSO population projection between 2015 and 2045 at the national level (NSO 2017), and the numbers were very close showing the estimation is right. The NSO (2017) recommends using the medium population growth scenario for policy options which research is used for the estimation of population and further analysis. The estimation of population projections from 2015 to 2030 using regional data is shown in Table 5.2. The results of this projection by rural and urban areas are shown in Figure 5.1

Table 5.2 Projected population for 2030 using regional data for Mongolia, (millions).

Region and city	2015		2020		2025		2030		Annual average growth, %		
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	2015 2020	2020 2025	2025 2030
National level by NSO, 2017		3,027		3,354		3,662		3,950	2.16	1.84	1.57
Western Region	127	263	134	276	141	292	152	315	0.99	1.13	1.58
Khangai Region	240	337	250	352	259	365	275	388	0.88	0.72	1.24
Central Region	245	229	251	235	256	240	268	251	0.53	0.37	0.96
Eastern region	88	90	91	93	95	96	101	103	0.76	0.68	1.29
Ulaanbaatar	1,396	-	1,653	-	1,852	-	2,061	-	3.67	2.42	2.25
Total	2,096	920	2,379	957	2,603	993	2,857	1,056	-	-	-

Sources: Derived from the Mongolian National Statistical Database, 2018 and the Renewed 2015-2045 population projection by NSO, 2017.

Figure 5.1 Urban and rural population projection from 2015 to 2030 in Mongolia, (millions).



Sources: Derived from the Mongolian National Statistical Database, 2018 and the Renewed 2015-2045 population projection by NSO, 2017.

According to this projection, the urban population will gradually increase, whereas the rural population will grow only marginally. Hence, the increasing Government attention is required on urban population growth and its drinking water supply issue. However, in rural areas, the existing water quality issues and the disparity of drinking water access due to water resources scarcity is enormous.

Based on this current population number and related projections, the existing population number that has access to drinking water services and the required population number that needs to achieve 90 percent by 2030 was estimated. The latest WHO & UNICEF (2017) report and its Mongolian data were used in this estimation. According to this report, 94 percent of the urban population has a basic water supply service including 35 percent of them which have a safely managed service that is a piped network to their premises. The remaining 6 percent of the urban population is still using unimproved drinking water sources. In rural areas 56 percent of people are using basic water supply services: this figure includes 9 percent who have safely managed drinking water sources. Also, the report states that, 34 percent of the rural population are using unimproved drinking water sources. In relation to these percentages, the related population numbers were estimated. The baseline of the SDGs is 2015 so that the basic population number is taken from this year. The current drinking water supply proportion, the related population number in 2015, and the population number that is needed to achieve 90 percent by 2030 are shown in Table 5.3.

Table 5.3 The current drinking water supply proportion and proposed goal by 2030.

Service level	Urban population		Rural population		National level	
	Current %	Target 90%, Million (2030)	Current %	Target 90%, Million (2030)	Current %	Target 90%, Million (2030)
Basic water supply	94	-	56	0,360	83	0,360
Safely managed	35	1,571	9	-	44	1,571
Unimproved	6	-	44	-	17	-
Total target						1,931

Source: The current proportion taken from the WHO & UNICEF, 2017, pp. 68-98.

The research considered that in rural areas people can have only a basic water supply service due to the vast territory and nomadic herder’s lifestyle: it is impossible to connect a pipeline network to their premises. According to the estimation, the government needs to supply around 360,000 additional rural people to a basic water supply service and approximately 1,570 million urban people need to be connected to a safely managed water service by 2030.

Further, based on these population numbers, the research estimates required investment undertaken in two major ways. Firstly, using the report by Hutton and Varughese (2016), financed by the World Bank includes the evaluation of the capital cost per capita to supply by basic and safely managed service in 2015. Appendix E of this report illustrated that Mongolia's capital cost per person served by basic drinking water in the rural area was US$ 35.1 and safely managed service in the urban area was US$ 158.9 in 2015 (Hutton & Varughese 2016). The estimation is presented in Table 5.4. However, the research will not use this valuation in the future, because according to the borehole digging budget the norm of the US$ 35.1 per capita to establish a borehole in the rural area is considerably lower than the current cost (CMO 2013). To build and dig a borehole is different per each region (CMO 2013). For instance, in the Southern Gobi region water comes from around 150 metres and the cost per metre for digging is approximately US$ 60, and this will therefore be around US$ 9000 per borehole. It shows the domestic data and its lack of consistency may cause invalid international data information and their estimations. Also, according to Hutton and Varughese (2016) data Mongolia will need US$ 263 million to achieve the goal. Hence, the data used in this estimation is inconsistent, so their research will not be used for further analysis.

Table 5.4. Required investment to cover 90 percent of the rural and urban population by using the capital cost per capita by Hutton and Varughese (2016).

Area	**2030**		**Capital cost per person basic service, US dollar**	**Capital cost per person safely managed, US$**	**Required investment by 2030, US$ million**
	Basic service, thousand people	Safely managed, million people	Borehole	Pipeline	
Rural	360	-	35.1	-	13
Urban		1,571	-	158.9	250
Total					263

Source: Hutton and Varughese (2016) and its Mongolia row in the Appendix E, page 40.

Secondly, the research used the Mongolia SDG country costing summary report by the MCUD (2018) that estimates the investment to cover the additional rural and urban population number by 2030. The report uses related data as of 2016. According to the report, Mongolia needs annually an additionally US$ 4 million to maintain the current basic service and safely managed infrastructure. Similarly, to achieve universal coverage, i.e, 100 percent, Mongolia needs annually an additionally US$ 8 million for basic services and US$ 24 million for safely managed infrastructure. Based on these data, the required additional investment to the state budget to achieve the 90 percent was estimated. The estimation is shown in Table 5.5.

Table 5.5 Required investment to achieve the 90 percent access to water for total population by the MCUD 2016 report.

Required types of cost	**Required investments, US$ million**			
	Annual investment since 2019		By 2030	
	Basic service	Safely managed	Basic service	Safely managed
Maintaining services for served	4	3.6	44	39.6
Reaching target	7.2	19.8	79.2	217.8
Total cost	11.2	23.4	123.2	257.4
Required total cost as of 2016		34.6		380.6
Required total cost as of 2018 inflation 1.2				460.5

Source: MCUD, 2018.

The research also analysed the current state budget allocation in the country's construction and urban development sector that is responsible for the population's drinking water supply. The annual state budget approval documents from 2015 to 2018 as presented in the Mongolian Government's legal database www.legalinfo.mn. Annual state budgets are in Mongolian currency so that the amount is converted into US$ by average yearly exchange rates taken from the Mongolian Bank's online data source. These exchange rates were used for further estimation as well. It is taken by major sectors allocation, for instance, The Ministry of Construction and Urban Development, Ministry of Environment and Tourism, Ministry of Health, Ministry of Agriculture and so on. The state budget allocation in major sectors in Mongolia from 2015 to 2018 by MN$ and US$ is shown in Appendix 2. Other sectors such as the Ministry of Defence, Ministry of Law and Justice, Ministry of Foreign Affairs are not shown, but the total approved budgets are included in Appendix 2. The state budgets are converted by the percentage shown in Table 5.6. According to the evaluation, the government of Mongolia allocates to over 40 percent of the budget to the MEd in 2015 and 2018, whereas only a small proportion is allocated to the MET which is lower than 5 percent from the total in last five years.

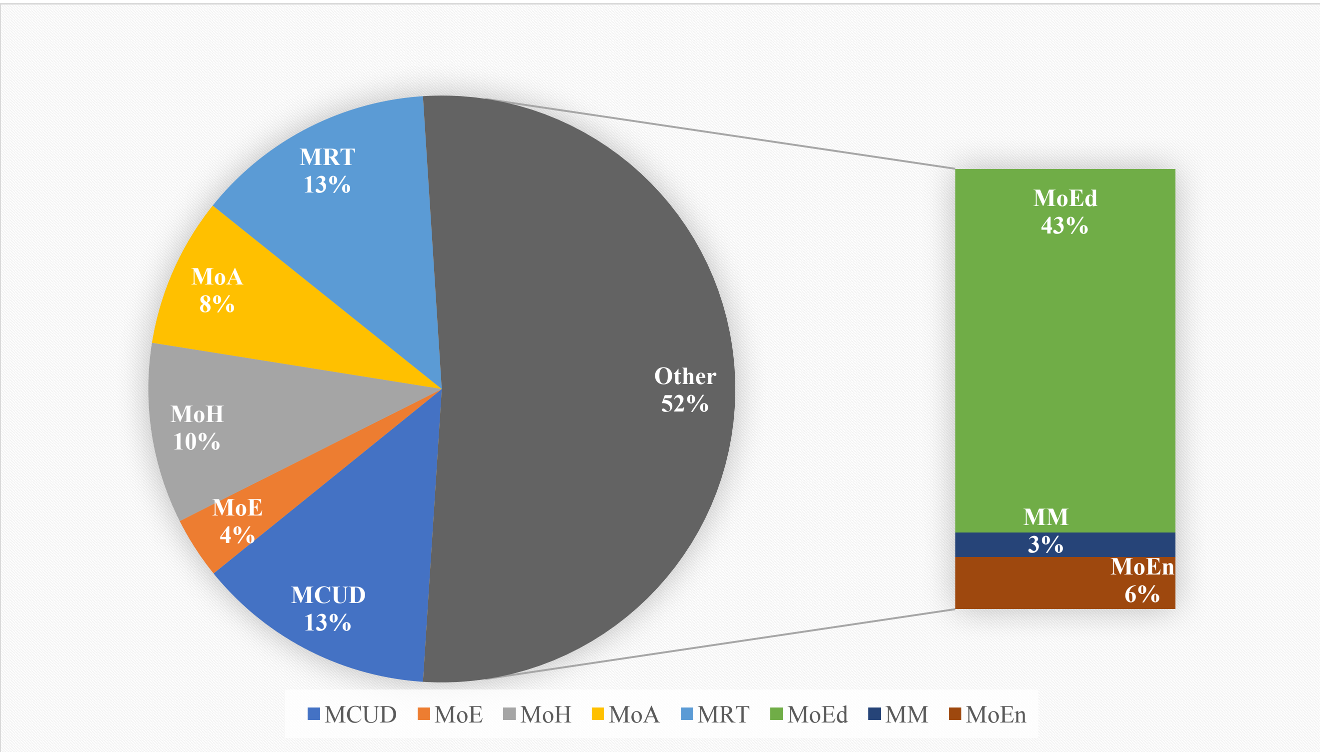
Table 5.6 The State budget allocation in major sectors in Mongolia from 2015 to 2018, (%).

Sectors	2015		2016		2017		2018	
	US$ million	%	US$ million	%	US$ million	%	US$ million	%
MCUD	11	7	24	6	30	14	32	13
MET	4	2	4	1	4	2	8	4
MoH	28	19	30	8	25	11	24	10
MoA	9	6	8	2	20	9	20	8
MRT	27	18	234	59	59	26	32	13
MoEd	64	42	79	20	31	14	105	43
MM	6	4	4	1	7	3	7	3
MoE	3	2	10	3	46	21	15	6
Total	151	100	391	100	223	100	244	100

Source: www.legalinfo.mn

According to the last four years' data, the MCUD sector comprises an average of 10 percent from the total state budget. In 2018, the state budget of the MCUD sector comprises around 13 percent of the total, with a similar allocation provided to the MRT, while the majority, 43 percent, is distributed to the MED. The state budget allocation in 2018 is illustrated in Figure 5.2.

Figure 5.2 Mongolian state budget allocation in 2018.



Source: www.legalinfo.mn

The government also approved the ODA investments each year. In this regard, the overall investment for the MCUD in last three years was estimated, the calculation is shown in Table 5.7. According to the estimation, the overall investment for the MCUD was at US$ 23.5 million in 2015, and this doubled to US$ 50.5 million in 2018.

Table 5.7 Overall investment for the MCUD from 2015 to 2018.

Type of investment	2015		2016		2017		2018	
	Billion MN$	Million US$	Billion MN$	Million US$	Billion MN$	Million US$	Billion MN$	Million US$
State budget	22	11	51	24	74	30	80	33
ODA financing	25	13	4	2	24	10	42	17
Total	46	24	55	26	98	40	122	50.5

Source: www.legalinfo.mn

The MSDV 2030 policy plans to increase the economic growth of the country by at least by 6.6 percent every year during the SDGs period so that the research assumes the budget for the sector can increase by this growth. Also, the policy plans to increase more than four times the per capita GNI to US$ 17,500 in 2030 from US$ $ 3850 in 2015. The MF (2018b) data information, it was provided general economic indicators of the country as presented in Table 5.8.

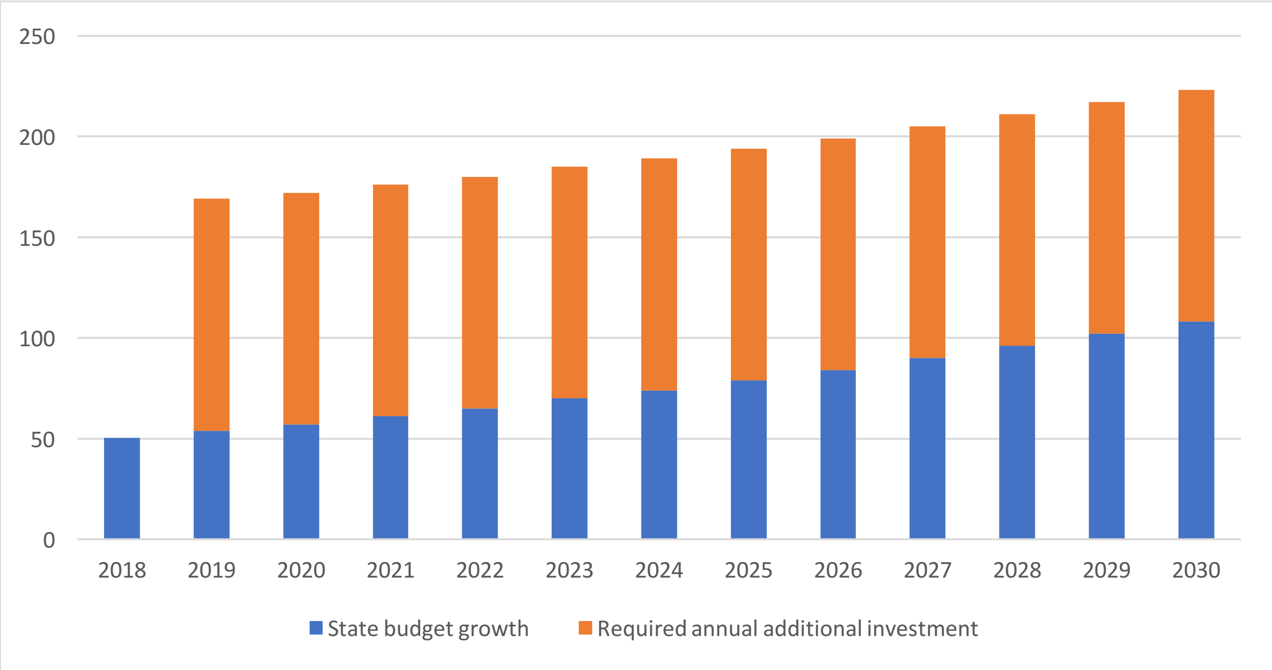
Table 5.8 The current economic indicators and the MSDV 2030 policy document's proposed goals.

Indicators	2015	2016	2017	2018	MDSV 2030 plan
Economic growth, %	2.4	1.2	5.1	7	>6.6
GDP, US$ billion	11,675	11,188	11,065	12,000	69,125
GDP per capita, USD$	3.850	3,590	3,290	3.689	17.500
Inflation rate, %	1.9	1.1	6.4	7.6	-

Source: MF, 2016 & 2018b.

The state budget allocation projections to the MCUD and the additional annually required investment to achieve the MSDV 2030 is shown in Figure 5.3. The research considered that the total required investment (Table 5.1) is the additional cost to the state budget allocation to the MCUD, however the state budget can be used to implement other actions and activities that are planned in the National Water Program and Integrated Water Resources Management planning of the country. Therefore, the total estimated investment which is US$ 1206.5 million by 2030 or annually US$ 115 million is required to increase to achieve the MSDV 2030 water goal. The MCUD state budget growth projections and the further investment necessary that need to increase annually are shown in Figure 5.3. It assumes that the annual growth of change in the budget is at least 6.6 percent that planned in the MSDV 2030 and remains the same throughout the entire projected period.

Figure 5.3 The MCUD state budget growth projection and the total additional required investment each year by 2030, (million US$).



Source: MF, 2016 and 2018.

The results of the estimation show that the required water infrastructure investment to achieve the MSDW 2030 drinking water goal equate to around two times higher than the current funding for the MCUD sector of the country over the SDG period. However, the state budget to the sector can be enlarged due to the further economic growth, so that the additional required investment may decrease in the future. Nonetheless, it is apparent the Government will need to undertake the massive responsibility of imposing a substantial investment effort to achieve the MSDV 2030 drinking water goal. Furthermore, the required additional investment of US$ 115 million is the equivalent of around a maximum of 6 percent of the country's total GDP in 2030. The estimation of this 6 percent is derived from the total GDP proportion by 2030. The MSDV 2030 policy plan is to increase the GDP per capita at US$ 17,500 by 2030; thus, the total GDP in 2030 for the projected 3,950 million total population expected to be around US$ 69,125 billion. Hence, the US$ 115 million accounts for around 6 percent of it. It is obvious that to invest 6 percent in water infrastructure alone every year can be difficult for the Government to afford. Nonetheless, as discussed earlier in the section 5.1, the Government has opportunities to increase the water infrastructure by improving the governance, database and advancing partnerships. It would however be necessary for the Government to analyse various investment planning options in advance and evaluate their benefits to the country's environment and social sector as well as economic development. This research analysed these investment planning options of increasing water infrastructure by using the T21 Mongolia model as outlined in the next section.

5.3 Analysis of investment assumptions and the impact on socio-economic and environmental sector using the T21 Mongolia model

It is crucial to analyse investment options and policy assumptions to examine the funding alternatives and their importance to the water infrastructure and their financial planning which is closely linked to the sustainable development of the country. The T21 Mongolia model enables exploration of this analysis. The primary goal of the T21 Mongolia model is to examine various policy assumptions and their impacts on three major sustainable development pillars (MF & MI 2015). The model indicates general trends of assumptions such as whether the policy is positive or negative and its increase or decrease compared to the baseline scenario and so on (MF & MI 2015; MI 2018). Precise statistical data is not necessarily required and, estimations to simulate assumptions can be used in the model, because it provides long-term projections and tendencies or perspectives of the policy, not the ultimate final answers. The assumption is that a policy option is to be analysed through models to examine their impact factors and trends (MF & MI 2015). The results of assumptions provide possible solutions and alternative approaches to achieve any targets or goals. The assumptions of this research are based on common a logical flow to attain the MSDV 2030 drinking water goal rather than on the data estimations from the previous sections. The analysis has utilised the model to analyse the water infrastructure investment options of policy assumptions to improve the drinking water supply and the impact on the country's development. There are two main assumptions analysed by utilising the T21 Mongolia model and their comparison to the baseline scenario. Assumption 1 illustrates the impact of the investment increase to water infrastructure on the domestic financial capacity to achieve the MSDV 2030 drinking water goal. Assumption 2 demonstrates the effects of foreign investment and its contribution to the Mongolian water infrastructure to attaining the proposed population drinking water goal stated in the MSDV 2030 policy document. Based on these analyses, the Government is able to express an appropriate long-term investment policy and planning options for the country's sustainable development. The results of the model are presented by the following socio-economic and environmental indicators of the T21 Mongolia model. The indicators that processed the results are presented in Table 11.

Table 5.9 The indicators to analyse the water infrastructure investment and their impact.

No	Indicators
To analyse social sector impact	
1	Life expectancy by gender
2	Infant mortality
3	Proportion of population below poverty line
4	Unemployment
To analyse economic sector impact	
5	Real GDP
6	Revenue and Grants
To analyse environmental sector impact	
7	Per capita CO2 emission
8	Total BOD (Biochemical Oxygen Demand) discharge-water quality
To analyse impact to Ulaanbaatar city water supply	
9	UB Water recycling capacity

Source: T21 Mongolia model.

It should be noted that the model does not analyse the impact of assumptions on equality and affordability of drinking water supply due to lack of possible indicators to examine them by the T21 Mongolia model. The model needs related adjustment and improvements to assess these drinking water supply indicators.

In this research, there are two policy assumptions proposed to increase the water infrastructure investment of the country. One assumption is the opportunity to reach the goal by using domestic financial capacity, and the second is the foreign investment contribution to the country's water infrastructure development and the impact to the social, environmental and economic sectors. The results based on these assumptions are then compared to the business as usual (BAU) scenario.

BAU scenario: This is the baseline of all assumptions which has no any changes and calibrations to the country's financial planning and investment.

Under the BAU the scenario is that the country can develop by their own economic momentum and the current socio-economic development pathway without any foreign investment and specific alterations of the state budget allocation to sectors. In this scenario, the future patterns of the country's development assume no significant changes to population attitudes to drinking water supply such as water use efficiency, water savings and so on. The scenario is without any changes in environment, social and economic sector development. The existing T21 Mongolia model's baseline year of the BAU scenario is 2014 (MF & MI 2015). The MF is updating the model as of 2016, but this is currently not available to utilise for this research due to the fact that adjustments are still in process. The BAU scenario is displayed as the red line in each of the following graphs. The study analysed and compared the BAU scenario with the following two assumptions:

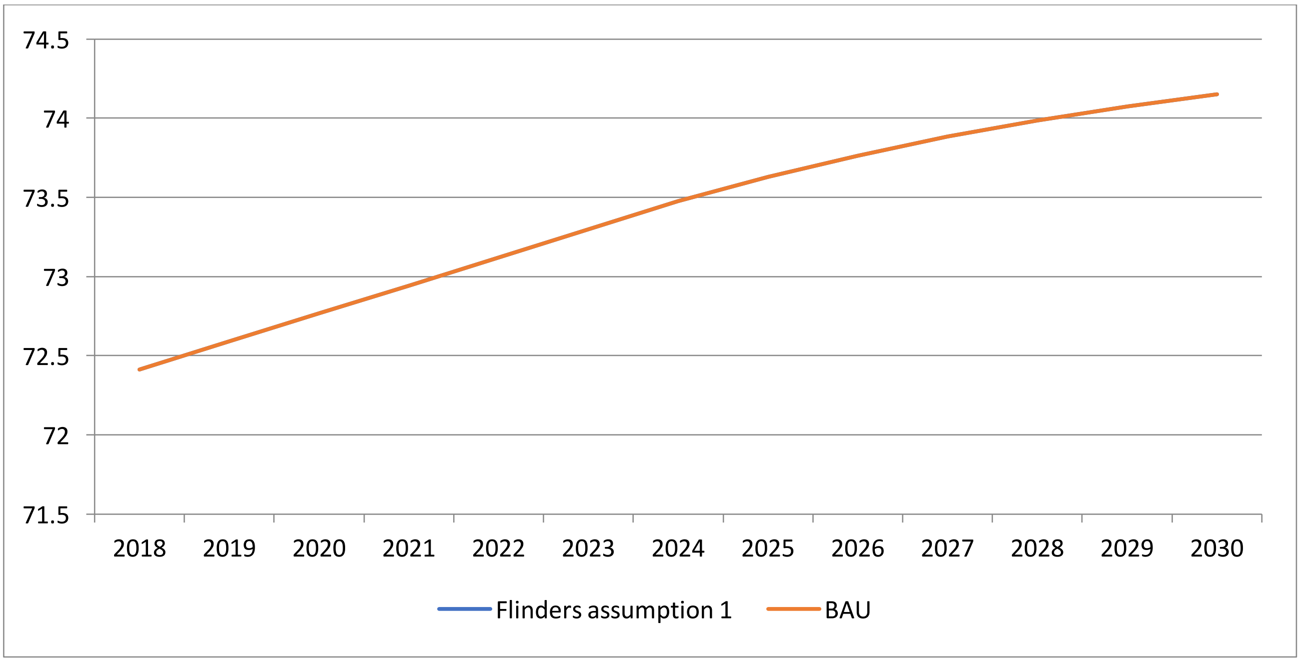
Assumption 1: Assume the Government increases domestic investment in the water infrastructure by 50 percent from the current state budget of the MCUD sector by 2030.

The research therefore assumes that the distribution of the current state budget for the water infrastructure field of the MCUD sector is negligible. The state budget of the MCUD comprises only 13 percent of the country's total in 2018 and this budget splits into several fields as the MCUD undertake urban construction and planning, land management, public utilities, construction material and manufacturing issues of the country. The drinking water supply is one of these areas of the Ministry so that the state budget allocation to water infrastructure can be considered minimal. Assumption 1 assumes an increase of this marginal allocation to water infrastructure by 50 percent from the total budget of the MCUD which means half of the sector's budget goes to the drinking water supply. The reason for increasing this by 50 percent is that this can be the maximum available capacity to accumulate for the water infrastructure field from the whole MCUD sector of the country as the Ministry deals with other urban planning issues too. This research argues that it might be unsustainable or risky for the sector's development policy planning if the MCUD invests 50 percent more to water infrastructure, it assumes a 50 percent increase from the total sectoral budget. The main implication of Assumption 1 is to analyse the expansion of domestic funding to water infrastructure and its impact on the socio-economic and environmental sector of the country as well as its contribution to achieving the MSDV 2030 drinking water goal. Assumption 1 analysis is of the domestic investment option to accomplish the proposed drinking water goal. The following calibrations are made into the T21 Mongolia model and their policy variables to analyse this policy assumption.

- To increase the investment share of the green economy to the water sector by 50 percent and reduce the share of renewables by 20 percent. The water infrastructure is one of the four green economy sectors of the T21 Mongolia model (see section 2.2). The share of water and renewables are the main policy variables that exist in the T21 Mongolia model. Hence, the parallel green economy sector which is the share of renewables was reduced to ensure the economic structure of the country. This may cause inconsistency and change economic structure if the major sectors such as tourism, agriculture or mining etc. were reduced. In addition, the share of the renewables is the only parallel sector to water infrastructure that is included in the current version of the T21 Mongolia model. The research also presumes that it would be risky to the green economy sector of the country if the share of the renewables was reduced by more than 20 percent. Likewise, the renewable energy is a vital economic sector of the country. Thus, the research reduced the share of the renewables by 20 percent in the model.

Result: Although the Government increases the national funding by 50 percent for the water infrastructure, it cannot improve the current situation of the drinking water access. The reason is most indicators are unchanged and remained as the BAU scenario. For example, the result of life expectancy by females is shown in Figure 5.4.

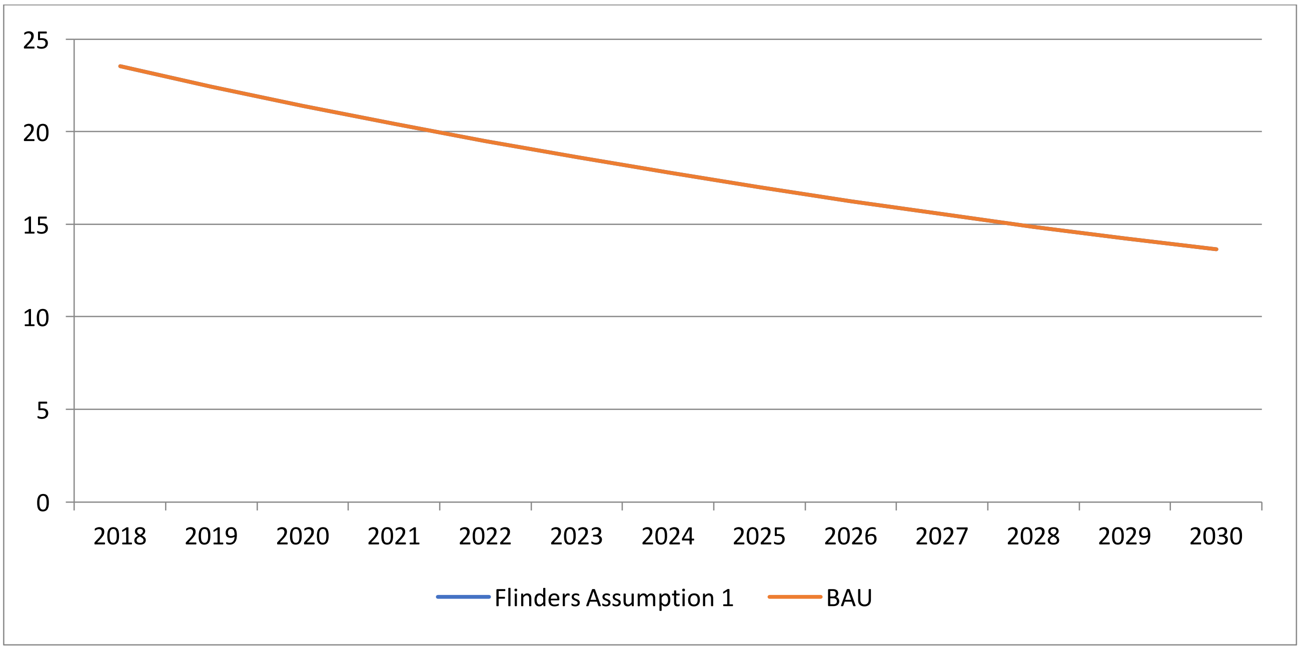
Figure 5.4 Simulation result of Assumption 1 by the indicator of life expectancy females, (ages).



It can be perceived that the current state budget allocation (13 percent) to the MCUD, especially to the water infrastructure field of the country is insignificant. Even if the water infrastructure investment is increased by 50 percent which is half of the total sector's budget going to drinking water, it cannot impact on any changes to improve the current situation at all. Assumption 1, which is 50 percent of domestic financing expansion, is still minimal and seems similar to the BAU funding. Consequently, from the result of Assumption 1 it can be inferred that the domestic financial attempt to increase water infrastructure is ineffective and still not enough to achieve the goal.

It is interesting to note that the indicator for Ulaanbaatar's water recycling capacity is reduced and remained equal to the BAU scenario as well due to Assumption 1 result (Figure 5.5).

Figure 5.5 Simulation result of Assumption 1 by the indicator of UB water recycling capacity, (million m3).



This result can be understood to illustrate that the domestic funding cannot improve the capital city's capacity to supply safe and good quality of water to the population due to the minor budget allocation. Instead, it decreases the current water recycling capacity in the future so that makes it unlikely to achieve the goal. The result may perceive that the domestic investment option can be just enough to operate the drinking water supply because it has not declined more than the BAU. Nonetheless, the government may face a serious capacity problem of the population water supply issue in Ulaanbaatar in the future. This result shows that the government must increase the investment substantially to improve the current capacity of the drinking water supply in Ulaanbaatar.

The outcome of Assumption 1 shows that the 50 percent of domestic investment increase to water infrastructure is not competent enough to achieve the MSDV 2030 drinking water goal. It is therefore seen to be impractical to make the goal by managing only domestic funding. The Government should seek international support in the water infrastructure development of the country. This national investment option indicates that the national capacity is insufficient and it cannot impact on the country's socio-economy and environmental sectors.

Assumption 2: Assume an increase in the water infrastructure investment annually by 6 percent of the country's total GDP from 2019 to 2030 and expect that 50 percent of this funding is from the foreign investment and other 50 percent is from domestic financial sources.

This assumption is based on the estimation that the required additional investment to achieve the MSDV 2030 involves a maximum 6 percent of annual investment from the country's total GDP (see the section 5.2). The research assumes that 50 percent of this additional required investment comes from foreign investment support and the other 50 percent can be found from domestic sources. The result of Assumption 1 has shown that the domestic investment capacity is ineffective and it is better the Government seek foreign investment support. Thus, the research presumes 50 percent of this 6 percent of the total GDP can be maintained from international financial support and the rest of the 50 percent needs to be invested from domestic sources. Assumption 2 softens the domestic financial pressure by 50 percent by providing half of the required investment from foreign financial aid. The main difference between Assumptions 1 and 2 is that Assumption 1 increases the green investment share to water infrastructure by 50 percent, whereas Assumption 2 is increasing overall investment to the water infrastructure by 6 percent each year from the total GDP of the country by 2030 and half of the amount can be invested by domestic funding and the other half is supported by international financial sources. The implication of Assumption 2 is to analyse the foreign investment contribution to achieve the MSDV 2030 drinking water goal and its impact on the socio-economic and environmental sectors of the country. The following calibrations are made into the T21 Mongolia model and their policy variables to analyse the investment policy Assumption 2.

- The existing policy variable, the so-called green investment, was increased as a share of the total GDP. This share of the GDP to green investment is increased annually by 6 percent from 2019 to 2030. This policy variable examines the impact of the GDP share to the country's green investment. As mentioned earlier in section 2.2 the MET and the MF jointly developed the four green economic sectors (water, waste, energy and building) into the T21 Mongolia model in 2015. The research assumes all this 6 percent of annual green investment can be allocated only to the water infrastructure field of the country.
- The assumption also increased an additional policy variable which is the share of green economic investment from the foreign source by 50 percent and reduced its domestic source by 50 percent. This policy variable examines the share of the green investment sources and their impact on the sustainable development sectors. The reason for choosing 50 percent of foreign investment expansion is based on the recommendations of Assumption 1 that

suggested water infrastructure in the country requires substantial investment. This can be assumed to be an average amount to evaluate the contribution of foreign investment to the sector. The research inferred that less than 50 percent of international investment would be too low to show impacts and investment changes. In contrast, if more than 50 percent of foreign investment was used, this may be too much for one economic sector and the changes to the development of water infrastructure could be too high in the results. Also, it is uncertain whether there is enough capacity to invest more than 50 percent of the resources that can be found from overseas. Thus, the research has chosen the data assuming an international investment increase of 50 percent, and considering its influence on the water infrastructure development in Mongolia.

Result: The international financial investment in the water infrastructure sector in Mongolia is the vital investment that supports the country's sustainable development. Assumption 2 provides a substantial positive impact on the social (Figures 5.6, 5.7, 5.8, 5.9, 5.10), and environmental sectors (Figure 5.11, 5.12, 5.15) while the economy sector has some improvement but it is not extensive (Figure 5.13, 5.14). Although the economic sector has only marginal improvement there is significant enhancement of the social and environmental sector which means that this investment option is sustainable. If there was the economic improvement without social and environmental sector growth, the investment cannot be considered as sustainable.

The simulation result of Assumption 2 for the indicator of average life expectancy by gender shows that this variable can be improved by around 2.5 years for both females (Figure 5.6) and males (Figure 5.7). It contributes around 36 percent to the MSDV 2030's average life expectancy goal of the country. The MSDV 2030 aims to increase the country's life expectancy at birth by 7 years from 70 in 2015 to 77 by 2030 (MF 2016). The research considers this is a remarkable contribution because water infrastructure expansion alone improves 2.5 years input to the whole country's average life expectancy indicator.

Figure 5.6 Simulation result of Assumption 2 by the indicator of life expectancy by females, (ages).

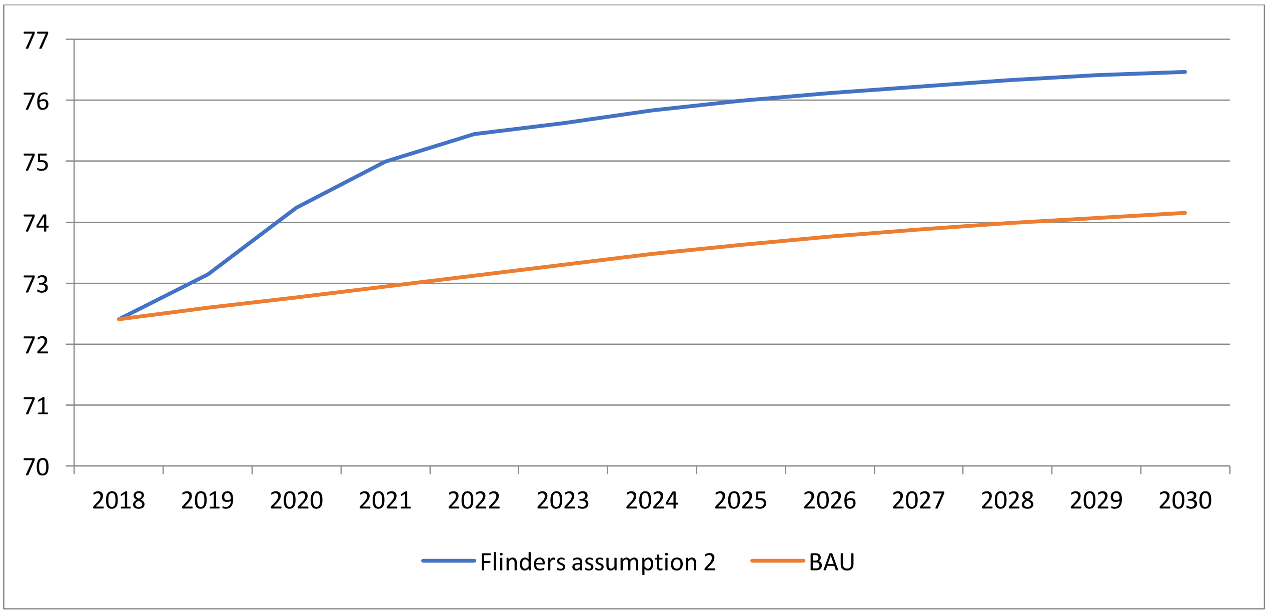
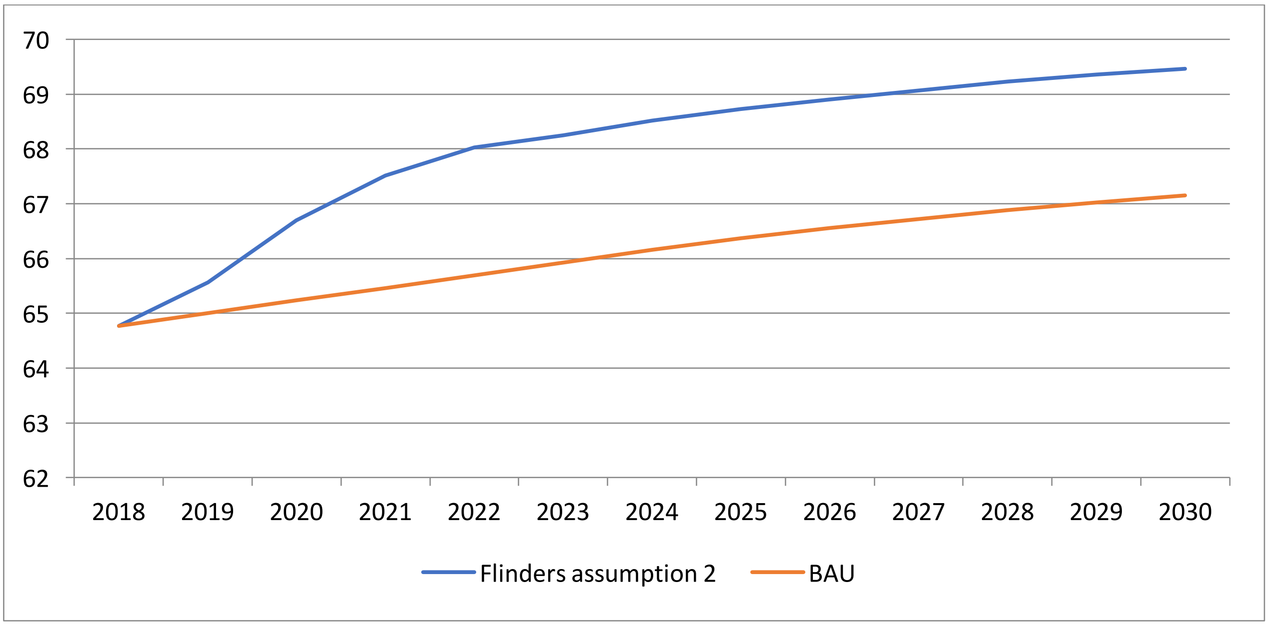
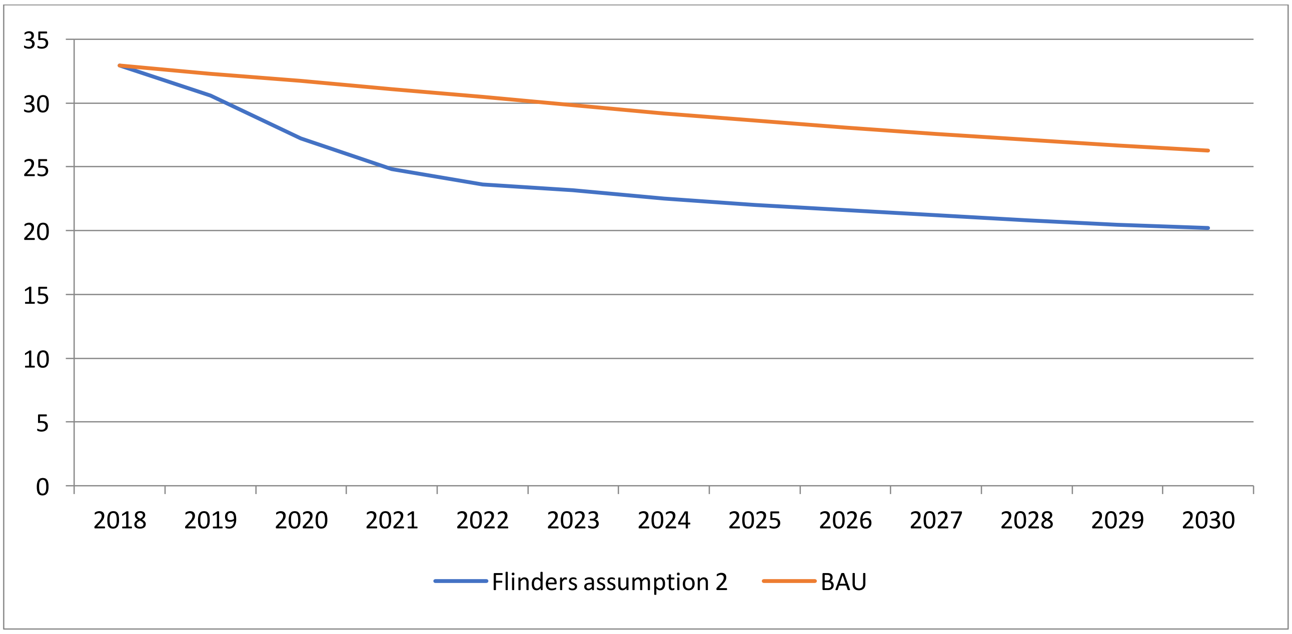


Figure 5.7 Simulation result of Assumption 2 by the indicator of life expectancy by males, (ages).



The research also analysed the impact of the indicator of infant mortality. The result of Assumption 2 shows that infant mortality drops by about 13 deaths every 1000 births in almost every year to 2030. In Mongolia, the average childbirth rate is roughly 230 daily and 80,000 per year (NSO 2018). Hence, Assumption 2 contributes to saving 1040 new-borns every year and it is predicted that it will save 12,480 deaths during birth by 2030. This number is big in the Mongolian case and a massive improvement to the social sector. It improves the current situation around 37 percent. The Government can be also profit by reducing the cost of these medical services that has a valuable positive impact on the country's social sector growth. The result of infant mortality is presented in Figure 5.8.

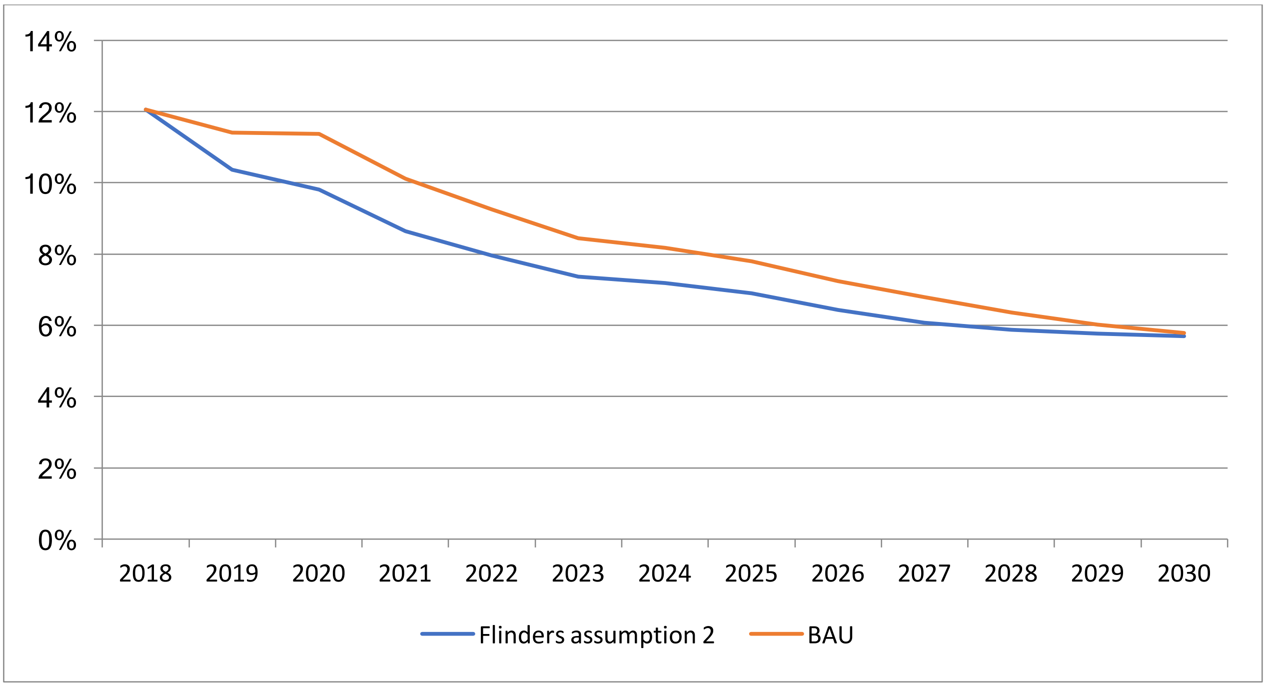
Figure 5.8 Simulation result of Assumption 2 by the indicator of infant mortality rate, (number of death in 1000 birth).



The result implies that the improvement of drinking water access and use is valuable in advancing the public health sector. This investment is vital to accomplishing other sustainable development goals as stated in the MSDV 2030 policy. This impact can also affirm that water is the basis of sustainable development.

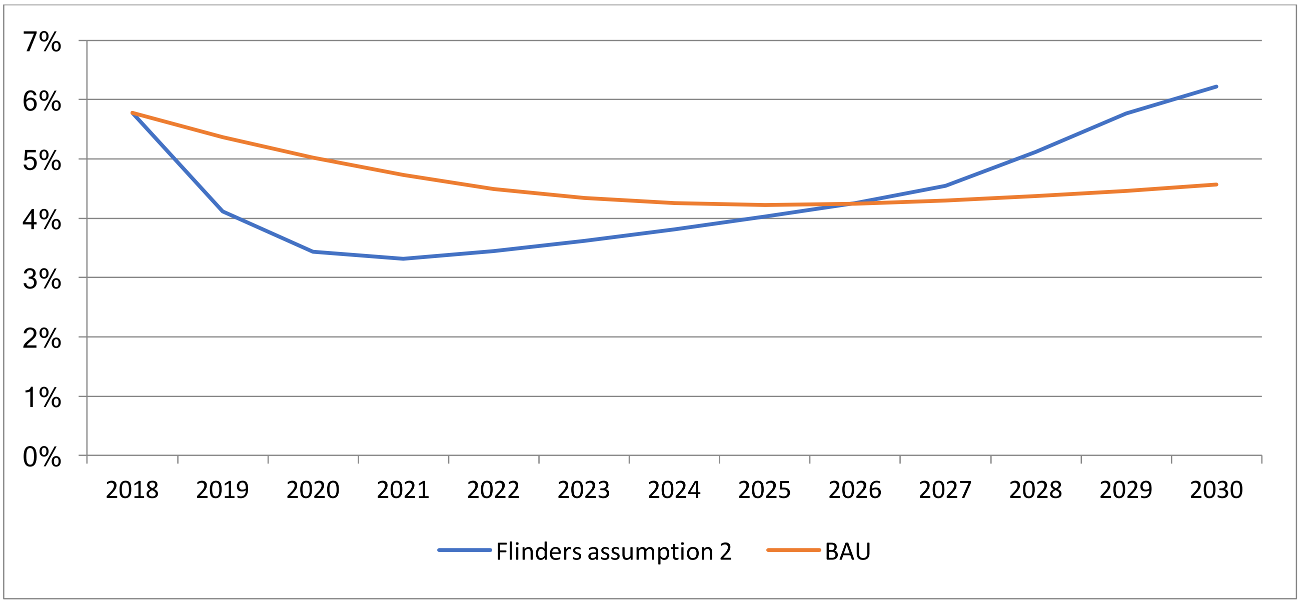
When Assumption 2 is applied the proportion of population below the poverty line can decline by approximately 6 percent during the period from 2019 to 2030, and its trend is observed to be steadily falling (Figure 5.9). This is also a significant impact to social sector and its poverty reduction. The MSDV 2030 planned to illuminate poverty from 21.6 percent in 2014 (MF 2016). Thus, 6 percent of reduction which about 30 percent of poverty reduction from water infrastructure development is obviously remarkable contribution not only in society but also country's development. As poverty drops the population's living environment and other indicators such as inequality, employment and education can improve which shows how essential the population access to drinking water sources is for achieving the rest of the sustainable development goals. However, the poverty reduction can only reach a similar point as the BAU in 2030. This can be explained by the fact that the water infrastructure expansion and its contribution to poverty reduction may have had been exhausted by that time. The country's poverty proportion can be reduced further by other influencing factors such as employment rate, health and education services. Nonetheless, Assumption 2 contributes to lowering the proportion of the population below the poverty line of the country which is an essential positive impact to the social sector's development.

Figure 5.9 Simulation result of Assumption 2 by the indicator of the proportion of population below poverty line, (%).



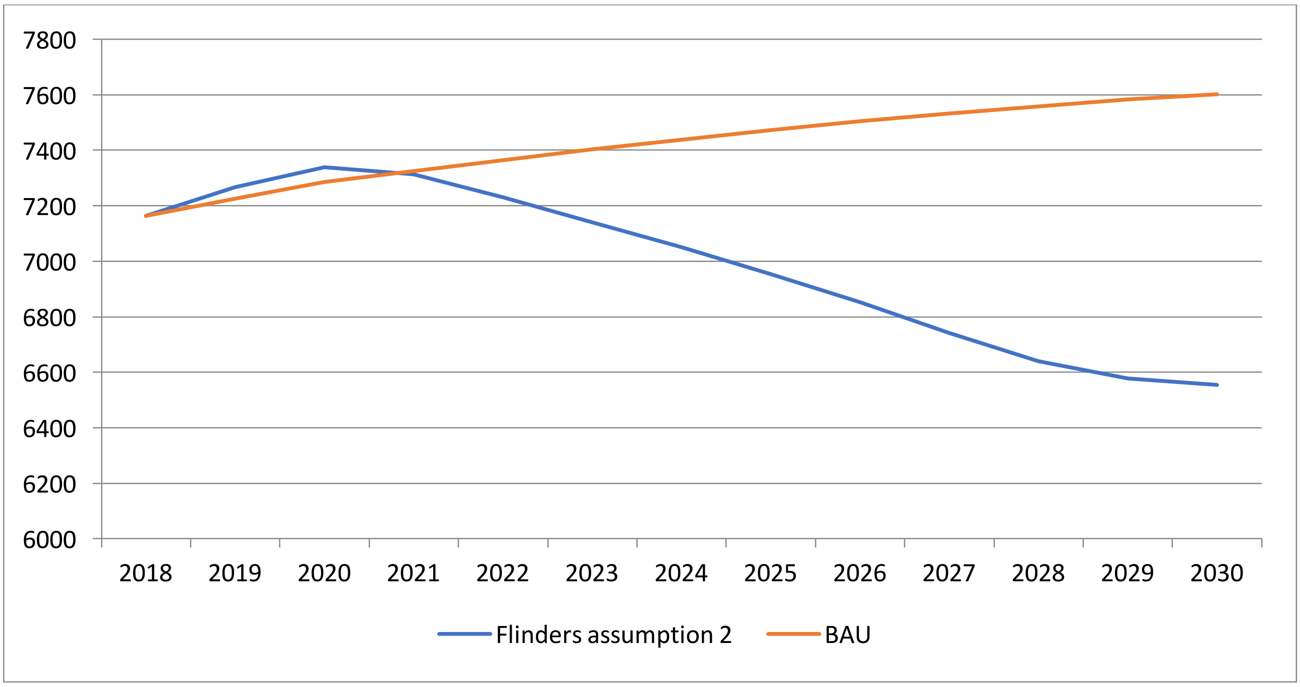
It is interesting to note that the result of Assumption 2 for the indicator of unemployment and its impact on the social sector is different from other indicators (Figure 5.10). It is significantly reducing unemployment by around 3 percent by 2026, but further the trend is outweighing the BAU. This can be explained by the number of jobs created during the construction of water infrastructure, but further those who work on water construction may lose their employment when wastewater plants start their operation. Also, the new water infrastructure may have been installed with the latest technology that can replace human labour. Thus, the Government needs to implement policy to increase employment in advance by strengthening the population's work readiness, especially in the water sector.

Figure 5.10 Simulation result of Assumption 2 by the indicator of unemployment rate, (%).



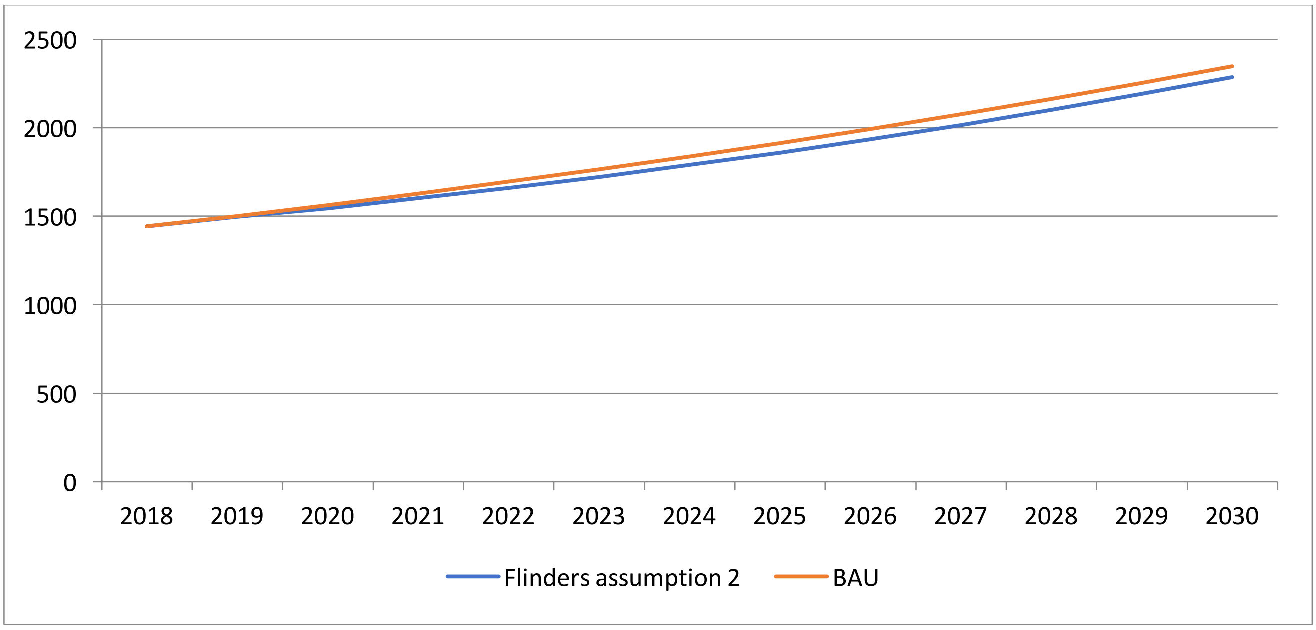
The result of Assumption 2 also illustrates that it is beneficial to the environmental sector of the country. It has the potential to cut the per capita CO2 emission by approximately 1000 kg per person every year from 2021 (Figure 5.11). This fall is a sufficient transformation when considering the total population number. This decline has an extensive impact compared with the result of Assumption 1.

Figure 5.11 Simulation result of Assumption 2 by the indicator of per capita CO2 emission, (Kg/ Person*Year)



With regards to the result of the Biochemical Oxygen Demand (BOD) discharge which represents water quality improvements there was only a marginal change (Figure 5.12). The reason for this may be linked to the fact that the investment to improve water quality requires more funding to achieve more significant change. Also, it may be that some adjustment and modification is required to improve the water quality indicators in the T21 Mongolia model. For instance, the link between green investment and water quality indicators in the model should be analysed. Although the water quality improvement is marginal by 2030, the trend increases further so that the impact should be higher in the future. Nevertheless, it has an improvement, and the model reveals the positive correlation.

Figure 5.12 Simulation result of Assumption 2 by the indicator of total BOD discharge, (thousand ton/year).



Generally, the investment policy Assumption 2 provides considerable benefits to the country's social and environmental sectors that benefit the population's well-being so that society and the environment can be enhanced due to the implementation of this approach.

Assumption 2 also provides a positive impact to the economy as shown in Figure 5.13 and 5.14. Both the country's GDP and the income from the revenue and grants may be increased, but the amount is negligible until 2030, however, the trend is also rising over time, so in further it may have substantial impacts in the long-term period. This also illustrates that revenue and grants from international investment are marginal due to the construction of water infrastructure developments, but later when the infrastructure developments become operational the value or income of water supply development is possibly increased via the growth trend. Moreover, this shows that the Government still needs to increase the proportion of the foreign investment in the water infrastructure sector. Furthermore, the T21 Mongolia model may need to improve adjustment of benefits from the water infrastructure sector based on the academic sources such as the estimation by Haller, Hutton and Bartram (2007). As noted earlier, Haller, Hutton and Bartram (2007) estimated every dollar of water investment returns roughly US$ 5 to 45 which is substantial revenue. The current research considers that the T21 Mongolia model may not reflect this kind of investment returns. Thus, the result of Assumption 2 to the country's economic sector indicated a low return in comparison to results from other indicators. However, even the economic indicators have negligible growth the assumption has remarkably increased the social and environmental indicators of the model, particularly life expectancy, poverty reduction and per capita CO2 emission. Accordingly, Assumption 2 considers as the sustainable investment opportunity for the country's development.

Figure 5.13 Simulation result of Assumption 2 by the indicator of real GDP, (trillion MN$/Year).

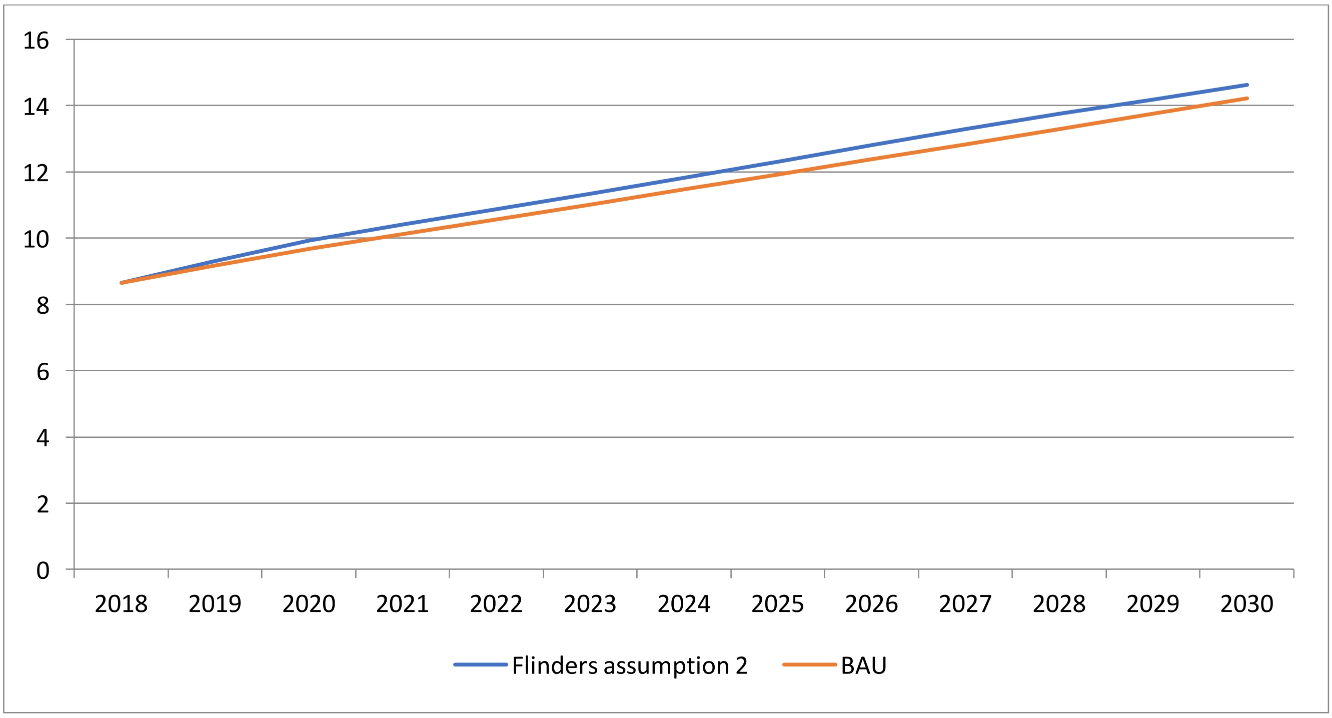
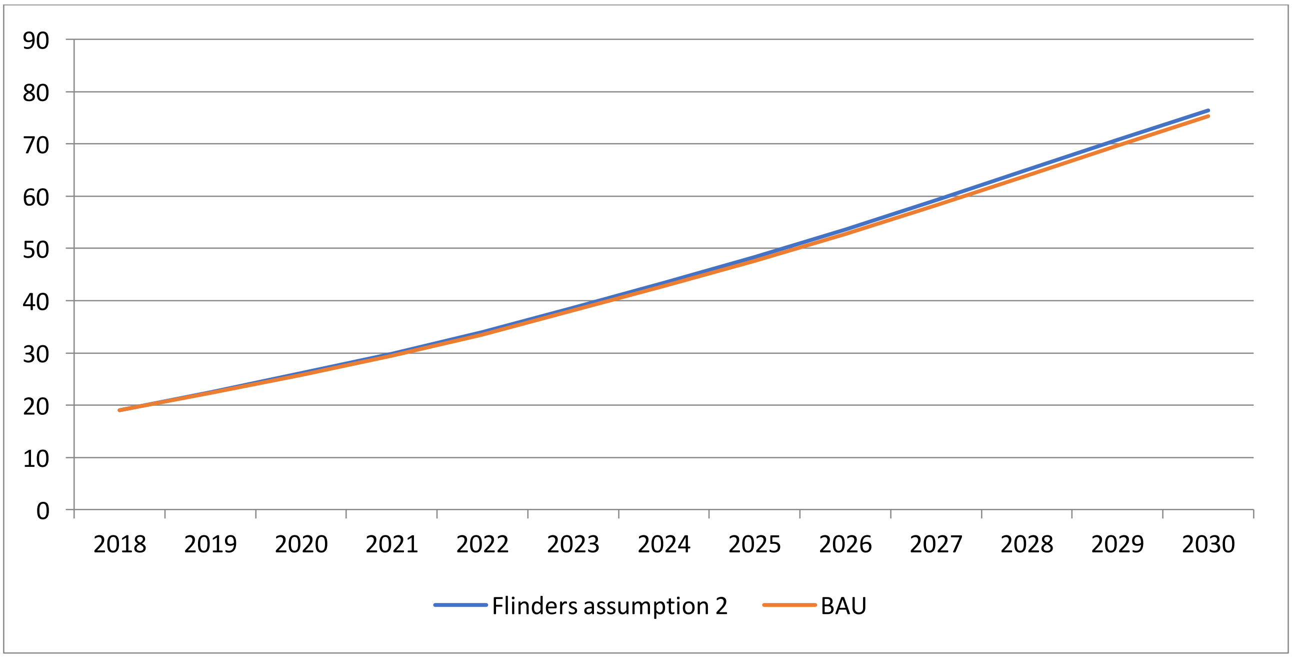
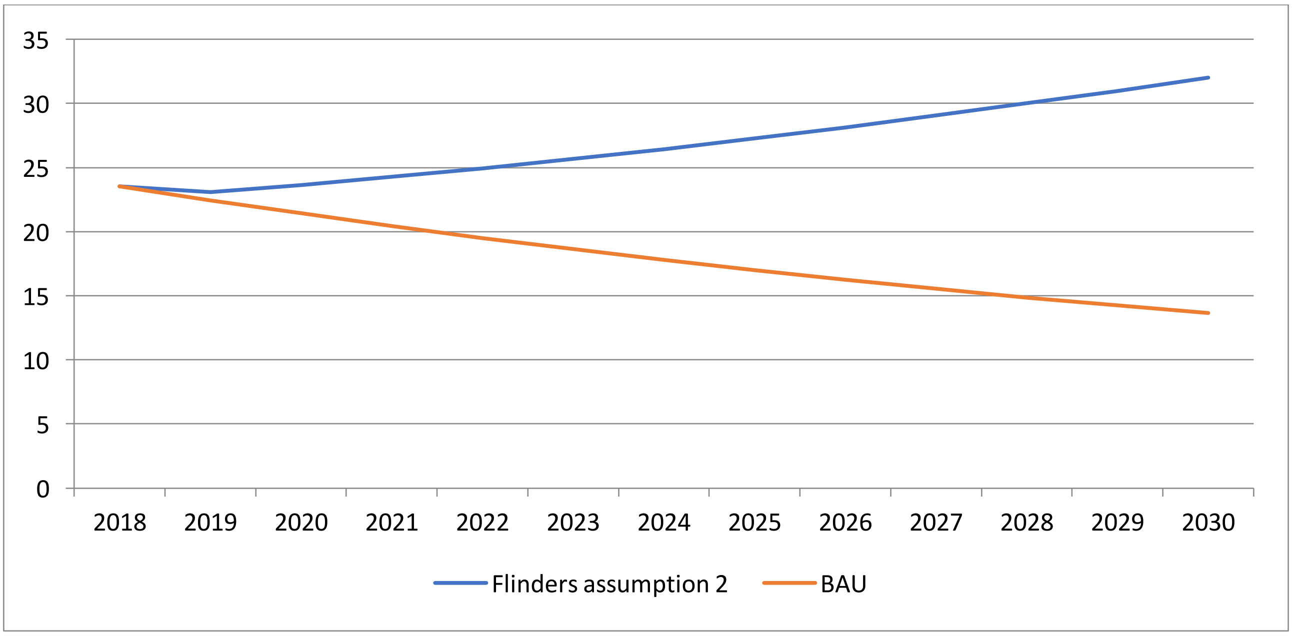


Figure 5.14 Simulation result of Assumption 2 by the indicator of revenue and grants, (trillion MN$/Year).



The result of Assumption 2 for the capital city's water recycling capacity indicator has also increased significantly (Figure 5.15). The water recycling capacity of the capital was raised from 2 million m^3 in 2020 to almost 10 million m^3 water in 2030, and the trend shown indicates it will increase further. This tendency demonstrates a notable improvement compared to the BAU. The MSDV 2030 drinking water goal in Ulaanbaatar can be achieved because of Assumption 2 investment policy planning. As it has remarkable progress in the Ulaanbaatar water recycling capacity, the Government should adjust the investment allocation from the water infrastructure development in Ulaanbaatar into water quality and monitoring issues for the rational utilisation of foreign investment.

Figure 5.15 Simulation result of Assumption 2 by the indicator of Ulaanbaatar water recycling capacity, (million m3).



In conclusion, the impact of the overseas investment is valuable contribution to the country's socio-economic and environmental sectors' development. The result that emerge from the analysis show that the current and future sustainable development of the country can surely benefit from achieving the MSDV 2030 drinking water goal. The economic growth with significant improvement of the social and environmental development is the groundwork of sustainability that accounts the current and future generation demand and prosperity. This result also affirms that water is the basis of sustainable development that can influence other sectors' growth. Therefore, the research highly recommends that the Government must expand international cooperation and partnership actions to increase foreign investment in the water infrastructure field to achieve the MSDV 2030 drinking water goal.

6. Conclusion of the research

Access to safe drinking water is recognised as a basic human right and the foundation of sustainable development that all Governments must stress with great importance. The research explored the access and supply of drinking water in the current Mongolian context and the future target as stated in the sustainable development policy document the co-called MSDV 2030. The study investigated whether it is possible to attain the goal of drinking water access to 90 percent by 2030 of the population as stated in the MSDV 2030 policy document. The research also sought to explore challenges and opportunities, required investment to making the goal a reality, and its funding policy alternatives and their impact on social, environmental and economic sectors of the country. The general literature on this subject and particularly in the context of Mongolia is inconclusive on several vital questions within the diversification discourse. The study required to pursue the following objectives to address the research question mentioned above:

- To identify the challenges and opportunities in achieving the drinking water goal stated in the MSDV 2030;
- To make an approximate estimation of investment required to achieve the goal;
- To find out the impact of increasing the investment on water infrastructure and its related policies on the country's sustainable development.

The chapter will provide the synthesis of empirical findings presented in this thesis including significance, limitation of the research and direction of a further similar field of study.

6.1 Main findings of the research

Main challenges and opportunities to achieve the drinking water goal stated in the MSDV 2030

According to the research undertaken for this thesis, the drinking water goal of the MSDV 2030 is not achievable with the current water supply situation unless the Government addresses the following critical challenges and urgently implements the proposed opportunities.

Challenges: The fundamental challenge identified in this research is poor water governance in Mongolia. Water-related institutional structure is immense, and it frequently changes due to events following each election. This causes lack of coordination, unclear responsibilities and inconsistent policies and their weak enforcement. There is a lack of reliable data and no proper database on the water in Mongolia is maintained despite the fact of its importance in policy development and financial planning. The data scarcity and lack of reliable data may cause inaccurate estimations of Mongolia's water supply issue in the international arena. The research draws attention to the fact that a number of policy regulations, including the MSDV 2030, were adopted without any clear financial mechanism and investment planning to implement them. The state budget allocation to the entire sector Ministry of Urban Development and Construction is on average 10 percent from the total in the last four years. Accordingly, the investment in water infrastructure from this limited sectorial budget is negligible too. If the water infrastructure amount is not increased by 50 percent than the current allocated budget, it is almost impossible to achieve the goal. Moreover, water is scarce and inaccessible in major population centres and the industrial development areas of Mongolia. At the same time the intensive climate change is affecting the region negatively the water resources availability. Furthermore, water quality is a massive challenge and drawback to achieving the goal. The quality of available water does not meet the required standards, mainly due to the pollution caused by mining, and other industrial development, and water contain naturally high levels of mineralisation in rural areas. This research indicated that the capital city, Ulaanbaatar, faces inequality in water supply accessibility and affordability among households and water shortages and financial difficulties as well, and this is happening alongside the rapid population growth in the city. The study acknowledges that these challenges and barriers are not easy to fix. They require a massive effort from the Government. The research alerts the regime that slow progress will result in unsuccessful accomplishment of the MSDV 2030 drinking water goal.

Opportunities: In contrast, based on these challenges, the research found opportunities that can assist the Government of achieving access to water for 90 percent of the population. The results of the study acknowledge that cooperation and coordination of water institutions creates the key opportunity to increase accountability, and subsequently to implement the enforcement of laws and regulations and therefore the future realisation of policies in Mongolia. However, this cannot be done without the Government taking a strong leadership role to ensure collaboration and coordination of responsibilities. The research has also recognised that good governance based on cooperation at both the national and international level provides a crucial opportunity to improve quality of data information so that adequate and proper planning can be enhanced. The required investment can be increased by domestic and international partnerships and by introducing a water economy mechanism, such as encouraging water efficiency technologies, enforcing polluter’s pay charges and providing incentives for water saving. The research highlights that the investment in water infrastructure is cost-beneficial, leading to multiple socio-economic benefits which the Government of Mongolia should be aware of. The study claims all these opportunities are available to enhance the establishment and implementation of better access to water, but the government’s determination and ambition is a vital precondition to the success of the MSDV 2030 drinking water goal.

Approximately how much investment is required to achieve the goal?

The findings based on the required investment estimation indicated three major outcomes. The report by Hutton and Varughese (2016), which was supported by the World Bank, has estimated per capita cost for basic water services for many developing countries separately. The cost was US$ 35.1 per capita for rural areas in Mongolia. This amount appears to be quite low and inconsistent with Mongolia's average cost to build a borehole in rural areas. However, it is essential to conduct separate research to confirm whether the data is low or appropriate. The research estimated the required additional investment to be approximately US$ 115 million annually, which will need massive on-going commitments from the government. This additional investment is two times higher than the current state funding for the whole water infrastructure sector in Mongolia.

Over two-thirds of the total required investment will rely heavily on the Mongolian Government's international project agreements and ongoing negotiations. The Ministry of Finance of Mongolia plan to make an agreement with the Chinese Government to support the construction of the Central Wastewater Treatment Plant in Ulaanbaatar. The Government of Mongolia also plans to develop an agreement with the Asian Development Bank and the Korean Government to support these projects and further to establish Wastewater Treatment Plants in 21 provinces in Mongolia. The wastewater infrastructure is a primary focus of the country because the existing drinking water resources are very vulnerable to pollution. Thus, the country does not have the sufficient domestic capacity unless it relies on international cooperation.

What are the impacts of increasing water infrastructure investment and related policy scenarios on the country's sustainable development?

The research analysed two primary investment policy scenarios; one is an increase in domestic funding; and the other is an increase in international investment in the sector.

The first policy scenario assumes an increase in the water infrastructure investment by 50 percent from the total state budget of the Ministry of Urban Development and Construction which means half of the sector's funding goes to the drinking water supply improvement. This budget increase to water infrastructure is possibly the highest domestic funding allocation compared to the current distribution in order to ensure the sustainability of the sector's development. However, the results show that there was not much change in the country's social, environmental and economic sectors. And at the same time, the investment remains still insufficient to achieve the goal. Hence, achieving the goal through the national budget as described in policy scenario one is quite unrealistic. The required additional investment to reach the drinking water goal is estimated two times larger than the current budget of the entire sector. This large amount of investment requires cutting down the other sectors' funding allocation such as education, health, and agriculture, etc. These budget reductions in other economic sectors may cause adverse impacts on those sectors' development as well as the economic structure of the country. With policy scenario two, the half of the required investment comes from the international support for the water infrastructure field in Mongolia. The policy scenario two is based on the foreign investment support which is not harmful to other sectors' budget allocation of the country. The main findings of scenario two show that adequate foreign investment in the sector can make the remarkable contribution not only to the water infrastructure development but also to the country's sustainable development. The result of this scenario shows it has the opportunity to improve the social and environmental sector development by at least 30 percent and consequently the country's economic sector will grow steadily over the years. The economic growth with poverty reduction, improved life expectancy and other environmental indicators can be considered as sustainable growth. At the same time, the Government of Mongolia should be cautious with partnership on privatisation of water sources and international agreements, especially if considering foreign support in the form of loans and soft loans. The Government needs to focus on ensuring sustainable development and its intergenerational equity issues when expanding overseas support and partnership. The international agreements should not be at a cost to the next generation's burden to repay heavy debt. The international collaboration and partnership should also address to strengthen the domestic financial capacity and improve water quality in mining, and industrial development is valuable in the country. Therefore, long term and adequately guaranteed international support of water infrastructure is essential in Mongolia to achieve the MSDV 2030 drinking water goal. This assistance will also contribute enormously to the country's sustainable development and human well-being. The Government of Mongolia must act quickly and effectively to expand international cooperation to progress the investment in the water infrastructure of the country, otherwise challenges will remain and halt the attainment of the goal and threaten sustainability of the country. Furthermore, the research urges raising the investment and advancing the cooperation and partnerships on water to ensure global sustainable development.

6.2 Significance and limitations of the research

There have been some areas of significance and limitation identified throughout the research. The study has offered an evaluative perspective on an important national development policy, and it investigated the analysis by using the biggest macroeconomic database of the country, the T21 Mongolia model. The research supports the global SDGs and its successful implementation. The research also focused on the foundation of sustainability issues and basic human demands for a safe and equitable drinking water supply. It is not only for Mongolia but the findings of this research can be utilised to identify the main challenges and opportunities in other developing countries' water supply problems and their sustainability concerns. The simulation result of the T21 Mongolia model shows that adequate investment, especially international financial support, plays a vital role in achieving the MSDV 2030 drinking water goal in Mongolia.

However, the study defined some limitations, which need to be considered. The research does not represent the roadmap for the entire SDGs planning of the country which includes 17 different goals. Moreover, due to limitations of time and size the research could not include the sanitation issues of the country although sanitation issues are very closely linked to adequate drinking water availability. Furthermore, this research had to use the 2014 data as the baseline data for T21 Mongolia model as the model has not yet been updated as per the MSDV 2030 policy document.

6.3 Recommendation for future research

To develop attainable policy and strategies and development goals with regards to a drinking water supply, there is a demand for more case studies at the national level to allow an improvement of any further assessment. Exploring the following as future research aspects can assist the attainment of this goal:

- Current data information and provision for coverage of the drinking water supply ought to be evaluated and updated urgently under the country's real situation and international requirements to improve the policy planning in the sector;
- Domestic opportunities, particularly water economy instruments, should be researched in depth and precisely identified to advance the national capacity and capability to increase the funding in water infrastructure development;
- Cost-benefit analysis of the investment planning of the sector should be conducted in the Mongolian case, to attract not only international funding and partnerships, but also to

facilitate Public Private Partnerships (PPPs) within the country. Such analysis can also demonstrate to the government why investment in water is beneficial, sustainable and vital. This research can reduce the Government's hesitation regarding investment in water infrastructure and provide them with the confidence to implement plans;

- Mining sector development and its policy regulation that can improve water quality should be analysed further;
- Research on gender issues and women's role of access to water in Mongolian drinking water context is vital to define challenges and opportunities to achieve drinking water goals;
- Comprehensive research that will include the sanitation issues of the country, should be conducted urgently;
- Projection of the required investment, its financial planning and funding mechanisms to implement the whole MSDV 2030's socio-economic and environmental goals should be studied to enable successful completion of the policy;
- Research and regular evaluations to improve the international guidance on assessing drinking water affordability is found to be a critical aspect of providing a comprehensive assessment of the subject;
- Indicators to assess water scarcity with relation to climate change should be developed and expanded in the T21 model to the extensive analysis of drinking water supply.

6.4 Conclusion

The renewed Mongolian Law on Water in 2012 declared water as the most important strategic resource of the country. The Government of Mongolia has recognised the importance of water resources. However, little attention is being given to management and planning levels, especially in the population drinking water supply issue of the country.

The advancement and improvement of the governance constitutes the subsequent opportunities such as data improvement and progressing the financial planning of the country. It was apparent that without adequate funding mechanisms the policy documents cannot be implemented, enforced and achieved. Developing countries like Mongolia require international financial support to achieve the goal. The research has shown that for many reasons the domestic capacity is limited and insufficient even if plans to significantly increase finance from the current budget distribution are implemented. Foreign investment to Mongolia's water infrastructure sector is vital and it can support massive contributions, not only in drinking water supply provision but also escalating the achievement of the country’s long-term sustainable development goals which are included in the MSDV 2030 policy document. Otherwise, huge challenges will remain which will halt the attainment of the MSDV 2030 drinking water goal and are also likely to cause failure for the long-term sustainable development policy and human prosperity of the country. Hence this research urgently calls for meaningful partnerships and investment so that adequate access to drinking water, which is a basic human right, can be achieved for each and every citizen of the country. The Government of Mongolia must act quickly to access international support and advance infrastructure, as otherwise development will be compromised and the population will continue to struggle and be left far behind and unable to achieve their well-being in the 21st Century.

Appendix 1. Drinking water supply and demand relationship by 29 River Basins.

No	River Basins	2010	2015	2021	Water use sources	Water quality condition	Comments on supple and demand gap	Required actions related to drinking water supply by the National Water Program by 2021
		Water consumption and demand for drinking water, million m3/ year						
1	Selenge RB	0.11	0.15	0.24	75% groundwater 25% surface	Adequate	Vater resources availability is enough to supply overall demand	Protect drinking water sources; Research possibility of building water pond and reserviours in 24 places; Build 103 borehole for drinking and pastureland.
2	Khuvsgul lake- Eg RB	0.07	0.1	0.13	63% groundwater 37% surface	Adequate	Vater resources availability is enough to supply even for further	Research possibility of building water pond and reserviours in 23 places; Build 106 borehole for drinking and pastureland.
3	Shishhed RB	0.03	0.03	0.05	52% groundwater 48% surface	Adequate, small lakes dring up	Vater resources availability is enough to supply overall demand	Research possibility of building water pond and reserviours in 9 places; Build 48 borehole for drinking and
4	Delgermoron RB	0.52	0.8	0.98	92% groundwater 8% surface	Adequate	Vater resources availability is enough to supply even for further	Renovate water supply and sewage system; Establish new WWTP in Murun city; Research possibility to build water pond and reservior in 10 places; Build 52 borehole for drinking and pastureland.
5	Ider RB	0.09	0.12	0.17	61% groundwater 39% surface	Adequate	Vater resources availability is enough to supply even for further	Research exploration for new drinking water sources; Research possibility of building water pont and reserviours in 15 places; Build 63 boreholes for drinking and pasturelend
6	Chuluut RB	0.06	0.08	0.11	58% groundwater 42% surface	Adequate	Vater resources availability is enough to supply overall demand	Research possibility of building water pond and reserviours in 21 places; Build 66 borehole for drinking and pastureland.
7	Khanui RB	0.06	0.08	0.1	56% groundwater 44% surface	Adequate	Vater resources availability is enough to supply overall demand	Research possibility of building water pond and reserviours in 17 places; Build 54 borehole for drinking and pastureland.
8	Orkhon RB	5.43	7.74	8.38	97% groundwater 3% surface	Surface water- Orkhon River upper stream contaminated by heavy metals from mining and Erdenet copper industry. GW is adequate.	Vater resources availability is enough to supply overall demand	Maintenance and expansion of Kharkhorin water supply network; Research exploration for new drinking water supply source in Uvurkhangai soum; Research possibility of building water pond and reserviour in 42 places; Build 79 boreholes for drinking and pastureland.
9	Tuul RB	45.85	60.69	64.01	100% groundwater	Downstream of Ulaanbaatar city is contaminated with organic substance and heavy metals due to mining industires; It is reported some groundwater sources in Central and Industrial districts are polluted.	Water resources availability is not enough to supply demand, especially in high scenario.	Protect UB city drinking water sources; Renovate and expand water supply network in UB city, Establish new WWTP; Build reserviour for new drinking water source; Establish Hydroelectrostation in the Tuul River Basin; Rehabilitate river pollution and degraded river channels by mining.
10	Kharaa RB	4.31	5.04	5.39	95% groundwater 5% surface	SW and GW contaminated with heavy metals by mining activities	Required additional groundwater resources exploration due to increasing demand for agriculture	Protect drinking water sources; Maintain and expand drinking water supply network; Exploration for new drinking water sources; Research possibility of building water pond and reserviour for drinking water and agriculture use in 26 places; Build 110 boreholes.
11	Eroo RB	0.03	0.04	0.07	75% groundwater 25% surface	SW contaminated with heavy metals by mining activities. GW is adequate.	Vater resources availability is enough to supply overall demand	Research possibility of building water pond and reserviours in 41 places; Build 86 borehole for drinking and pastureland.
12	Onon RB	0.04	0.05	0.09	60% groundwater 40% surface	Adequate	Vater resources availability is enough to supply overall demand	Protect drinking water sources; Research possibility of building water pond and reserviours in 1 places; Build 23 borehole for drinking and pastureland.
13	Ulz RB	0.04	0.06	0.1	70% groundwater 30% surface	Adequate	Water resources availability is enough. However, it is required groundwater exploration for increasing mining water demand.	Research possibility of building water pond and reserviours in 12 places; Build 47 borehole for drinking and pastureland.
14	Kherlen RB	1.59	2.39	2.83	93% groundwater 7% surface	GW is adequate. SW is contaminated by household and livestock pollution.	Vater resources availability is enough to supply overall demand	Protect drinking water sources; maintain and expand water supply network; Build new water supply network and water kiosks in Undurkhaan and Choibalsan cities; Research possibility of building water pond and reserviours in 42 places; Build216 boreholes for drinking and pastureland.
15	Khalkh RB	0.01	0.01	0.02	86% groundwater 14% surface	Adequate	Water resources availability is not enough, very limited.	Protect drinking water sources; Research and exploration for new drinking water sources; Research possibility of building water pond and resourviours in 4 places; Build 26 boreholes.
16	Menengiin Tal Water Basin	0.02	0.03	0.04	100% groundwater	Lack of SW; GW is adequate	Additional groundwater source exploration is required to supply overall demand.	Research exploration for new drinking water sources; Research possibility of building water pont and reserviours in 41 places; Build 72 boreholes for drinking and pasturelend
17	Umard Gobi Guveet-Khalhiin Dundad Tal Water Basin	2.1	2.9	3.46	100% groundwater	Lack of runoff water. Few seasonal lakes. GW is highly mineralised.	Groundwater resources availability is just enough to supply overall demand.	Protect drinking water resources; Maintain and expand water supply network and water kiosks in province centres; Research and exploration for new drinking water sources in Mandalgobi, Choir, Bor-Ondor province centers; Research possibility of building water pond and reserviours in 89 places; Build 371 boreholes for drinking and pastureland.
18	Galba-Uush-Dolooding Gobi Water Basin	0.14	0.25	0.49	100% groundwater	Lack of runoff water. Few seasonal lakes. GW is highly mineralised. And included natural tsianit, arsenic.	Groundwater resources availability is not enough to supply overall demand. Mining water demand is increasing in the future.	Protect drinking water sources; Research and exploration of new drinking watersources; maintain and expand water supply network and water kiosks; Research possibility of building water pond and water reserviours in 29 places; Build 66 boreholes for drinking and
19	Ongi RB	0.7	1.08	1.35	95% groundwater 5% surface	SW is contaminated by mining activities so that Ongi river dries up some years. GW is highly mineralised.	Groundwater resources availability is not enough to supply overall demand. Mining water demand is increasing in the future.	Protect drinking water sources; Research and exploration of new drinking watersources; maintain and expand water supply network and water kiosks; Reseach possibility of building water pond and water reserviours in 14 places; Build 28 boreholes for drinking and
20	Altain Uvur Gobi Water basin	0.11	0.14	0.22	100% groundwater	GW is highly mineralised.	Water resources availability is enough.	Protect drinking water sources; Research and exploration of new drinking water sources; maintain and expand water supply network and water kiosks; Reseach possibility of building water pond and water reserviours in 62 places; Build 273 boreholes for drinking and
21	Taats RB	0.06	0.08	0.14	100% groundwater	SW is adequate; GW is highly mineralised. Tsaatiin White lake is dried up.	Additional groundwater source exploration is required to supply overall demand.	Protect drinking water sources; Research and exploration of new drinking water sources; maintain and expand water supply network and water kiosks; Reseach possibility of building water pond and water reserviours in 17 places; Build 74 boreholes for drinking and
22	Orog Lake-Tuin River Basin	0.47	0.72	0.9	93% groundwater 7% surface	GW is highly mineralised.	Water resources availability is not enough. Required to explore water sources to supply increasing agriculture water demand.	Protect drinking water sources; Maintain water supply network; Research possibility of building water pond and water reservoirs in 6 places; Build 27 boreholes for drinking and pastureland.
23	Boontsagaan Lake-Baidrag River Basin	0.07	0.09	0.16	58% groundwater 42% surface	SW is contaminated by mining activities. GW is highly minealised.	Water resources availability is not enough during dry years.	Protect drinking water sources; Maintain and water supply network ; Reseach possibility of building water pond and water reserviours in 13 places; Build 25 boreholes for drinking and pastureland.
24	Khyargas Lake- Zavkhan River Basin	0.72	1.05	1.35	65% groundwater 35% surface	Lakes and GW are highly mineralised.	Required to explore additional water sources due to increasing agriculture demand.	Protect drinking water sources; Maintain and water supply network ; Research possibility of building water pond and water reservoirs in 72 places; Build 288 boreholes for drinking and pastureland.
25	Khuisiin Gobi-Tsetseg Lake Water basin	0.06	0.08	0.14	67% groundwater 33% surface	GW is highly mineralised.	Required to explore additional water sources due to increasing agriculture demand.	Protect drinking water sources; Maintain and water supply network ; Research possibility of building water pond and water reservoirs in 2 places; Build 62 boreholes for drinking and pastureland.
26	Uench-Bodonch River Basin	0.04	0.05	0.09	65% groundwater 35% surface	GW is highly mineralised.	Surface water utilisation is increasing so required to explore additional water sources.	Protect drinking water sources; Research possibility of building water pond and water reservoirs in 20 places; Build 66 boreholes for drinking and pastureland.
27	Bulgan River Basin	0.04	0.05	0.09	50% groundwater 50% surface	Adequate	Required to explore additional grounwater water sources to future demand.	Protect drinking water sources; Research possibility of building water pond and water reservoirs in 8 places; Build 25 boreholes for drinking and pastureland.
28	Khar Lake-Khovd River Basin	1.19	1.77	2.35	87% groundwater 13% surface	SW and GW are contaminated due to industrial water pollution.	Vater resources availability is enough to supply overall demand	Protect drinking water sources; Research possibility of building water pond and water reservoirs in 54 places; Build 89 boreholes for drinking and pastureland.
29	Uvs Lake-Tes River Basin	0.53	0.81	1.06	50% groundwater 50% surface		Required to explore additional water sources research to supply increasing agriculture demand.	Protect drinking water sources; Maintain and expand water supply network; Research possibility of building water pond and water reservoirs in 38 places; Build 145 boreholes for drinking and pastureland.

Source: Derived from the Mongolian National Integrated Water Resources Management Plan 2013 and National Water Program 2010.

Appendix 2. The State budget allocation in major sectors in Mongolia from 2015 to 2018.

Major Sectors	2015		2016		2017		2018	
	billion MN$	million US$	billion MN$	million US$	billion MN$	million US$	billion MN$	million US$
MCUD	22	11	51	24	74	30	80	32
MET	7	4	4	2	10	4	21	8
MH	55	28	64	30	62	25	61	24
MA	17	9	17	8	49	20	50	20
MRT	54	27	502	234	144	59	81	32
MEd	126	64	170	79	76	31	263	105
MM	11	6	9	4	16	7	17	7
ME	5	3	22	10	113	46	38	15
Total in major sectors	297	151	839	391	545	223	611	244
Total approved state budget including other sectors	358	182	304	142	602	247	683	273
Annual average US$ exchange rate, MN$	1,970		2,145		2,440		2,500	

Source: www.legalinfo.mn and www.mongolbank.mn

Reference lists

Abera, B, Bezabih, B & Hailu, D 2017, 'Microbial quality of community drinking water supplies: A ten year (2004–2014) analyses in west Amhara, Ethiopia', *Sustainability of Water Quality and Ecology*, vol. 9, pp. 22-6.

Adank, M, Butterworth, J, Godfrey, S & Abera, M 2016, 'Looking beyond headline indicators: water and sanitation services in small towns in Ethiopia', *Journal of Water Sanitation and Hygiene for Development*, p. washdev2016034.

ADB 2005, *Asia Water Watch 2015, Are Countries in Asia on Track to Meet Target 10 of the Millennium Development Goals?* Asian Development Bank, Manila, Philippines.

— 2013, *Asian Water Development Outlook 2013*, Asian Development Bank, Metro Manila, Philippines.

— 2014, *Demand in the Dessert: Mongolia's water, energy and mining nexus*, Asian Development Bank, Manila, Philippines.

Anwar, KM & Aggarwal, V 2014, 'Analysis of groundwater quality of Aligarh City, (India): Using water quality index', *Current World Environment*, vol. 9, no. 3, p. 851.

Araral, E 2010, 'Improving effectiveness and efficiency in the water sector: institutions, infrastructure and indicators', *Water Policy*, vol. 12, no. S1, pp. 1-7.

Araral, E & Wang, Y 2015, 'Does water governance matter to water sector performance? Evidence from ten provinces in China', *Water Policy*, vol. 17, no. 2, pp. 268-82.

Araral, E & Wu, X 2016, 'Comparing water resources management in China and India: policy design, institutional structure and governance', *Water Policy*, vol. 18, no. S1, pp. 1-13.

Araral, E & Yu, DJ 2013, 'Comparative water law, policies, and administration in Asia: Evidence from 17 countries', *Water Resources Research*, vol. 49, no. 9, pp. 5307-16.

Baer, M 2014, 'Private water, public good: water privatization and state capacity in Chile', *Studies in Comparative International Development*, vol. 49, no. 2, pp. 141-67.

Bahram, A, Hamid, B & Akram, N 2012, 'Estimation of coliform contamination rate and impact of environmental factors on bacterial quality of tube well water supplies in Khorramdarreh County, Iran', *African Journal of Biotechnology*, vol. 11, no. 31, pp. 7912-5.

Bain, R, Cronk, R, Hossain, R, Bonjour, S, Onda, K, Wright, J, Yang, H, Slaymaker, T, Hunter, P & Prüss-Ustün, A 2014, 'Global assessment of exposure to faecal contamination through drinking water based on a systematic review', *Tropical Medicine & international Health*, vol. 19, no. 8, pp. 917-27.

Bakker, K, 2008, 'The Ambiguity of Community: Debating Alternatives to Private- Sector Provision of Urban Water Supply', *Water Alternatives,* vol. 1, no. 2, pp. 236-252.

Barney, GO, Eberlein, R, Qu, W & Sharma, P 1995, 'The threshold 21 sustainable development model', *System Dynamics*, vol. 1, pp. 21-9.

Bartram, J 2007, 'Improving on haves and have-nots', *Nature*, vol. 452, no. 7185, p. 283.

Batbayar, G, Pfeiffer, M, von Tümpling, W, Kappas, M & Karthe, D 2017, 'Chemical water quality gradients in the Mongolian sub-catchments of the Selenga River basin', *Environmental Monitoring and Assessment*, vol. 189, no. 8, p. 420.

Batnasan 2003, *Freshwater issues in Mongolia*, World Wildlife Fund Mongolia Programme Office, Ulaanbaatar, Mongolia.

Batsuuri, T & Wang, J 2017, 'The impacts of climate change on Nomadic livestock husbandry in Mongolia', *Climate Change Economics*, vol. 8, no. 03, p. 1740003.

Berkes, F 2009, 'Evolution of co-management: role of knowledge generation, bridging organizations and social learning', *Journal of Environmental Management*, vol. 90, no. 5, pp. 1692-702.

Bulag, UE 2010, 'Mongolia in 2009: from landlocked to land-linked cosmopolitan', *Asian Survey*, vol. 50, no. 1, pp. 97-103.

Carter, N 2018, *The politics of the environment: Ideas, activism, policy*, Cambridge University Press, Cambridge, UK.

Chakraborti, D, Rahman, MM, Mukherjee, A, Alauddin, M, Hassan, M, Dutta, RN, Pati, S, Mukherjee, SC, Roy, S & Quamruzzman, Q 2015, 'Groundwater arsenic contamination in Bangladesh—21 Years of research', *Journal of Trace Elements in Medicine and Biology*, vol. 31, pp. 237-48.

Chen, DC, Maksimovic, C & Voulvoulis, N 2011, 'Institutional capacity and policy options for integrated urban water management: a Singapore case study', *Water Policy*, vol. 13, no. 1, pp. 53-68.

Chen, Z & Wei, S 2014, 'Application of system dynamics to water security research', *Water Resources Management*, vol. 28, no. 2, pp. 287-300.

Chung, P-L, Chung, C-Y, Liao, S-W & Miaw, C-L 2009, 'Assessment of the school drinking water supply and the water quality in Pingtung County, Taiwan', *Environmental Monitoring and Assessment*, vol. 159, no. 1-4, p. 207.

City Mayor's Office (CMO) 2013, *Survey on groundwater wells in 2013*, Ulaanbaatar City Mayor's Office, Adelaide, viewed 30 August 2018, <http://baigal.ub.gov.mn/wpcontent/uploads/gunii_khudgiin_2013_onii_toollogo_ ulaanbaatar_2013-11.pdf>.

Coggan, A & Whitten, SM 2005, 'Market Based Instruments (MBIs) in Australia: What are they, important issues to consider and some applications to date', in *Background paper presented at the Desert Knowledge CRC Workshop Alice Springs*, pp. 8-10.

Dar, OA & Khan, MS 2011, 'Millennium development goals and the water target: details, definitions and debate', *Tropical Medicine & International Health*, vol. 16, no. 5, pp. 540-4.

Davaasuren, J & Basandorj, D 2017, 'Status and challenges of water infrastructure development in Mongolia', *Proceedings of the Water Authority of Mongolia and Mongolian University of Science and Technology*, Ulaanbaatar, Mongolia, pp. 1-18.

de Andrade, JGP, Barbosa, PSF, Souza, LCA & Makino, DL 2011, 'Inter-basin water transfers: the Brazilian experience and international case comparisons', *Water Resources Management*, vol. 25, no. 8, pp. 1915-34.

Debaere, P 2014, 'The global economics of water: is water a source of comparative advantage?', *American Economic Journal: Applied Economics*, vol. 6, no. 2, pp. 32-48.

Dore, G & Nagpal, T 2006, 'Urban transition in Mongolia: pursuing sustainability in a unique environment', *Environment: Science and Policy for Sustainable Development*, vol. 48, no. 6, pp. 10-24.

Easterly, W 2009, 'How the millennium development goals are unfair to Africa', *World Development*, vol. 37, no. 1, pp. 26-35.

Falkenmark, M 1989, 'The massive water scarcity now threatening Africa: why isn't it being addressed?', *Ambio*, vol. 18, no. 2, pp. 112-8.

Fisher, J, 2008, 'Women in water supply, sanitation and hygiene programmes', *Proceedings of the Institution of Civil Engineers: Municipal Engineer,* UK, pp. 223-229.

Ford, DN & Andersen, JM 2008, 'Risk-aversion in water allocation policies in semi-arid regions', *Systems Research and Behavioral Science: The Official Journal of the International Federation for Systems Research*, vol. 25, no. 6, pp. 769-82.

Fragkou, MC & McEvoy, J 2016, 'Trust matters: Why augmenting water supplies via desalination may not overcome perceptual water scarcity', *Desalination*, vol. 397, pp. 1-8.

Free, CM 2015, *Mongolian Watershed*, Department of Marine & Coastal Sciences, Rutgers University Press, New Jersey, USA.

Fuller, JA, Goldstick, J, Bartram, J & Eisenberg, JN 2016, 'Tracking progress towards global drinking water and sanitation targets: a within and among country analysis', *Science of the Total Environment*, vol. 541, pp. 857-64.

Furlong, K 2012, 'Good water governance without good urban governance? Regulation, service delivery models, and local government', *Environment and Planning A*, vol. 44, no. 11, pp. 2721-41.

Ganbold, M & Ali, SH 2017, 'The peril and promise of resource nationalism: A case analysis of Mongolia's mining development', *Resources Policy*, vol. 53, pp. 1-11.

Garrick, D, Whitten, SM & Coggan, A 2013, 'Understanding the evolution and performance of water markets and allocation policy: A transaction costs analysis framework', *Ecological Economics*, vol. 88, pp. 195-205.

Gawel, E & Bernsen, K 2011, 'Globalization of water: the case for global water governance?', *Nature and Culture*, vol. 6, no. 3, pp. 205-17.

Gawel, E, Sigel, K & Bretschneider, W 2013, 'Affordability of water supply in Mongolia: empirical lessons for measuring affordability', *Water Policy*, vol. 15, no. 1, pp. 19-42.

Gleeson, T, Wada, Y, Bierkens, MF & van Beek, LP 2012, 'Water balance of global aquifers revealed by groundwater footprint', *Nature*, vol. 488, no. 7410, p. 197.

Gleick, PH 2009, 'Facing down the hydro-crisis', *World Policy Journal*, vol. 26, no. 4, pp. 17-23.

Government of Mongolia (GM) 2012, *National action program on climate change*, BCI Printing, Ulaanbaatar, Mongolia.

— 2014, *Green Development Policy*, Ministry of Environment and Green Development, Admon Printing, Ulaanbaatar, Mongolia.

— 2016, *Mongolia Sustainable Development Vision 2030*, Ministry of Finance, Ulaanbaatar, Mongolia.

— 2018, *State Budget Law in 2018*, Ministry of Finance of Mongolia, Ulaanbaatar, viewed 30 August 2018, <http://www.legalinfo.mn/law/details/12964>.

Grey, D & Sadoff, CW 2007, 'Sink or swim? Water security for growth and development', *Water Policy*, vol. 9, no. 6, pp. 545-71.

Grit, R, Jörg, L, Steffen, D & Gerel, O 2015, 'Integrated urban water management: development of an adapted management approach', *Environmental Earth Sciences*, vol. 73, no. 2, pp. 709-18.

Gu, A, Zhang, Y & Pan, B 2017, 'Relationship between Industrial Water Use and Economic Growth in China: Insights from an Environmental Kuznets Curve', *Water*, vol. 9, no. 8, p. 556.

Gundry, S, Wright, J & Conroy, R 2004, 'A systematic review of the health outcomes related to household water quality in developing countries', *Journal of Water and Health*, vol. 2, no. 1, pp. 1-13.

Haller, L, Hutton, G & Bartram, J 2007, 'Estimating the costs and health benefits of water and sanitation improvements at global level', *Journal of Water and Health*, vol. 5, no. 4, pp. 467-80.

Harmancioglu, NB 2017, 'Overview of water policy developments: pre-and post-2015 development agenda', *Water Resources Management*, vol. 31, no. 10, pp. 3001-21.

Heitzinger, K, Rocha, CA, Quick, RE, Montano, SM, Tilley Jr, DH, Mock, CN, Carrasco, AJ, Cabrera, RM & Hawes, SE 2015, '"Improved" but not necessarily safe: An assessment of fecal contamination of household drinking water in rural Peru', *The American Journal of Tropical Medicine and Hygiene*, vol. 93, no. 3, pp. 501-8.

Hepburn, C 2010, 'Environmental policy, government, and the market', *Oxford Review of Economic Policy*, vol. 26, no. 2, pp. 117-36.

Hofmann, J, Venohr, M, Behrendt, H & Opitz, D 2010, 'Integrated water resources management in central Asia: nutrient and heavy metal emissions and their relevance for the Kharaa River Basin, Mongolia', *Water Science and Technology*, vol. 62, no. 2, pp. 353-63.

Hofmann, J, Watson, V & Scharaw, B 2015, 'Groundwater quality under stress: contaminants in the Kharaa River basin (Mongolia)', *Environmental Earth Sciences*, vol. 73, no. 2, pp. 629-48.

Horlemann, L & Dombrowsky, I 2012, 'Institutionalising IWRM in developing and transition countries: the case of Mongolia', *Environmental Earth Sciences*, vol. 65, no. 5, pp. 1547-59.

Houdret, A, Dombrowsky, I & Horlemann, L 2014, 'The institutionalization of River Basin Management as politics of scale–Insights from Mongolia', *Journal of Hydrology*, vol. 519, pp. 2392-404.

Hutton, G 2012, 'Monitoring "Affordability" of water and sanitation services after 2015: Review of global indicator options', *A paper submitted to the UN Office of the High Commissioner for Human Rights,* 20 March.

Hutton, G, Haller, L, Water, S & WHO, 2004, *Evaluation of the costs and benefits of water and sanitation improvements at the global level*, World Health Organization, Geneva.

Hutton, G & Varughese, M 2016, *The costs of meeting the 2030 sustainable development goal targets on drinking water, sanitation, and hygiene*, The World Bank.

Institute of Geoecology, 2018, *Tuul River Basin in Mongolia,* Institute of Geoecology, Ulaanbaatar, Mongolia.

Jaeger, WK, Plantinga, AJ, Chang, H, Dello, K, Grant, G, Hulse, D, McDonnell, JJ, Lancaster, S, Moradkhani, H, Morzillo, AT, Mote, P, Nolin, A, Santelmann, M, and Wu, J, 2013, 'Towards a formal definition of water scarcity in natural-human systems', *Water Resources Research,* vol. 49, pp. 4506-17.

Janchivdorj, L 2012, 'Groundwater Governance in Mongolia', *Proceeding of the International Regional Consultation on Groundwater Governance in Asia and the Pacific region*, Shijiazhuang, China.

Jemmali, H 2017, 'Mapping water poverty in Africa using the improved Multidimensional Index of Water Poverty', *International Journal of Water Resources Development*, vol. 33, no. 4, pp. 649-66.

Joshi, N, Bolorhon, B, Narula, I, Zhu, S & Manaseki-Hollan, S 2017, 'Social and environmental determinants of child health in Mongolia across years of rapid economic growth: 2000-2010', *International Journal for Equity in Health*, vol. 16, no. 1, p. 189.

Kahil, MT, Albiac, J, Dinar, A, Calvo, E, Esteban, E, Avella, L & Garcia-Molla, M 2016, 'Improving the performance of water policies: Evidence from drought in Spain', *Water*, vol. 8, no. 2, p. 34.

Karn, S.K & Harada, H, 2002, 'Field survey on water supply, sanitation and associated health impacts in urban poor communities- a case from Mumbai City, India', *Water Science and Technology,* vol. 46, pp. 269-275.

Karthe, D, Chalov, S, Moreido, V, Pashkina, M, Romanchenko, A, Batbayar, G, Kalugin, A, Westphal, K, Malsy, M & Flörke, M 2017, 'Assessment of runoff, water and sediment quality in the Selenga River basin aided by a web-based geoservice', *Water Resources*, vol. 44, no. 3, pp. 399-416.

Karthe, D, Hofmann, J, Ibisch, R, Heldt, S, Westphal, K, Menzel, L, Avlyush, S & Malsy, M 2015, 'Science-based IWRM implementation in a data-scarce central Asian region: experiences from a research and development project in the Kharaa River Basin, Mongolia', *Water*, vol. 7, no. 7, pp. 3486-514.

Kates, RW, Parris, TM & Leiserowitz, AA 2005, 'What is sustainable development? Goals, indicators, values, and practice', *Environment: Science and Policy for Sustainable Development*, vol. 47, no. 3, pp. 8-21.

Khan, S, Shahnaz, M, Jehan, N, Rehman, S, Shah, MT & Din, I 2013, 'Drinking water quality and human health risk in Charsadda district, Pakistan', *Journal of Cleaner Production*, vol. 60, pp. 93-101.

Kida, M, Myangan, O, Oyuntsetseg, B, Khakhinov, V, Kawahigashi, M & Fujitake, N 2018, 'Dissolved organic matter distribution and its association with colloidal aluminum and iron in the Selenga River Basin from Ulaanbaatar to Lake Baikal', *Environmental Science and Pollution Research*, vol. 25, no. 12, pp. 11948-57.

Kirby, MA, Nagel, CL, Rosa, G, Lyakaremye, L, Zambrano, LD & Clasen, TF 2016, 'Faecal contamination of household drinking water in Rwanda: A national cross-sectional study', *Science of the Total Environment*, vol. 571, pp. 426-34.

Kremen, C 2005, 'Managing ecosystem services: what do we need to know about their ecology?', *Ecology Letters*, vol. 8, no. 5, pp. 468-79.

Lautze, J, Cai, X & Matchaya, G 2014, 'Water productivity', in Lautze, J (ed.), *Key concepts in water resource management: A review and critical evaluation*, Earthscan/Routledge Taylor 7 Francis Group, London and New York, pp. 57-73.

Li, Y, Cao, J, Shen, F & Xia, J 2014, 'The changes of renewable water resources in China during 1956–2010', *Science China Earth Sciences*, vol. 57, no. 8, pp. 1825-33.

Loucks, DP 2000, 'Sustainable water resources management', *Water International*, vol. 25, no. 1, pp. 3-10.

Lu, W-C 2018, 'Industrial water use, income, trade, and employment: environmental Kuznets curve evidence from 17 Taiwanese manufacturing industries', *Environmental Science and Pollution Research*, pp. 1-13.

Malagnoux, M 2007, 'Arid land forests of the world: global environmental perspectives', in *International Conference on Afforestation and Sustainable Forests as a Means to Combat Desertification, Jerusalem, Israel*, pp. 16-9.

Malsy, M, Flörke, M & Borchardt, D 2017, 'What drives the water quality changes in the Selenga Basin: climate change or socio-economic development?', *Regional Environmental Change*, vol. 17, no. 7, pp. 1977-89.

Martínez-Santos, P 2017, 'Does 91% of the world’s population really have “sustainable access to safe drinking water”?', *International Journal of Water Resources Development*, vol. 33, no. 4, pp. 514-33.

Massoud, M, Al-Abady, A, Jurdi, M & Nuwayhid, I 2010, ‘International perspectives: The challenges of sustainable access to safe drinking water in rural areas of developing countries: case of Zawtar El-Charkieh, Southern Lebanon’, *Journal of Environmental Health,* vol. 72, no. 10, pp. 24-31.

McIntyre, N, Bulovic, N, Cane, I & McKenna, P 2016, 'A multi-disciplinary approach to understanding the impacts of mines on traditional uses of water in Northern Mongolia', *Science of the Total Environment*, vol. 557, pp. 404-14.

Ministry of Construction and Urban Development (MCUD) 2014, *Mongolian Water Supply and Sanitation Coverage*, report prepared by Mongolian Water Forum, Ulaanbaatar, Mongolia.

— 2016, *Mongolia HABITAT-III National Report*, report prepared by the United Nations HABITAT, Ulaanbaatar, Mongolia.

— 2018, *Mongolia SDG Country Costing Summary Report*, report prepared by the Strategic Planning Department, of the MCUD, Ulaanbaatar, Mongolia.

Ministry of Economic Development (MED) 2013, *Achieving the Millennium Development Goal: Fifth national progress Report*, United Nations Development Program, viewed 06 June 2018, <http://www.undp.org/content/dam/mongolia/Publications/MDGreports/MDG%20National%20Report%205%20full_ENG.pdf >.

Ministry of Environment and Tourism (MET) 2010, *National Water Program*, Mongol Us Authority, viewed 20 July, < http://mglwater.com/?page_id=2956&lang=en>.

— 2013, *Integrated Water Resources Management of Mongolia*, prepared by the Dutch Government Project, DDC Printing, Ulaanbaatar, Mongolia.

— 2014, *Mongolia Second Assessment Report on Climate Change 2014*, MET, Ulaanbaatar, Mongolia.

Ministry of Finance (MF) 2018a, 'Introduction of the Central Wastewater Treatment Plant in Ulaanbaatar city', *Proceedings of the Central Wastewater Treatment Plant Project Economic Comparison*, Ulaanbaatar, Mongolia.

— 2018b, *Macroeconomic projection of Mongolia*, Ministry of Finance of Mongolia, viewed 31 August 2018, <https://mof.gov.mn/article/entry/c-BUDGET>.

Ministry of Finance & Millennium Institute (MF & MI) 2015, *T21 Mongolia Model: Technical Handbook*, Ministry of Finance of Mongolia, Ulaanbaatar, Mongolia.

Millennium Institute (MI) 2018, *Introduction and Purpose of Threshold 21*, viewed 28 August 2018, <http://ledsgp.org/wp-content/uploads/2015/10/T21Overview1.pdf.>.

Moran, TH 2013, *Avoiding the "resource curse" in Mongolia*, Peterson Institute for International Economics, Washington, DC.

Morris, JC 2017, 'Planning for water infrastructure: Challenges and opportunities', *Public Works Management & Policy*, vol. 22, no. 1, pp. 24-30.

Moss, T 2004, 'The governance of land use in river basins: prospects for overcoming problems of institutional interplay with the EU Water Framework Directive', *Land Use Policy*, vol. 21, no. 1, pp. 85-94.

Mukherjee, M, Chindarkar, N & Grönwall, J 2015, 'Non-revenue water and cost recovery in urban India: the case of Bangalore', *Water Policy*, vol. 17, no. 3, pp. 484-501.

Nagara, G, Lam, W-H, Lee, NCH, Othman, F & Shaaban, MG 2015, 'Comparative SWOT analysis for water solutions in Asia and Africa', *Water Resources Management*, vol. 29, no. 1, pp. 125-38.

Naik, PK 2017, 'Water crisis in Africa: myth or reality?', *International Journal of Water Resources Development*, vol. 33, no. 2, pp. 326-39.

Nickum, JE 2012, 'Exploring the Boundaries of Water Quality Management in Asia', *International journal of water resources development*, vol. 28, no. 2, pp. 233-45.

Noda, K 2018, 'Governance, rights, and resource development costs of water: lessons from post-war Japan', *Water Policy*, vol. 20, no. 1, pp. 189-201.

Norman, ES, Dunn, G, Bakker, K, Allen, DM & De Albuquerque, RC 2013, 'Water security assessment: integrating governance and freshwater indicators', *Water Resources Management*, vol. 27, no. 2, pp. 535-51.

Nriagu, J, Johnson, J, Samurkas, C, Erdenechimeg, E, Ochir, C & Chandaga, O 2013, 'Co-occurrence of high levels of uranium, arsenic, and molybdenum in groundwater of Dornogobi, Mongolia', *Global Health Perspectives*, vol. 1, no. 1, pp. 45-54.

National Statistics Office (NSO) 2017, *Renewed 2015-2045 Population Projection*, NSO, Ulaanbaatar, Mongolia.

— 2018, *Total Population in Mongolia*, NSO, viewed 29 August 2018, <http://www.1212.mn/stat.aspx?LIST_ID=976_L03>.

Obeed Al-Azawi, AA & Ward, FA 2017, 'Groundwater use and policy options for sustainable management in Southern Iraq', *International Journal of Water Resources Development*, vol. 33, no. 4, pp. 628-48.

Oki, T & Kanae, S 2006, 'Global hydrological cycles and world water resources', *Science*, vol. 313, no. 5790, pp. 1068-72.

Olkhanud, PB 2012, 'Survey of Arsenic in Drinking Water in the Southern Gobi region of Mongolia', Master's thesis, Johns Hopkins University, Baltimore, USA.

Osei, L, Amoyaw, J, Boateng, GO, Boamah, S & Luginaah, I 2015, 'The paradox of water accessibility: understanding the temporal and spatial dimensions of access to improved water sources in Rwanda', *Journal of Water Sanitation and Hygiene for Development*, vol. 5, no. 4, pp. 553-64.

Otaki, Y, Otaki, M & Sakura, O 2007, 'Water systems and urban sanitation: A historical comparison of Tokyo and Singapore', *Journal of Water and Health*, vol. 5, no. 2, pp. 259-65.

Oyunchimeg 2016, 'The current situation of water supply and sanitation', Proceedings of the Ministry of Construction and Urban Development, Ulaanbaatar, Mongolia.

Perveen, S & James, LA 2011, 'Scale invariance of water stress and scarcity indicators: Facilitating cross-scale comparisons of water resources vulnerability', *Applied Geography*, vol. 31, no. 1, pp. 321-8.

Pfeiffer, M, Batbayar, G, Hofmann, J, Siegfried, K, Karthe, D & Hahn-Tomer, S 2015, 'Investigating arsenic (As) occurrence and sources in ground, surface, waste and drinking water in northern Mongolia', *Environmental Earth Sciences*, vol. 73, no. 2, pp. 649-62.

Ragab, R & Prudhomme, C 2002, 'Sw—soil and Water: climate change and water resources management in arid and semi-arid regions: prospective and challenges for the 21st century', *Biosystems Engineering*, vol. 81, no. 1, pp. 3-34.

Rebecca, B, 2010, 'Unequal burden: Water privatisation and women's human rights in Tanzania', *Gender & Development,* vol. 18, no. 1, pp. 59-67.

Reeves, J 2011, 'Mongolia's environmental security: Chinese unconscious power and Ulaanbaatar's state weakness', *Asian Survey*, vol. 51, no. 3, pp. 453-71.

Rijsberman, FR 2006, 'Water scarcity: fact or fiction?', *Agricultural Water Management*, vol. 80, no. 1-3, pp. 5-22.

Rockström, J, Steffen, W, Noone, K, Persson, Å, Chapin III, FS, Lambin, EF, Lenton, TM, Scheffer, M, Folke, C & Schellnhuber, HJ 2009, 'A safe operating space for humanity', *Nature*, vol. 461, no. 7263, p. 472.

Rode, S 2014, 'Drinking water supply management through public participation in municipal councils of Pune district', *Management Research and Practice*, vol. 6, no. 1, p. 79.

Rodriguez, R, Pruski, F & Singh, V 2016, 'Estimated per capita water usage associated with different levels of water scarcity risk in arid and semiarid regions', *Water Resources Management*, vol. 30, no. 4, pp. 1311-24.

Sachs, JD 2015, *The age of sustainable development*, Columbia University Press, New York, USA.

Saint-Jacques, N, Parker, L, Brown, P & Dummer, TJ 2014, 'Arsenic in drinking water and urinary tract cancers: a systematic review of 30 years of epidemiological evidence', *Environmental Health*, vol. 13, no. 1, p. 44.

Saskia, I, 2008, 'Does increased water access empower women?', *Development,* vol. 51, no. 1, pp. 63-67.

Shaheed, A, Orgill, J, Ratana, C, Montgomery, MA, Jeuland, MA & Brown, J 2014, 'Water quality risks of 'improved' water sources: evidence from Cambodia', *Tropical Medicine & International Health*, vol. 19, no. 2, pp. 186-94.

Sivakumar, M, Das, H & Brunini, O 2005, 'Impacts of present and future climate variability and change on agriculture and forestry in the arid and semi-arid tropics', in *Increasing climate variability and change*, Springer, New York, USA, pp. 31-72.

Smets, H 2009, 'Access to drinking water at an affordable price in developing countries', *Options Méditerranéennes, A nº*, vol. 88, pp. 57-68.

Stafford-Smith, M, Griggs, D, Gaffney, O, Ullah, F, Reyers, B, Kanie, N, Stigson, B, Shrivastava, P, Leach, M & O'Connell, D 2017, 'Integration: the key to implementing the Sustainable Development Goals', *Sustainability Science*, vol. 12, no. 6, pp. 911-9.

Sterman, JD 2000, *Business dynamics: Systems thinking and modelling for complex world*, McGraw-Hill Companies, Boston, USA.

Tecco, N 2008, 'Financially sustainable investments in developing countries water sectors: what conditions could promote private sector involvement?', *International Environmental Agreements: Politics, Law and Economics*, vol. 8, no. 2, pp. 129-42.

Thomas, RL 2004, 'Management of freshwater systems: The interactive roles of science, politics and management, and the public', *Lakes & Reservoirs: Research & Management*, vol. 9, no. 1, pp. 65-73.

Thorslund, J, Jarsjö, J, Chalov, SR & Belozerova, EV 2012, 'Gold mining impact on riverine heavy metal transport in a sparsely monitored region: the upper Lake Baikal Basin case', *Journal of Environmental Monitoring*, vol. 14, no. 10, pp. 2780-92.

Tong, H 2012, *Threshold models in non-linear time series analysis*, vol. 21, Springer Science & Business Media, New York, USA.

Törnqvist, R, Jarsjö, J, Pietroń, J, Bring, A, Rogberg, P, Asokan, SM & Destouni, G 2014, 'Evolution of the hydro-climate system in the Lake Baikal basin', *Journal of Hydrology*, vol. 519, pp. 1953-62.

Tortajada, C & Joshi, YK 2014, 'Water quality management in Singapore: the role of institutions, laws and regulations', *Hydrological Sciences Journal*, vol. 59, no. 9, pp. 1763-74.

Tsutsumida, N, Saizen, I, Matsuoka, M & Ishii, R 2015, 'Addressing urban expansion using feature-oriented spatial data in a peripheral area of Ulaanbaatar, Mongolia', *Habitat International*, vol. 47, pp. 196-204.

Uddin, SMN, Li, Z, Gaillard, J, Tedoff, PF, Mang, H-P, Lapegue, J, Huba, EM, Kummel, O & Rheinstein, E 2014, 'Exposure to WASH-borne hazards: A scoping study on peri-urban Ger areas in Ulaanbaatar, Mongolia', *Habitat International*, vol. 44, pp. 403-11.

United Nation (UN) 2000, *Charting the progress of population'*, Department of Economic and Social Affairs Population Division, New York, USA.

–– 2018, *Sustainable Development Goal 6 Synthesis Report 2018 on Water and Sanitation*, United Nations, Geneva, Switzerland.

United Nation Water (UN Water) 2009, *World Water Development Report: Water in a Changing World,* UNESCO, Paris, France.

–– 2015, *World Water Development Report 2015: Water for a Sustainable World*, UNESCO, Paris, France.

–– 2016, *United Nations World Water Development Report 2016: Water and Jobs*, UNESCO, Paris, France.

–– 2017, *Water, Sanitation and Hygiene*, UN Water, Adelaide, viewed 27 August 2018, <http://www.unwater.org/water-facts/water-sanitation-and-hygeine/>

–– 2018, *World Water Development Report 2018: Nature-Based Solutions for Water*, UNESCO, Paris, France.

United Nations Department of Economic and Social Affairs (UNDESA) 2014, *World Urbanization Prospects 2014 Revision*, UN, New York, USA.

–– 2017, *The World population prospects: 2015 Revision*, UN, New York, USA.

United Nations Environmental Program (UNEP) 2010, *Clearing the Waters: A focus on water quality solutions*, UNEP, Nairobi, Kenya.

United Nations Educational, Scientific and Cultural Organization (UNESCO) 1998, *World Water Resources: A New Appraisal and Assessment for the 21st Century*, State Hydrological Institute of the St Petersburg, Russia.

—— 1999, *Sustainability Criteria for Water Resource Systems*, Cambridge University Press, Cambridge, UK.

van der Bruggen, B, Borghgraef, K & Vinckier, C 2010, 'Causes of water supply problems in urbanised regions in developing countries', *Water Resources Management*, vol. 24, no. 9, pp. 1885-902.

Veiga, LBE & Magrini, A 2013, 'The Brazilian water resources management policy: Fifteen years of success and challenges', *Water Resources Management*, vol. 27, no. 7, pp. 2287-302.

Velis, M, Conti, KI & Biermann, F 2017, 'Groundwater and human development: synergies and trade-offs within the context of the sustainable development goals', *Sustainability Science*, vol. 12, no. 6, pp. 1007-17.

Vitousek, PM, Mooney, HA, Lubchenco, J & Melillo, JM 1997, 'Human domination of Earth's ecosystems', *Science*, vol. 277, no. 5325, pp. 494-9.

Vlugman, A 2006, 'Progress of the MDG Water Supply and Sanitation Target1', *Global Watch*, vol. 1, no. 1, p. 77.

Vojdani, F 2004, 'Efficiency in water planning and management (an implementation experience)', *Water Science and Technology: Water Supply*, vol. 4, no. 3, pp. 67-80.

Wang, JF, Cheng, GD, Gao, YG, Long, AH, Xu, ZM, Li, X, Chen, H & Barker, T 2008, 'Optimal water resource allocation in arid and semi-arid areas', *Water Resources Management*, vol. 22, no. 2, p. 239.

World Economic Forum (WEF) 2016, *The Global Risks Report 2016 11th Edition*, World Economic Forum, Geneva, Switzerland.

Whittington, D 2003, 'Municipal water pricing and tariff design: a reform agenda for South Asia', *Water Policy*, vol. 5, no. 1, pp. 61-76.

World Health Organisation (WHO) 2010, *Drinking water quality in the South-East Asia region*, WHO Regional Office for South-East Asia, New Delhi, India.

World Health Organisation and United Nations Children's Fund (WHO & UNICEF) 2015, *Progress on Sanitation and Drinking Water: Update and MDG assessment*, New York, USA.

—— 2017, *Progress on Drinking Water, Sanitation and Hygiene 2017 Update and SDG Baseline*, World Health Organization and the United Nations Children's Fund, Switzerland.

Widmer, K, Van Ha, NT, Vinitnantharat, S, Sthiannopkao, S, Wangsaatmaja, S, Prasetiati, MAN, Thanh, NC, Thepnoo, K, Sutadian, AD & Thao, HTT 2013, 'Prevalence of Escherichia coli in surface waters of Southeast Asian cities', *World Journal of Microbiology and Biotechnology*, vol. 29, no. 11, pp. 2115-24.

Wiek, A & Larson, KL 2012, 'Water, people, and sustainability—a systems framework for analyzing and assessing water governance regimes', *Water Resources Management*, vol. 26, no. 11, pp. 3153-71.

Winkler, IT 2018, 'Glass half-full or glass half-empty? A human rights assessment of the WASH targets in the SDGs', *Social Alternatives*, vol. 37, no. 1, p. 25.

World Bank 2004, *The Human Right to Water: Legal and Policy Dimensions*, Washington, USA.

Water Resources Group (WRG) 2014, *Mongolia: targeted analysis on water resources management issues*, Water Resources Group 2030, Ulaanbaatar, Mongolia.

Wu, X, House, RS & Peri, R 2016, 'Public-private partnerships (PPPs) in water and sanitation in India: lessons from China', *Water Policy*, vol. 18, pp. 153-76.

Young, RA & Haveman, RH 1985, 'Economics of water resources: a survey', in *Handbook of natural resource and energy economics*, Elsevier, USA, vol. 2, pp. 465-529.

Yunus, FM, Khan, S, Chowdhury, P, Milton, AH, Hussain, S & Rahman, M 2016, 'A review of groundwater arsenic contamination in Bangladesh: the millennium development goal era and beyond', *International Journal of Environmental Research and Public Health*, vol. 13, no. 2, p. 215.

Zeneli, F 2016, 'Analysis of risks and investments' opportunities in water sector', *Academicus-International Scientific Journal,* vol. 130, pp. 128-137.