Protecting Groundwater Resource
Learning from Bandung, Bangkok and Tianjin
(The Case of Groundwater in Karo Regency, Indonesia)

THESIS

A thesis submitted in partial fulfilment of the requirements for
the Master Degree from University of Groningen and
the Master Degree from Institut Teknologi Bandung

By
EVANLIT SEMBIRING
RUG: S2706725
ITB: 25413034

DOUBLE MASTER DEGREE PROGRAMME

ENVIRONMENTAL AND INFRASTRUCTURE PLANNING
FACULTY OF SPATIAL SCIENCES
UNIVERSITY OF GRONINGEN

AND

DEVELOPMENT PLANNING AND
INFRASTRUCTURE MANAGEMENT
SCHOOL OF ARCHITECTURE, PLANNING AND
POLICY DEVELOPMENT
INSTITUT TEKNOLOGI BANDUNG

2015

Protecting Groundwater Resource
Learning from Bandung, Bangkok and Tianjin
(The Case of Groundwater in Karo Regency, Indonesia)

THESIS

A thesis submitted in partial fulfilment of the requirements for
the Master Degree from University of Groningen and
the Master Degree from Institut Teknologi Bandung

By
EVANLIT SEMBIRING
RUG: S2706725
ITB: 25413034

Supervisors:

Dr. Ferry Van Kann (RUG)
Ir. Djoko Santoso Abi Suroso, Ph.D (ITB)

DOUBLE MASTER DEGREE PROGRAMME

ENVIRONMENTAL AND INFRASTRUCTURE PLANNING
FACULTY OF SPATIAL SCIENCES
UNIVERSITY OF GRONINGEN

AND

DEVELOPMENT PLANNING AND
INFRASTRUCTURE MANAGEMENT
SCHOOL OF ARCHITECTURE, PLANNING AND
POLICY DEVELOPMENT
INSTITUT TEKNOLOGI BANDUNG

2015

Abstract

This master thesis explores the common groundwater issues namely groundwater table depletion and groundwater quality degradation. Although groundwater issues are also influenced by hydrogeological condition, other factors which contribute in causing groundwater issues are human interventions such as extraction and contamination. Moreover, due to population growth and economic development, pressure on groundwater resources will increase significantly. In response to these issues and to gain sustainability development, therefore, groundwater protection is a necessity. In this research, the groundwater issues and groundwater protection is explored by taking Karo regency as a case study.

This research reveals that groundwater issues have been recognised in this region since a past decade and have emerged several negative impacts. Water table has declined and in some areas groundwater has polluted in this region. Consequently, impacts caused by groundwater table decline and groundwater quality degradation are inevitable. Land subsidence, infrastructure damages and health problems are some of negative impacts that have been perceived in Karo. The intensive groundwater extraction and unmanaged waste disposal from domestic, industrial and agricultural activities have contributed in causing these issues. It is true, that Karo has tried to protect its groundwater resources; however, the current efforts are still not effective and need improvement.

To improve groundwater governance in Karo, this research used comparative analysis as method. The selected donor regions are Bandung, Bangkok and Tianjin. As well as Karo regency, these regions have also experienced groundwater issues including water table depletion and contamination and associated problems such as land subsidence, construction damage and health problem. The comparison with these regions is meaningful because, these regions have much experience in groundwater governance. Karo can learn strategies that have been implemented in donor regions and could be adopted to improve the current groundwater governance.

The strategies proposed in this research are distinguished into three categories namely regulatory, economic and other or supporting instruments. For regulatory instruments, Karo should establish a comprehensive groundwater regulation including groundwater permit, zoning area, and land use. For economic instruments, the implementation of incentive and disincentive approach perhaps could control groundwater extraction in Karo. In addition, to support regulatory and economic instruments, monitoring of groundwater table, land subsidence and groundwater quality should be conducted regularly in Karo. Moreover, the most important lesson to be learned in this research is that groundwater governance cannot be carried out within the regulatory or economic approach alone, but rather requires a comprehensive systems approach

Key words: Groundwater issues, Groundwater protection, groundwater governance, comparative analysis, policy transfer, hybridisation, synthesis, inspiration

Preface

This master thesis is completed as a partial fulfilment of the requirements for Double Degree Master Programme from Institut Teknologi Bandung and University of Groningen. The topic of this research is groundwater protection by taking case study in Karo regency as my hometown. Since groundwater is very crucial in Karo, for sustainability, this resource should be protected. In fact, current governance cannot solve the groundwater issues effectively. Therefore, the research is aimed to give recommendation for developing new groundwater governance in Karo regency. The new strategy is learned from Bandung, Bangkok and Tianjin and expected could improve the current groundwater governance in Karo regency.

On this occasion, I would like to thank God for blessing me in finishing my thesis. I also give my greatest thankful for everybody giving supports to me in in this thesis process. I would like to address my special thanks to my supervisors, Dr. Ferry van Kann (RuG) and Ir. Djoko Santoso Abi Suroso, PhD (ITB) for guiding me on my thesis work. Respectively, I also would like to address my thanks to all my lecturers and faculty staff members in ITB and RuG. I also would like to express my appreciation for National Development and Planning Board (Bappenas) and the Netherland Education Support Office (NESO) through StuNed program for giving me institutional and financial support. Special gratitude I dedicated for all friends DD ITB 2013-2015 for sharing great moments in Bandung, Groningen, and anywhere. I would also like to convey thanks to my colleagues in Department of Mining and Energy of Karo regency for all support.

Finally great thanks are addressed to my lovely family in Indonesia especially for my parents, my beloved wife and my wonderful children for supporting me during my study in Bandung and Groningen. Thank you for all of enormous love, pray and spirit.

Groningen, August 2015

Evanlit Sembiring

Table of Contents

List of Tables

List of Figures

Chapter I

Introduction: Policy Transfer for Improving Groundwater Governance

1.1. Background

Groundwater is indispensable; besides it is useful for human life, the presence of groundwater is also important for ecological function. On the one hand, groundwater can be extracted to supply fresh water either to fulfil human need or to support their daily activities. It can be used for cooking, drinking, bathing, etcetera. On the other hand, ground water is a part of hydrology process which cannot be separated from surface water to keep water balance in nature (Kraemer, 2001; Llamas & Martinez-Santos, 2005; Bredehoeft and Durbin 2009; Giardano, 2009; Theesfeld 2010; Aral and Taylor, 2011).

Even though, theoretically, the availability of water on the earth, both underground and surface water, is basically constant, the groundwater availability and quality in one area will depend on the natural factor (hydrological process) and also human activities in that area (Aral and Taylor, 2011; Badan Geologi, 2013). Seasonal change, natural disaster and hydrogeological characteristics such as aquifer and lithology are some natural factors which can influence the groundwater condition. Besides that, human activities such as groundwater extraction, land use change and waste disposal could also cause the groundwater table depletion and degradation of groundwater quality. These issues have become even more severe in the future due to the increase in the population and economic development (Kemper, 2003, 2004, 2007).

However, there are some consequences of groundwater table depletion and contamination. The depletion of this aquifer table could cause environmental problems such as land subsidence, groundwater scarcity, and drought. Further these environmental problems could lead to economic and social problems (Ebraheem et al, 2003; Llamas & Martinez-Santos, 2005; Kamel et al, 2006). The collapsing constructions, the necessity of groundwater well deepening, the scarcity of water availability and even social conflict are some impacts of groundwater table depletion (Feng et al, 2008; Martínez et al 2013; Modoni et al, 2013). Monitoring over three decades, in many parts of the globe, has provided clear evidence of environmental problems as a result of groundwater table decline. In Indonesia, for example, the groundwater decline has caused land subsidence in some areas - purportedly due to groundwater table declining (Braadbaart, 1997).

Besides groundwater table depletion, another crucial issue is related to degradation of groundwater quality (Bredehoeft and Durbin 2009; Giardano, 2009; Theesfeld 2010; Aral and Taylor, 2011; Badan Geologi, 2013). Since, groundwater is consumed and used to support human activities; the poor quality of groundwater could lead to health problems and even social conflict. Using groundwater which contain pollutants exceeding quality standards is not safe and health anymore. It could cause several health problems such as cholera, diarrhoeal, typhoid, skin diseases, and etcetera. Moreover, as well as groundwater table depletion, groundwater contamination may also generate externality, which means that the contamination of water in one area can cause groundwater pollution in other areas and it could trigger social conflict.

Considering the impacts caused by groundwater depletion and contamination, it is very important and crucial to protect groundwater resources (Kemper, 2004, 2007; Bredehoeft and Durbin 2009; Giardano, 2009; Theesfeld 2010). It is true that, since a long time ago, several strategies such a restriction of groundwater extraction have been taken in order to manage groundwater resources. These 'classic' strategies were usually run through regulatory instruments and sound could minimize groundwater over-exploitation (Aral and Taylor, 2011). However, such kind of strategy seems ineffective and has poor performance (Kemper, 2003, 2007; Bredehoeft and Durbin 2009; Giardano, 2009; Theesfeld 2010). Nowadays, the goal of groundwater governance is not only limited to 'protect' the groundwater alone but also, further, it shall obtain a sustainable development (Kemper, 2003, 2007). Besides it wants to meet the needs of present and future generation, current groundwater development should search the synergies between social, economic and environmental (Kemper, 2003, 2007). Unfortunately, to gain sustainable development is not an easy task, we will face a complicated problem. Groundwater issues not only cause multiple scale problems but also involve various stakeholders with dissimilar perspectives, norms, and values (Braadbaart , 1997; Kemper, 2003; 2007: Aral and Taylor, 2011).

Due to the complexity of groundwater development, the classic strategies which only focus on simple technical approaches perhaps increasingly unable to respond groundwater issues effectively and efficiently (Kemper, 2004, 2007; Bredehoeft and Durbin 2009; Giardano, 2009; Theesfeld 2010). Therefore, recently, new strategies have been introduced which shift from simple technical to more communicative governance (Kemper, 2004, 2007, Mukherji & Shah, 2005). These new trends are Environmental Policy Integration (EPI), Communicative turn (participative), Neoliberal turn (market based), Multilevel Governance, Decentralization, Ecological Modernization (EM) (Lafferty & Hovden, 2003; Lemos & Agrawal, 2006; Jordan et al., 2005; Jänicke & Jörgens, 2006). Unlike technical approaches, these new strategies can an approach be more integrated, proactive and participative.

Although, those new strategies seem better than classical one, in fact, according to Zuidema (2013), the performance of governance approaches are influenced by the circumstances encountered which depend on its complexity degree. The complexity of groundwater governance depends on groundwater characteristics, stakeholders to be involved, and also socio economic condition (Kemper, 2007). Hence, the degree of complexity should be considered as criterion to choose the approach that will be taken.

In this research, I take my hometown, Karo regency, North Sumatera, Indonesia, as case study. Although Karo has implemented several regulatory instruments to manage groundwater resources, those efforts have poor performance or have not shown the intended effect (Pemerintah Kabupaten Karo, 2013). Data show that the exploitation of groundwater through well pumping has been increasing significantly and tends to be uncontrolled in Karo during last decade (Sumut Berita, 2012). This issue is predicted will become more severe due to population growth and improvement of agriculture, tourism, and the industrial sector in this region. Besides intensive groundwater exploitation, degradation of groundwater quality in this region has been also noticed in some places (Kementerian Pekerjaan Umum, 2013). Waste generated from industrial, agricultural and domestic activities, which dispose freely without treatment, contributes to contaminate groundwater in this region (Pemerintah Kabupaten Karo, 2013). Therefore, this region is a good example to study groundwater issues and to reveal the weakness or even the failure of a classic approach to protect groundwater resources.

Moreover, this research wants to propose recommendations to improve existing groundwater governance in Karo. In doing so, comparative analysis will be used as method by selecting Bandung, Bangkok and Tianjin as donor regions. Strategies that have been implemented in donor regions will be learned and evaluated. After that, the suitable and appropriate strategies that might be transferred to Karo will be selected.

1.2. Research Objectives

The pressure on groundwater resources increases particularly due to population growth and economic development (Braadbaart and Braadbaart, 1997; Kemper, 2003, 2007: Aral and Taylor, 2011). Although efforts have been taken to protect this resource, in many regions, the current strategies seem to have a poor performance and cannot work effectively and efficiently (Kemper, 2004, 2007; Bredehoeft and Durbin 2009; Giardano, 2009; Theesfeld 2010). Therefore, it is believed as has stated in many studies that the environment governance should shift from technical to more communicative approach (Lafferty & Hovden, 2003; Kemper, 2004; Lemos & Agrawal, 2006; Jordan et al. , 2005; Jänicke & Jörgens, 2006) as well as for groundwater resources (Kemper, 2004, 2007; Bredehoeft and Durbin 2009; Giardano, 2009; Theesfeld 2010).

Therefore, the aim of this research is threefold. First of all, this research aims to reveal how the classic approach particularly through centrally law enforcement has poor performance and could not protect groundwater resources effectively and efficiently. In doing so, examples are drawn from case study which are Karo, Bandung, Bangkok and Tianjin—all of which make very intensive use of groundwater. Secondly, this research wants to formulate and propose suitable and appropriate strategy to protect the groundwater resources in the case study of Karo regency. This proposal will be gained through policy transfer by learning from selected donor regions. Third and finally, it is expected that the new governance that will be proposed in Karo regency will contribute to groundwater management in general and will be possible to be implemented in other areas.

1.3. Research Questions

To focus on those objectives, the main question that will be answered is

'What kinds of governance should be established, comparatively, to protect the groundwater resources in the context of Karo regency?'

Further, to answer that main question, some research sub questions have been formulated.

1. What are the current conditions of groundwater in Karo regency?

   There are many factors that influence the groundwater condition in one region, not only natural factors such as seasonal change, natural disasters and hydrogeological characteristics, but also human interventions such as groundwater extraction, land use change and waste disposal. Both natural factors and human factors could cause groundwater depletion and contamination. The causes and the impacts of groundwater issues in Karo regency will be examined through this question.

2. How does Karo regency govern its groundwater?

   Karo regency has its own ways and strategies in order to protect its groundwater resources. The strategies including instruments, regulation, and stakeholders will be discussed clearly. Moreover, through this question it is expected that the performance include the effectiveness and the obstacles of the current groundwater governance in Karo can be identified.

3. How do other regions govern their water resources?

   As comparative analysis will be used as method in this research, other relevant regions will be selected as donor policy. The conditions of their groundwater resources will be studied as well as their strategy to protect the groundwater. Through this study, it is expected that the effectiveness and the obstacles of their approaches can be identified.

4. What policy could be proposed in order to improve groundwater governance in Karo?

   After discussing groundwater governance in both Karo as borrower region and donor regions, the possible and appropriate policy recommendations will be proposed to improve groundwater governance in Karo. That possible and appropriate policy will be learned and transferred from donor regions.

5. What is contribution of this research for groundwater management in general?

   Through this question it is expected the contribution of this research for groundwater management will be known. Further, the opportunity of the new governance proposed to Karo regency could be implemented in other regions will be also known.

1.4. Conceptual Model

Conceptual model of this research is shown in Figure 1.1. The discussion will focus on groundwater issues, groundwater protection and strategies for improvement. Both natural factor and human intervention that cause groundwater issues including groundwater table depletion and degradation of groundwater quality will be explored. This situation obviously brings consequences especially for environment degradation and human life.

Although efforts have been conducted to protect groundwater resource, current groundwater governance seems to have a poor performance and cannot work effectively. Therefore, the improvement of current governance is a necessity. To develop new governance, comparison analysis will be used as method. Various strategies from donor regions that have been published through journal papers will be synthesised in order to obtain policy options that can be transferred to Karo. However, to develop new groundwater governance, assessing the suitability of selected policy options in the context of Karo is crucial. In this stage, principles of contingency theory and policy transfer are highly employed in order to formulate suitable and appropriate recommendations. Finally, if this research will be continued, topics on the impact of proposed strategies are highly suggested since this issue has not been covered in this research.

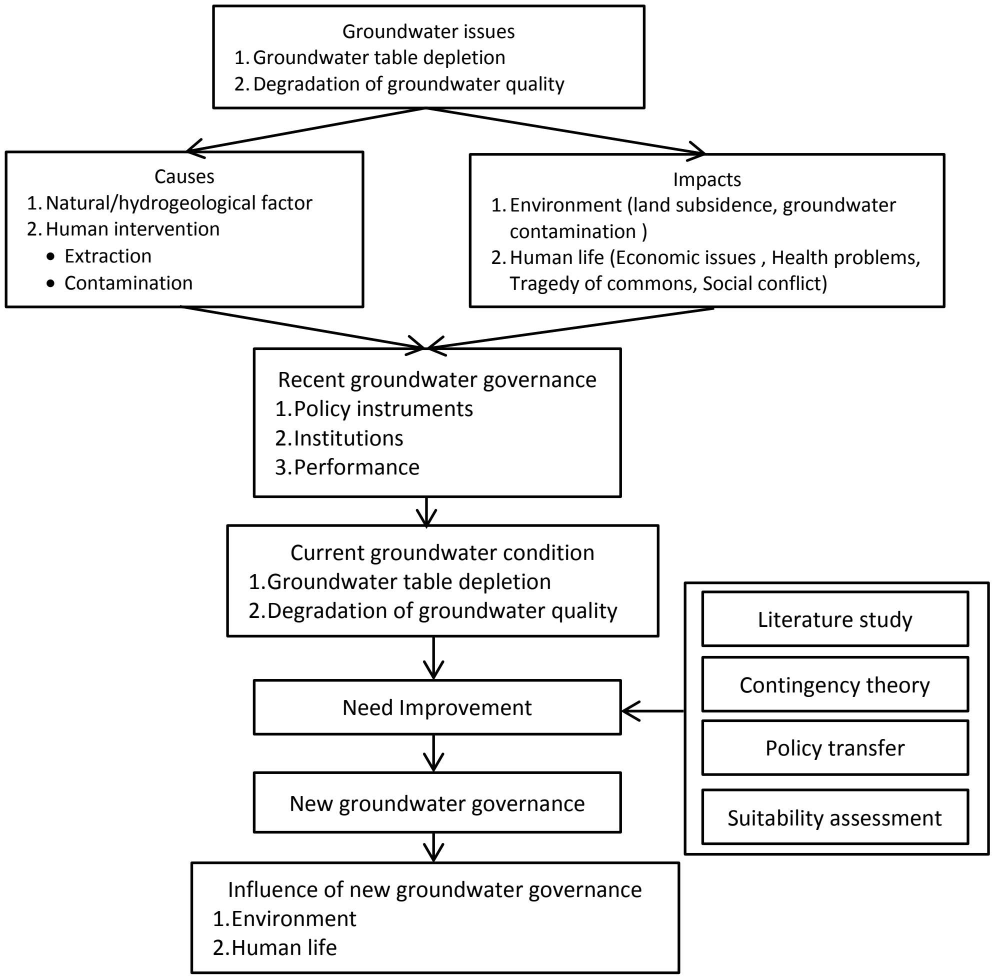

Figure 1.1. Conceptual model of the research

1.5. Research Methodology

To achieve the objectives of this research and to answer the research questions qualitative analysis approach and comparative analysis are used in this research. In doing so, specific cases study will be selected which in this research can be distinguished into two types; borrower and lender regions. Therefore, in the beginning of this section, how to select the cases study will be described. After that, how to conduct this policy transfer will be elaborated. However, before conducting this comparative analysis, relevant data related to groundwater issues in both borrower and lender regions must be collected. How to collect these data will be also described in this section.

Cases study selection

According to Swanborn (2010), case studies refer to studying a specific phenomenon in its natural context. Moreover, the importance of case studies has been stated by Flyvbjerg (2006, p.242): "a discipline without a large number of thoroughly executed case studies is a discipline without systematic production of exemplars". In a case study approach, practical, experience-based knowledge is more important than theoretical knowledge (Flyvbjerg, 2006). The grasping of this context-dependent experience is at the very heart of case study research. Since groundwater governance is context-dependent (Kemper, 2007; Giardano, 2009; Theesfeld 2010), a case study approach, therefore, seems appropriate for this research, which focuses on local groundwater characteristics.

The borrower region will be not selected randomly, it is expected that through the selected case study the objectives of this research will be answered well. As this research wants to reveal the importance of groundwater protection and to reveal the failure of current groundwater governance, there are several importance prerequisites in selecting case study. First, pressure on groundwater in a case study should relatively high due to intensive groundwater extraction and increasing groundwater contamination. Second, the case study has had experience relate to groundwater issues such as land water table depletion and decreasing groundwater quality. Third, the case study has tried to protect it groundwater, however, the current efforts relatively has poor performance.

As well as borrower region, the lender regions will be also selected selectively. To make comparison meaningful, some obligatory prerequisites must be met by lender regions

(Dolowitz and Marsh, 1996). As this research focuses on groundwater protection, lender regions that will be selected must have similar issues with borrower region. First, groundwater in lender regions has become a big issue due to intensive groundwater extraction and contamination. Second, as this research wants to improve groundwater governance in the borrower region, the lender regions should has much more experience in groundwater governance than case study. Therefore, the borrower region could learn much regarding groundwater governance including the obstacle and challenges that will be faced. Third, in order to avoid policy transfer failure, the borrowing country must have sufficient information about policy/institution and how it operates in the country from which it is transferred (Dolowitz et al 2000). In term of groundwater governance, the important data consist of: hydrogeological characteristic such as climate and topography, groundwater issues such as groundwater extraction and contamination, impacts of groundwater issues such as water table depletion and land subsidence, groundwater governance such as instruments, regulations, stakeholders, effectiveness and also obstacles, and socio economic condition (Kemper, 2003, 2007).

Data collection and theoretical review

In the beginning, the theoretical review will help to develop the understanding of groundwater with a focus on its issues such as groundwater table depletion and contamination. In addition, concept of groundwater protection to deal with those issues will be also helpful as references to develop groundwater governance in borrower region. These theoretical bases are derived from secondary sources such as journals, books, research papers and other related and relevant sources.

After developing theoretical bases, appropriate and relevant data related to groundwater governance in both borrower and lender regions will be collected. There are some data needed for this research; causes of groundwater issues, impacts of groundwater issues and groundwater governance (Table 1.1). Firstly, socio economic conditions of cases study. Secondly, causes of groundwater issues including natural characteristics of groundwater such as hydrogeological conditions and also human intervention such as groundwater extraction and contamination. Thirdly, impacts of groundwater table depletion and contamination such as land subsidence, groundwater salinization, health problem, economic problem, social problem and also ecological problem. Finally, data related to groundwater governance in both borrower and lender regions including policy instruments, institutions, stakeholders, and effectiveness of current policy instruments and obstacles in its implementation.

There are two possible methods that can be taken to collect the data (Sugiyono, 2012). First option is direct observation within field study. This method is likely more suitable to gain specific and detail data of groundwater issues and governance in cases study, however, besides it need much money and time, this method seems to be less relevant to understand groundwater issues in wider perspective. Second alternative is secondary data collected from journals, articles, government reports, internet and other relevant sources. Unlike primary data, through this method, it is expected that wider figure of the recent condition of groundwater issues in cases study can be understood. Moreover, compared to the first method, collecting data from secondary sources will need less budget and time. Therefore, due to limited time and budget as well as geographical constraints, in this research, gathering secondary data that has been published is preferable.

Table 1.1. Data collection

Data collection	Sources	Goal
Socio economic condition of cases study		
Demography	Government website	To get updated information about population number and estimated population growth rate
Economy	Government website, internet	To get updated information about economic condition of cases study
Groundwater issues in cases study		
Causes of groundwater issues	Journals, articles, research reports, government publication, internet	To get information about causes of groundwater issues for both natural characteristics and human interventions.
Impacts of groundwater issues	Journals, articles, research reports, government publication, internet	To get information about impacts of groundwater issues for both environment (land subsidence, ecology) and human life (economic issues, health problems, tragedy of commons, social conflict)
Groundwater governance in cases study		
Policy instruments	Journals, articles, research reports, government publication, internet	To know the efforts that have been taken to protect groundwater resource in cases study
Institutions	Journals, articles, research reports, government publication, internet	To know the groundwater institutions that have been developed and the role of institutions in cases study
Performance	Journals, articles, research reports, government publication, internet	To get information about the effectiveness of policy instruments that have been implemented and also obstacles faced in its implementation

Research analysis

To develop groundwater governance in borrower region, comparative analysis is used in this research. Through comparison, the experience from other regions either their failure or success can be evaluated. It means that borrower learn not only what has worked in other regions but also can learn what not to repeat. Then, suitable and an appropriate policies from lender will be transferred and adopted to borrower region (Dolowitz and Marsh, 1996), however, by analysing its suitability. In this analysing process, a series of questions needs to be address. They are: Why do actors engage in policy transfer? Who are the key actors involved in the policy transfer process? From where are lessons drawn? What is transferred? What are the different degrees of transfer? What restricts or facilitates the policy transfer process? According to Dolowitz and Marsh (2000), these questions will help researchers examine the process of policy transfer and help themselves and practitioners evaluate the "value added" aspect of the concept.

To satisfy these six questions, some steps have been developed in this research as shown in figure 1.2. To answer the first until the third question, qualitative analysis will be conducted. Qualitative approach is used because most of data that will be used in this research are qualitative data and this research will work mostly with story, text and images (see Bexter, 2008; Merriam, 2009). In doing so, qualitative data from journals, books, research papers and other related and relevant sources are collected first. Then, the data will be observed primarily focused on exploring the unique groundwater governance in both borrower and lender region. The second step is comparison. Through this comparison, the similarities and the differences of groundwater issues as well as the groundwater governance in both borrower and lender regions could be identified. Therefore, the policy options that are possible to transfer could be identified and it will answer the fourth question.

The next step is to assess the suitability of the policy options and to review the selected strategy. This stage will give explanation to the fifth and sixth question. Alternative that can be undertaken to satisfy the purposes of this suitability and review stages is by conducting interview (Sugiyono, 2012). Respondents may come from various groups such as government officers, politicians, private sectors, and communities in Karo regency. It is true that by asking those people's opinion can reveal their preference and more suitable strategies can probably be well formulated. However, to conduct this interview requires respondents who have capability and much experience in groundwater management, and such respondent is very difficult to find in Karo. Therefore, in this research, the suitability of policy and its pitfall in Karo regency case will be evaluated only based on experience of donor regions synthesised from literatures. Moreover, through this literature synthesis, the tendency of subjective opinions gained in interview could be avoided (Sugiyono, 2012).

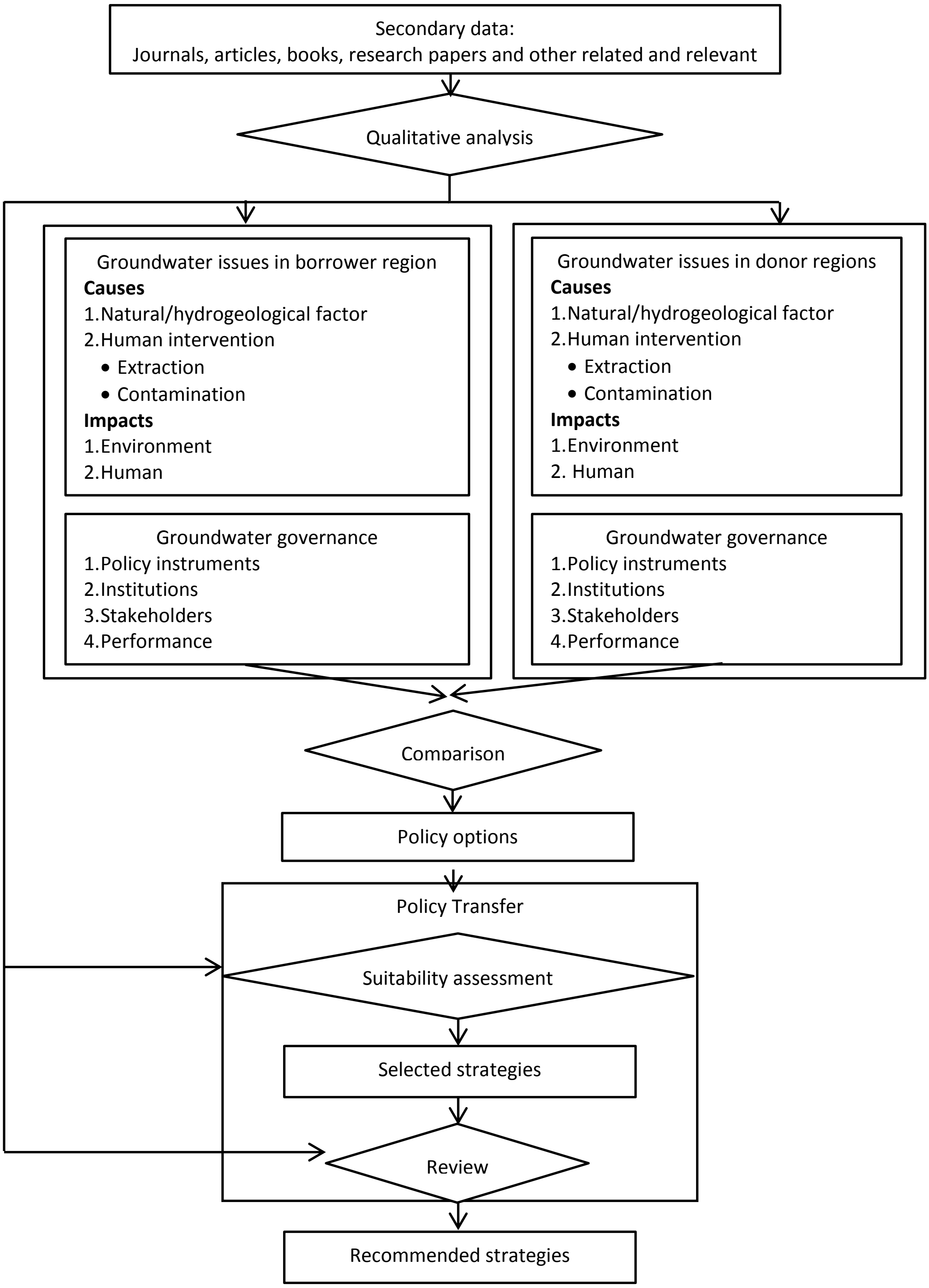

Figure 1.2. Research Methodology

Although the suitability of policy transfer will depend on various factors, in this research, the suitability of the policy transfer will be focused on groundwater characteristics such as hydrogeological condition. Finally, by answering these six questions, it is expected that policy from lender could be transferred to borrower region appropriately and successful. More detail about policy transfer concept will be provided in theoretical framework.

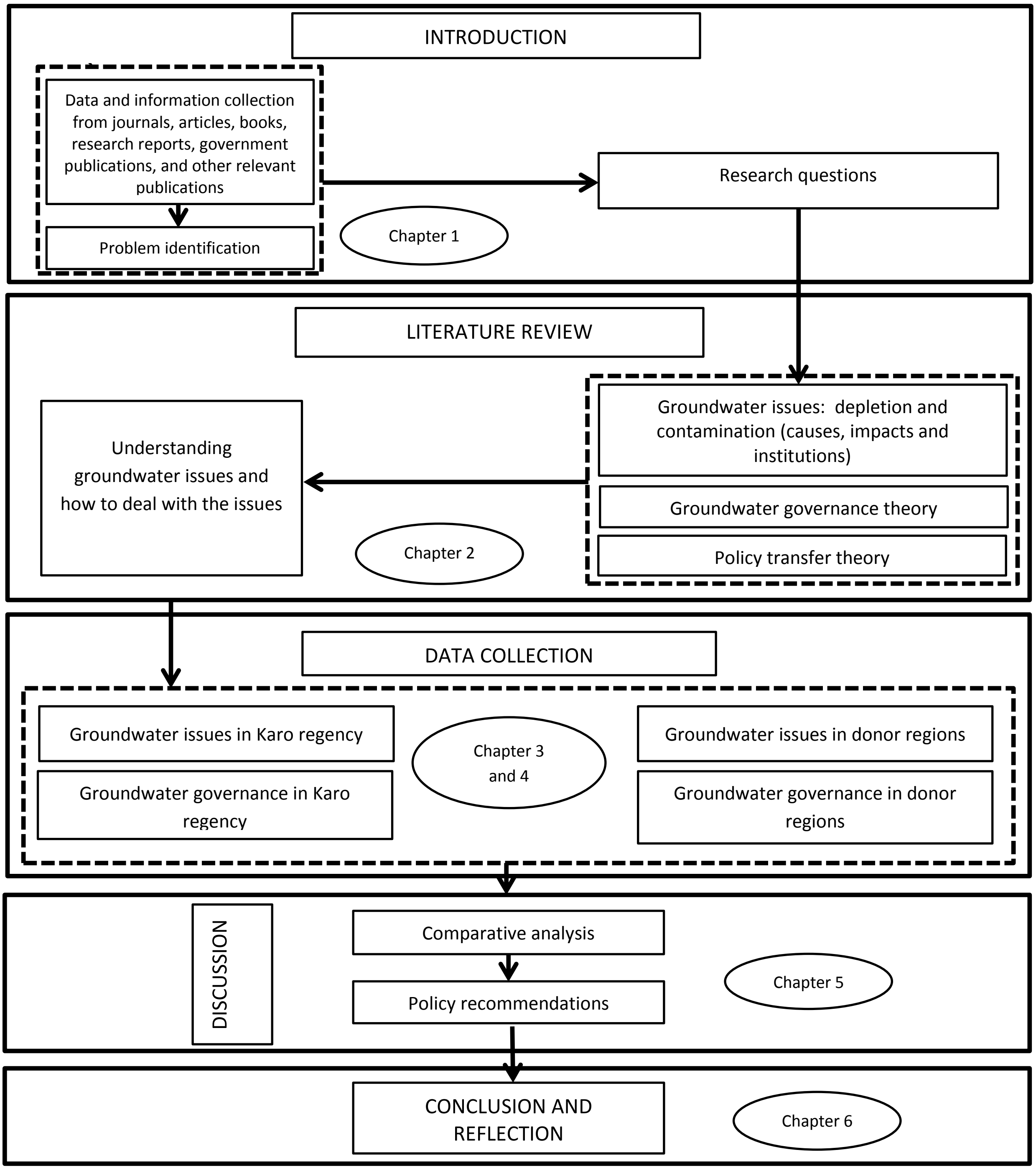

Figure 1.3. Research Framework

1.6. Research Content

This research is developed into six chapters (Figure 1.3) of which the last three chapters are the most interesting for those who would like to obtain practical findings more directly. Chapter 1 provides introduction of this research including background, research objectives, research questions, and research methodology and research content.

Chapter 2 will present theoretical framework underlying this research. In this chapter groundwater issues including causes and impacts will be introduced. The second section will be present groundwater protection concept for both traditional and communicative governance. Finally, concept of policy transfer as methods to develop groundwater governance will be elaborated.

Chapter 3 and 4 will picture groundwater condition in both case study and donor regions. In chapter 3, groundwater issues in Karo Regency as case study will be provided. At first, it will describe causes of groundwater issues Karo regency including hydrogeological characteristics and human intervention. Then, impacts of groundwater issues for both environment and human will be also described. Finally, groundwater governance in Karo will be analysed. In similar to borrower region, in chapter 4, groundwater issues and groundwater protection in donor regions will be also pictured.

Chapter 5 is comparative analysis. After discussing the groundwater issues and governance in those regions of case study and donor regions, this chapter will provide an analysis by using comparative method. Elements of groundwater conditions and governance for both Karo and other regions will be compared to find the policy options that possible to transfer.

The last chapter will provide conclusion and reflection. In conclusion, the answer of research question will be given. After that the reflection regarding this research will be described. Finally, the possible contribution of this research for planning practice will be given.

Chapter II

Groundwater Issues and Groundwater Governance

Groundwater is the water found underground in the cracks and spaces in soil, sand or rock. Even though, in the perspective of hydrogeology, it is believed that the total amount of water is fairly constant, the availability and the quality of groundwater in some regions could be disturbed either by natural activities or human interventions (Heath, 1983; Giardano, 2009; Aral and Taylor, 2011). If the decreasing of groundwater quantity and quality continuous, in the future problems could emerge in twofold. On the one hand groundwater contributes to supply of clean water for human needs and activities; hence, lack of quantity and quality of groundwater could cause social and economic issues. On the other hand, the groundwater is a part of the water cycle in the nature. Reducing of its availability and quality could cause environmental problems such as drought and land subsidence. Considering role of groundwater in those economic, social and ecological function, therefore, groundwater management is a necessity (Bredehoeft and Durbin 2009; Giardano, 2009; Theesfeld, 2010; Aral and Taylor, 2011).

In the perspective of planning today, the goal of environmental protection as well as groundwater is not only to 'protect' the environment alone. To gain sustainable development is also a necessity in environmental planning (Jordan, 2008; Loorbach, 2010) as well as groundwater management (Bredehoeft and Durbin 2009; Giardano, 2009; Theesfeld 2010). Although, the mean of sustainable development itself is still debatable, to search the synergies between social, economic and environmental seems more important and urgent. However, to gain sustainable development is not an easy task, we will face a complex problem. This complexity is due to the fact that groundwater issues not only cause multiple scale problems but also involve various stakeholders with dissimilar perspectives, norms, and values (Bredehoeft and Durbin 2009; Giardano, 2009; Theesfeld 2010; Aral and Taylor, 2011).

To deal with that complexity, rely only on a traditional form of hierarchical intervention and technical approach will not be appropriate and sufficient anymore as argued by Kemper (2003, 2007) and Giordano (2009). Therefore, improvement of groundwater governance in addressing this situation is becoming increasingly obvious (Kemper, 2003, 2007; Giordano, 2009). However, in developing this new groundwater governance, understanding groundwater issues, institutions and also policy instruments are obvious (Kemper, 2003, 2004; Theesfeld 2010). Therefore, in this chapter those aspects will be reviewed. In addition, principle of policy transfer will be also described in this chapter. These theoretical review will be used as a base to develop a good and an appropriate policy or strategy for Karo regency.

2.1. Groundwater issues

2.1.1. Declining ground water quantity.

Although, it has been believed that the amount of water is constant, the availability of groundwater in the aquifer can be changed due to two main factors; natural activities and human activities. How these two factors influence the groundwater conditions will be described in this section.

Natural activities

Natural activities such as seasonal change could cause the decreasing or increasing of the amount of groundwater (Heath, 1983; Aral and Taylor, 2011). For instance, in wet season the availability of groundwater is abundant, but, in dry season it will decrease. The influences of seasonal change for groundwater availability could be explained through hydrologic cycle (Figure 2.1). Besides that, physical characteristics of the region such as groundwater aquifer and lithology are the other important aspects that determine the availability of groundwater in that area.

Naturally, the water moves from one reservoir to another, such as from river to ocean, or from the ocean to the atmosphere, by the physical processes of evaporation, condensation, precipitation, infiltration, runoff, and subsurface flow. The movement of water on the earth's surface and through the atmosphere is known as the hydrologic cycle and a place where all hydrogeology events occur, such as the process of addition, and release of ground water is called groundwater basin. Moreover, the natural boundaries of one aquifer will not coincide with those of another aquifer. Thus, a basin may contain several aquifers of different ages and areal extent occurring at different depths (Aral and Taylor, 2011; Badan Geologi, 2013).

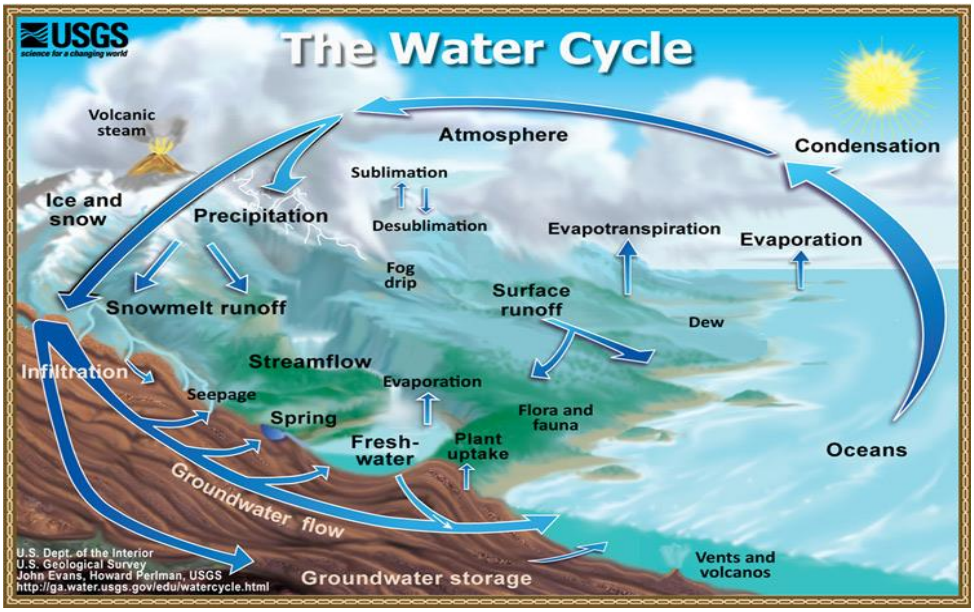

Figure 2.1. The hydrologic cycle
(Source: USGS, 2015)

The Sun, the water cycle driver, heats water in oceans, seas and other surface water, then, water evaporates as water vapour into the air or ice and snow can sublimate directly into water vapour. Besides evaporation and sublimation, evapotranspiration is another process where water is transpired from plants and evaporated from the soil. After those, rising air currents take the vapour up into the atmosphere where the temperature is cooler. This cooler temperature will condense water vapour into clouds. Air currents move water vapour around the globe and the vapours in the clouds condense more and more until they form water droplets. Water vapour continues to combine with the water droplet until it is too heavy to stay in the sky any longer. The next stage is that the cloud will grow, and fall out of the upper atmospheric layers as precipitation. Some precipitation falls as snow or hail, sleet, and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. However, most of water falls back into the oceans or onto land as rain, where the water flows over the ground as surface runoff. A portion of runoff then enters into rivers in valleys in the landscape, with streamflow moving water towards the oceans. Besides moving to the oceans, runoff and water emerging from the ground (groundwater) may be stored as freshwater in lakes, and not all runoff flows into rivers, much of it soaks into the ground as infiltration. Some water infiltrates deep into the ground and replenishes aquifers, which can store freshwater for long periods of time. Some infiltration stays close to the land surface and can seep back into surface-water bodies (and the ocean) as groundwater discharge. Some groundwater finds openings in the land surface and comes out as freshwater springs. In river valleys and flood-plains there is often continuous water exchange between surface water and ground water. Over time, finally, the water returns to the ocean, to continue the water cycle. In addition, from water cycle processes above, it is known that groundwater is only a part of hydrological process. Hydrological systems are interconnected and no parts can be fenced off and protected from disturbance since groundwater dissipates beneath the surface irrespective of boundaries (Theesfeld, 2010).

Moreover, the availability and the quality of groundwater in one area depend on recharge and discharge process and these processes depend on hydrogeological characteristic in that area. In dry season, the amount of precipitation decrease, but, the discharge process increases, hence, only a little infiltration occur, as a result groundwater table decline (Figure 2.3). Moreover, according to Sheng et al (2011), groundwater availability could be determined by calculating hydrologic balance, where change in water storage is equal to the different between total water inflow and total water outflow. The water inflow comprises of surface inflow into basin, subsurface (groundwater) inflow, precipitation and imported water. However, the water outflow consists of surface outflow, subsurface outflow, consumptive uses including human consumption, evaporation, and exported water.

Besides seasonal change, the amount of water that becomes groundwater also depends on the characteristics of the aquifer (underground saturated zone) and lithology (soil layers) in that area (Aral and Taylor, 2011; Badan Geologi, 2013) (Figure 2.2). In unconfined aquifer, the groundwater only takes a short time travel (only in days) to reach the discharge area, hence, the quantity and the quality of water in this aquifer could be influenced by seasonal change. However, in confined aquifer the travel time of groundwater flow is longer than the unconfined aquifer. Water reaches the discharge area in years or even in millennia. Therefore, once the availability of groundwater in this aquifer has been dropped, the replenishment of this aquifer will take a long time period.

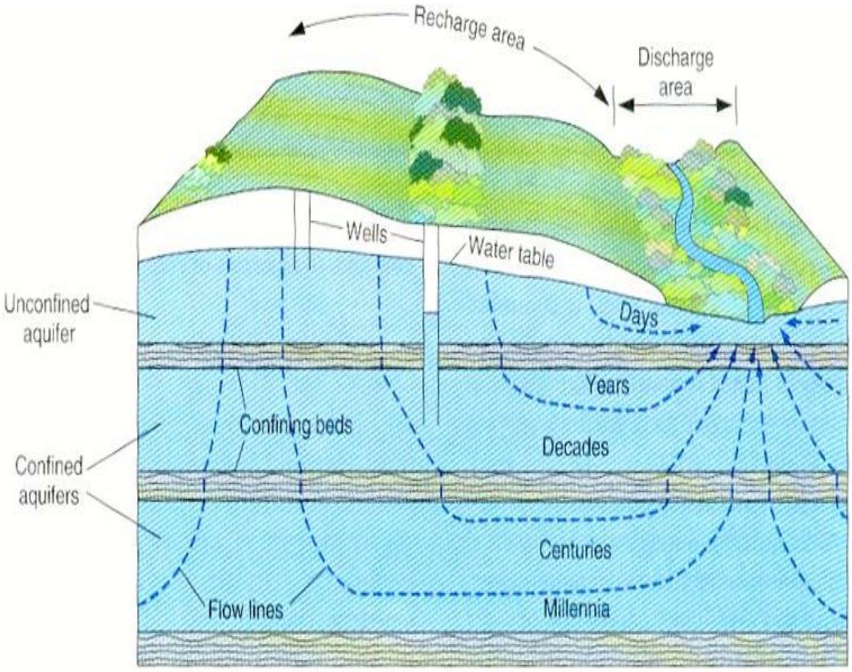

Figure 2.2. Relative groundwater travel times in the aquifer
(Source: USGS, 2015)

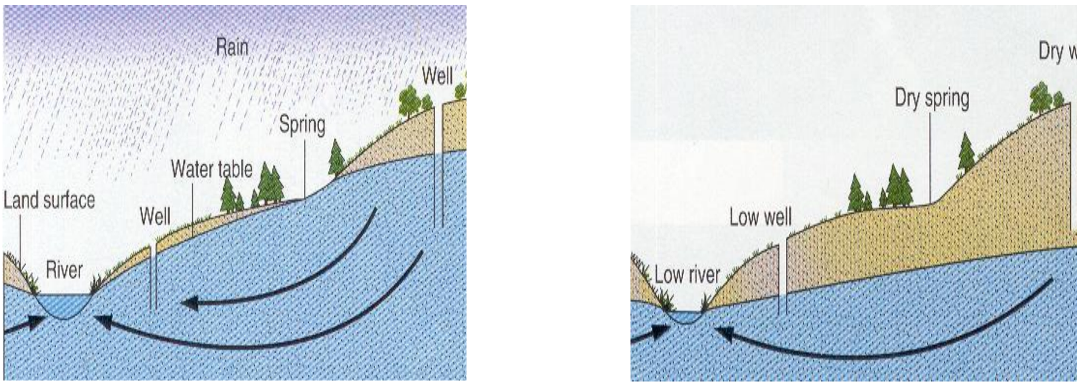

Figure 2.3. Water table change in wet season (left) and dry season (right)
(Source: USGS, 2015)

Further, the amount of water that infiltrates the soil varies with the degree of land slope, the amount and type of vegetation, soil type and rock type, and whether the soil is already saturated by water. The more openings in the surface or lithology (cracks, pores, joints), the more infiltration occurs (Aral and Taylor, 2011; Badan Geologi, 2013).

In conclusion, groundwater availability will depend on natural characteristics include seasonal change, land cover and also aquifer characteristics. In wet season, the groundwater table will increase, but in dry season it will fall. Land covered by plants is a better infiltration place than developed land such as settlement area. Finally, unconfined aquifer could change in a day, while, confined aquifer will change in year or even in millennia.

Human activities

Besides natural activities, human activities also play an important role to affect the groundwater availability. Exploiting groundwater intensively and changing land use due to economic activities are some of human activities that could affect groundwater availability in one region (Heath, 1983; Aral and Taylor, 2011). How groundwater extraction and how land use change can decline the water table either directly or indirectly will be described below.

As one of clean water resources, groundwater is the most reliable and cheapest source of fresh water. It has better quality and it is better protected from pollutants (FAO, 2003). As a result, the extraction of this natural resource increases extensively. Once groundwater is pumped, it will cause cone of depression and drawdown (Aral and Taylor, 2011). Cone of depression is a depression of the water table formed around a well when water is pumped out, which has shape like an inverted cone. However, drawdown is the lowering of the water table near a pumped well (Figure 2.4). When this process continues for a long time, and once water outflow is less than water inflow, the water table will fall. The speed of this water table decline will increase when number of wells or amount of groundwater withdrawal increase in that aquifer.

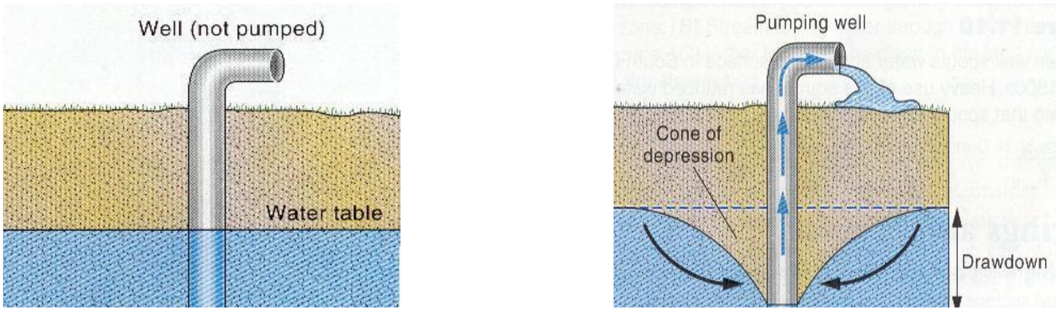

Figure 2.4. Effect of pumping well to the water table
(Source: USGS, 2015)

Besides the extraction, the depletion of groundwater table or the decreasing of groundwater quantity could be also caused by land use change due to human activities

(Lerner & Harris, 2009; Aral and Taylor, 2011). Forest and vegetation cover have long been recognized as major factors influencing runoff, infiltration and evapotranspiration from shallow water tables. They could reduce runoff and increase infiltration. However, land use change from recharge area to development area will cause the decreasing possibilities of infiltration and increasing of runoff. As consequence, the amount of water that infiltrate to the aquifer will reduce.

2.1.2. Groundwater contamination

Although natural phenomena such as volcanoes, storms, earthquakes etcetera also could cause major changes in groundwater quality, most of groundwater contaminations come from waste generated from human activities such as industrial, agricultural and other human activities waste. Firstly, industries dispose waste and smog without sufficient treatment. Secondly, poorly-treated or untreated sewage, surface runoff from construction sites, excess nutrients added by runoff containing detergents or fertilizers, underground storage tank leakage, landfill leachate disposal are waste generated from human or human activities.

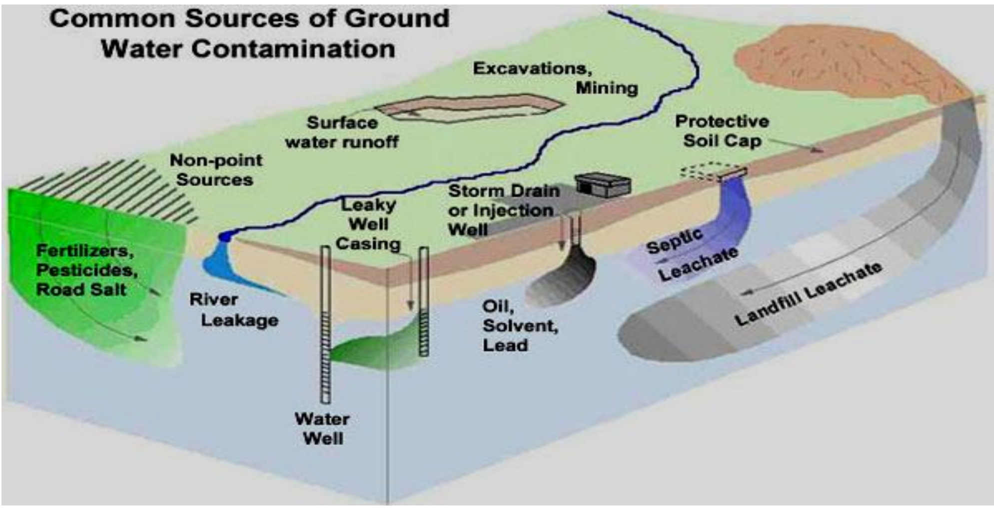

Figure 2.5. Sources of groundwater contamination
(Source: USGS, 2015)

All of the waste from industrial, agricultural and the other human activities could cause aquifer contamination. Those waste contaminate soil, water and air firstly, however through diffusion, adsorption, precipitation or decay, the waste will contaminate the groundwater (Lerner & Harris, 2009; Aral and Taylor, 2011; Badan Geologi, 2013) (Figure 2.5). Unlike in surface water which pollution in one point may immediately emerge in other areas, the effect of pollution in groundwater particularly in confined aquifer, can take decades before being recognized in other regions (Theesfeld, 2010).

2.1.3. Impacts of groundwater table decreasing and contamination

There are some consequences of groundwater table depletion and contamination. As well as the other environmental issues, impacts of groundwater table decline and contamination could cause multiple scales problems. Land subsidence, groundwater salinization, health problems, economic problems, social problems and ecological problems are some of the interrelated issues caused by groundwater depletion and contamination (Braadbaart, 1997; Giardano, 2009; Aral and Taylor, 2011; Badan Geologi, 2013).

Firstly, in its natural equilibrium state, the hydraulic pressure of groundwater in the pore spaces of the aquifer supports some of the weight of the overlying sediments (Aral and Taylor, 2011; Badan Geologi, 2013). Due to excessive pumping, groundwater is removed from aquifers, therefore, pore pressures in the aquifer drop and compression of the aquifer may occur. Although, this compression may be partially recoverable if pressures rebound, much of it is not. As a consequence, when the aquifer gets compressed, it may cause land subsidence, a drop in the ground surface. This land subsidence is very dangerous especially in urban areas and coastal areas. It could make infrastructure collapse and when it occur in coastal area, subsidence has resulted in increased flood risk (Feng et al, 2008; Martínez et al 2013; Modoni et al, 2013). In addition, the voids in aquifer caused by over pumping also allow saline water to infiltrate to fresh water zones. It often occurs particularly in coastal zones. It means that fresh water is polluted by saline water. As consequences water that is consumed by human is no longer safe (Llamas & Martinez-Santos, 2005; Braadbaart, 1997; Giordano, 2009).

Secondly, groundwater table depletion could lead to the increasing cost in obtaining fresh water because well must be deepened and energy for pumping also increase (Llamas & Martinez-Santos, 2005; Pfeiffer and Lin, 2009). Moreover, pumping by users in the same groundwater basin could lead to ‘‘tragedy of the commons’’ (Feeny et al 1990; Theesfeld 2010). Groundwater decline due to independent individuals well pumping will affect or influence the wells of the whole group and even further, could lead to social conflict (Llamas & Martinez-Santos, 2005).

Thirdly, as well as water declining, groundwater contamination could also cause serious problems. Once an aquifer is contaminated, it may be difficult, costly, or even technically impossible to reverse this contamination (Theesfeld, 2010). Further, it is true that the full impacts of groundwater pollution on health have not been assessed comprehensively (Pedley and Howard, 1997). However, using groundwater which has pollutants exceeded quality standard is not safe and health anymore. It is believed that consuming contaminated groundwater could lead to the health problems such as cholera, diarrhoeal, typhoid, skin diseases etcetera. Moreover, ss well as water table depletion, groundwater contamination may also generate externality, which means that the contamination of water in one area can cause groundwater pollution in other areas and it could lead social conflict (Llamas & Martinez-Santos, 2005; Martínez et al 2013; Modoni et al, 2013).

Finally, groundwater is also ecologically important. The importance of groundwater to ecosystems is often overlooked, even by freshwater biologists and ecologists (Kraemer, 2001; Llamas & Martinez-Santos, 2005; Aral and Taylor, 2011; Badan Geologi, 2013). As groundwater and surface water interact, it consequently brings influences in the availability of water on surface such as lakes and rivers where ecosystems exist. Groundwater sustains rivers, wetlands, and lakes, as well as subterranean ecosystems within karst or alluvial aquifers. Therefore, the depletion of groundwater also implicates to the depletion of surface water. And lack of water could harm ecosystems as well as humans (EEA2 Report, 2009). In addition, groundwater feeds soil moisture through percolation, and many terrestrial vegetation communities depend directly on either groundwater or the percolated soil moisture above the aquifer for at least part of each year.

2.2. Groundwater Protection

Having shown the detrimental impacts of groundwater over-extraction and contamination, the need for adequate and appropriate policies to protect groundwater becomes obvious. However, according to Kemper (2003, 2007) and Theesfeld (2010), besides groundwater issues, there are two other main aspects that must be considered to develop a policy to preserve groundwater resource; institutions, and policy instruments. These institutions and instruments influence each other and cannot be separated. For instance, laws to avoid groundwater overexploitation will not be effective if they are not enforced and they will not be enforced effectively if the different actors have no information about them or if, as in many countries, there is no interaction between the users and the water administration (Kemper, 2003). This section describes an overview of the groundwater protection ingredients that can be combined in a variety of ways in order to achieve improved groundwater governance, depending on the specific characteristics of a groundwater basin, a country or a region.

2.2.1. Institutions in groundwater protection

Institutions are described as the 'rules of the game' within which stakeholders act (North in Alexander, 2005). According to North (1990), institutions can be distinguished into two kinds namely regulation and organization. Regulations include formal laws and regulations, and also informal norms. In the context of groundwater, national or state water laws dealing with groundwater, groundwater regulations and decrees, as well as norms developed and applied in communities' areas regarding groundwater development and use (well construction and spacing norms, water extraction, rules, etc.), could be categorised as institutions (Kemper, 2003, 2007).

Organization that could be divided based on their interests and objectives, namely government/public, private/individual, and NGO or even international organization (Giordano, 2009; Aral and Taylor, 2011; Martínez et al 2013; Modoni et al, 2013). Firstly, in most regions, government has an important role in groundwater protection. As has stated above that mismanage of groundwater resources could cause 'tragedy of commons', government has important role in groundwater management. As groundwater basins are like shared bank accounts, government must manage groundwater resources including its utilization and protection. Generally, government comprises of national, regional and local level and they usually have their own authority (Hudalah & Woltjer, 2007; Busscher et al. , 2013; Zuidema, 2013). Secondly, private such as individual, industries and etc. also have interests in the groundwater. They utilize the groundwater either to consume or to support their activities. However, as a user, they have a significant contribution in causing groundwater level depletion and contamination. Thirdly, non-government organizations (NGO) also become important stakeholders in groundwater protection. Their roles include social controlling, giving suggestions and opinions and also giving complaints either to government or private. Finally, international organization could also have role in groundwater. In the case of groundwater basin is shared between two or more independent states, cooperative groundwater management among states is a necessity, and therefore international organization will be needed (Blomquist & Ingram, 2003; Giordano, 2009)

2.2.2. Policy instruments in groundwater protection

According to Mukherji & Shah (2005) and Theesfeld (2010), groundwater policy instruments can be distinguished into three typical types, namely regulatory, economic, and other/supporting. Regulatory is a command-and-control policy instrument including ownership and property right assignments and regulations for water use. Economic policy instruments make use of financial (dis-)incentives such as groundwater pricing, trading water rights or pollution permits, and subsidies and taxes. Other/supporting instruments are those that support regulatory and economic instruments such as monitoring.

Regulatory Instruments

Regulatory or command-and-control policy instruments consist of ownership, property right, statutory vestment, regulations and conjunctive use (Theesfeld, 2010). First ownership rights are the right to make use of physical objects, to alter them and derive income from them, and the power of management, including that of alienation. Generally, it implies that the landowner can extract ground water without restriction. Second, property rights generally divide into access rights, withdrawal rights, management rights, exclusion rights, and alienation rights. Third, statutory vestment in the public domain where the resource is then regarded as being held by the state in trust for the public, yet even when the state claims ownership rights to a body of groundwater, individual or collective users may nevertheless hold abstraction and use rights. Fourth, regulations for use, this includes use and quantity limitations, drilling permits and licensing, use licenses, special zones of conservation, and reporting and registering requirements. Last, conjunctive use, where aquifers and surface water resources are utilized complementary one each other according to situation.

Economic Instruments

Economic policy instruments make use of financial disincentives or incentive such as groundwater pricing, trading water rights or pollution permits, and subsidies and taxes (Theesfeld, 2010). Groundwater pricing means levying fees either directly for water abstraction (may vary according to volume, area, location, or source) or indirect pricing of groundwater by adjusting tariff for energy (electricity or diesel fuel for pumping). Since electricity or diesel power is required to pump groundwater, there is a strong link between groundwater and energy. Therefore, to restrict groundwater extraction, subsidies for electricity should be eliminated. In addition, incentives to reduce agrochemical leaching are needed in order to control pollution from agricultural cultivation. Subsidies for fertilizers and pesticides can be re targeted. A further step might even be the introduction of an environmental tax on fertilizers and pesticides. Besides that, a water market is a set of arrangements that permit water rights (for abstraction and use) to be traded. The ability of water rights owners to exchange, lease, or sell their rights is essential for successful groundwater protection.

Other/supporting Instruments

Besides regulatory and economic instruments, another instrument is supporting or other policy instruments. To build participation stakeholders' awareness in governing natural resources is one of the examples. This strategy motivates voluntary actions or behavioural changes without fiat or direct financial incentives (Theesfeld, 2010). According to Kemper (2003), one essential thing that could be done to optimize the awareness of related stakeholders is through campaign. However, before conducting this campaign, the campaigners particularly government must have adequate and reliable information. Groundwater users who do not know what the conditions of their resource are will be less willing to sacrifice their current income than those who are aware that overexploitation is going to hurt them in the foreseeable future. To provide comprehensible and reliable information, therefore, monitoring could be useful.

2.2.3. Groundwater governance

According to Kemper (2003, 2004 and 2007) and Mukherji & Shah (2005), a history of groundwater governance worldwide could be distinguished into two kinds, namely traditional approach and new governance. In the following sections, a strategy and a shift paradigm in groundwater protection approaches will be discussed.

Traditional approach

As well as other water resources, for a long time groundwater protection was either neglected entirely and the focus was on furthering groundwater exploitation – often without the basic hydrological knowledge of a given region – or regarded from a technical point of view (Kemper, 2003, 2004, 2007). In doing so, to study the groundwater resource (typically carried out by the government and/or universities) and to model it must be conducted firstly. Then, direct regulation through licensing and registration of wells and aggressive pricing policies were advocated. In cases of sinking groundwater levels, certain areas would then be delineated and declared off-limits for further abstraction. Although this approach seems logic and will be effective, unfortunately, these approaches have not been successful in curbing groundwater overexploitation or pollution in many regions all over the world. In Jakarta, Indonesia for instance, the water table depletion have been continuing although regulations which regulate the restriction of groundwater extraction have been implemented (see Braadbaart, 1997). Equally unsuccessful is the same recipe followed for groundwater quality management. Studies result in protection zones that are often not controlled due to absence of legislation and enforcement capacity (see Giordano and Villholth, 2007; Shah, 2008).

There are some doubts why a traditional approach will not appropriate and suitable to tackle current environmental issues (Lafferty&Hovden, 2003; Lemos & Agrawal, 2006; Jordan et al. , 2005; Jänicke & Jörgens, 2006; Zuidema, 2013). Traditional approach only focuses on single goal and involves only limited stakeholders. Although it is simple, the traditional strategy will not work effectively in current condition because in fact the issues are related each other and involve various stakeholders. Moreover, this classic approach focuses how to protect and to clean up (reactive policy), however it is only beyond damage control and could not prevent the issues. The last is the critique on central state control. Can the central government oversee things in unique circumstances? In fact, although in one state, each region has unique groundwater characteristics (Kemper, 2004, 2007; Mukherji & Shah, 2005; Giordano, 2009. Therefore, many argue that there is a need for a paradigm shift from groundwater management mode (in terms of purely technical management of an aquifer as viewed by hydrogeologists or purely legal management of groundwater as viewed by policy makers) to the broader and holistic concept of groundwater governance mode which has to be multi-level, multi-actor and multi-instrumental (Kemper, 2004, 2007; Mukherji & Shah, 2005; Giordano, 2009).

New groundwater governance

Unlike traditional approach with a relatively restrictive concept, the new groundwater governance tends to be holistic (Kemper, 2004, 2007; Mukherji & Shah, 2005; Giordano, 2009). The concept of new governance tries to be more inclusive, and takes into account the concerns of the other stakeholders including hydrologists (and other scientists), policy makers (all government levels) and most importantly, the users. In literature, there are some approaches for the governance renewal, some of them are Policy Integration (PI), Communicative turn (participative), Neoliberal turn (market based), Multilevel Governance, Decentralization, and Ecological Modernization (EM) (Lafferty&Hovden, 2003; Lemos & Agrawal, 2006; Jordan et al. , 2005; Jänicke & Jörgens, 2006).

Firstly, in traditional approach, the groundwater policy is separated with the other policy sectors. However, due to complexity of groundwater problems, it is believed that considering groundwater issues alone will not be able to protect groundwater resources effectively. Through policy integration, it is expected that sustainable development could be received and groundwater protection could be more effective. Moreover, contradictions between policies as well as within policies could be removed and mutual benefits and the goal of making policies mutually supportive could be released (Lafferty&Hovden, 2003).

Secondly, according to Lemos & Agrawal (2006), communicative turn is a type of new governance that shifts from fully state control to society involvement. The literature describes several types of communicative approaches, including informational campaigns, voluntary instruments and participative approaches (Lafferty&Hovden, 2003; Lemos & Agrawal, 2006; Jordan et al., 2005; Jänicke & Jörgens, 2006). First are information campaigns. Informational campaigns can be conducted by giving relevant information to all stakeholders. In the term of groundwater, the information could be related to the impacts of over-extraction and contamination of groundwater, and it could increase the awareness of stakeholders to protect groundwater (Kemper, 2004, 2007; Mukherji & Shah, 2005; Giordano, 2009). Second are voluntary instruments. They are usually established by public bodies like the International Standard Organization (ISO), which define certain performance criteria and other membership conditions (Jordan et al, 2006). In the term of groundwater, it could be addressed for industries, hence, they will concern to environment as well as groundwater. Third is participative approach. This approach uses creativity, capacity and knowledge of market parties and public in decision making for better environmental awareness. Although, participative can boost social support, the accountability and who should control become the drawbacks of this approach (Lafferty & Hovden, 2003).

Thirdly, unlike communicative turn, neo liberal turn is kind of new governance that shifts from fully state control to market involvement (Lemos & Agrawal, 2006). The neo liberal principal can be conducted by privatization, public private partnership and also negotiated contract. For instance, in some countries the water provision has been given for private company (Theesfeld, 2010). Although this approach can lead to ongoing innovation and decrease marginal cost, the system control and accountability still in question (Lemos & Agrawal, 2006)..

Fourthly, multi-level governance means that groundwater issue is not governed on one level, or on a number of separate levels, however various levels must interact (Mukherji & Shah, 2005; see also Bressers & Kuks , 2003; Lemos & Agrawal, 2006). The pluralisation of the central state into a number of vertical and horizontal layers, therefore, the international organizations, regional government, local government, private and society are involved in decision making (Figure 2.6). The involvement of multi-level networks can enhance the representation of the diversity of interests that are affected by environmental problems and enable a multiplicity of agencies to respond immediately to problems that require swift decision-making and consequent implementation (Theesfeld, 2010).

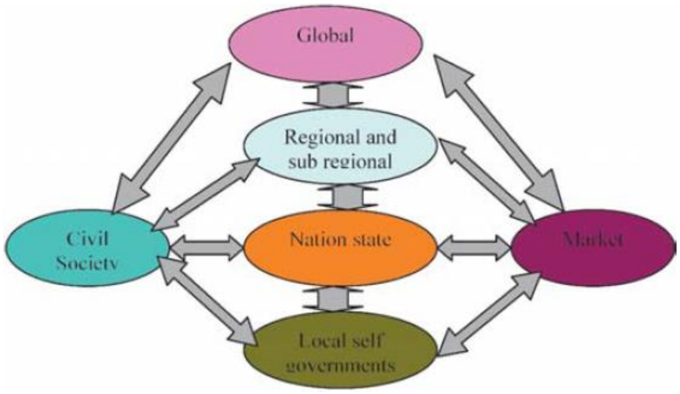

Figure 2.6. Concept of multilevel governance
(source : Mukherji & Shah, 2005)

Fifthly, decentralization means that groundwater governance shift from state to local affairs. By bringing decision making closer to local stakeholders and circumstances, decentralization can facilitate to more communicative rational approach (Zuidema, 2013). Moreover, it is often that groundwater issue is specific context, through decentralization; a place-specific knowledge about groundwater resources could be helpful (Kemper, 2004, 2007; Mukherji & Shah, 2005; Giordano, 2009). Besides those advantages, however, decentralization is not always possible and not always useful, the local ability and willingness usually become obstacles. In some cases, they do not have power and adequate finance to protect environment (Lemos & Agrawal, 2006).

Finally, ecological modernization (EM) is an approach that tries to combine both ecology and economy sectors (Warner, 2010). It is often that economic growth causes groundwater stress, however, in the EM approach, de-coupling both of them is possible. Therefore innovation and new environmental friendly technology are the key factors in EM. For instance, the invention of new technology in waste treatment can be implemented either to treat industries or households waste before they are disposed (Kemper, 2004, 2007; Mukherji & Shah, 2005; Giordano, 2009). This innovation can reduce the groundwater contamination significantly.

Contingency approach

The numerous of those governance theories have created a wide range of possible governance approaches that can be chosen. A wide range of alternatives poses interesting opportunities for coping and implementing with different and often changing societal conditions. However, according to Zuidema (2013), the performance of governance approaches are influenced by the circumstances encountered which depend on its complexity. Further, in term of groundwater governance, the complexity depends on groundwater characteristics, stakeholders to be involved, and also socio economic condition (Kemper, 2007). Groundwater characteristics vary not only in their spatial dimensions, but also in their yields and recharge profiles as well as contamination level. Moreover, various stakeholders, and socio-political settings, which influence strategy options, will diverge as much as aquifer characteristics. Strategies to protect groundwater resources will therefore have to be developed uniquely (Table 2.1). The key point is that the larger groundwater basin, the more the actors need to be involved. Further, the more the abstraction is compared to yield, the lesser groundwater availability in that aquifer. The combination of this situation will influence the complexity of issues to devise and the challenge to protect the groundwater resources in a sustainable manner.

Table 2.1. Governance implications for some types of aquifer–groundwater user relationships.

	Low abstraction rate compared to recharge and low intensity of contamination	**High abstraction rate compared to recharge and high intensity of contamination**
Small/medium groundwater basin	Limited complexity in developing groundwater governance	Medium to high complexity, but probably manageable due to small areal extent of intervention needed
	Few instruments (e.g. monitoring network) needed	Need groundwater protection in order to ensure sustainability
Large/extensive groundwater basin	Possibly higher complexity in developing groundwater governance due to spatial distribution	If extensive, major aquifer: Very high complexity to institute effective groundwater governance, both to achieve agreement and to monitor If extensive, but low permeability aquifer: High complexity due to high density of users; but low complexity because aquifer could be managed as local units
	Few instruments needed while abstraction remains low	Regulatory framework needed, based upon comprehensive resource assessment with critical appraisal of aquifer linkages

Source: adopted from Kemper, 2007

Note : The information shown in table 2.1 only serve as illustration and only divide into two extreme conditions, low and high, however in practice the condition often sit between them, therefore assessments will differ.

Moreover, according to Kemper (2007), the need and the option instruments for groundwater protection also changes over time. Figure 2.7 describes a typical curve for protecting groundwater, ranging from the baseline situation where groundwater is abundant to a high-stress situation where abstraction is very intensive and has caused groundwater issues. Logically, many people will argue that groundwater protection is needed only in the high-stress situation, however, Kemper (2007) thinks that it is not fully true and he said that groundwater protection would ideally be employed at any stage of aquifer use. Once groundwater has declined and contaminated, it may be difficult, costly, or even technically impossible to reverse this condition (Theesfeld, 2010). Moreover, although in baseline situation, monitoring is a necessity. However, since the action was not taken, the information may not be available. Consequently, it will be very difficult to develop a good strategy because the information is important as baseline (Kemper, 2007).

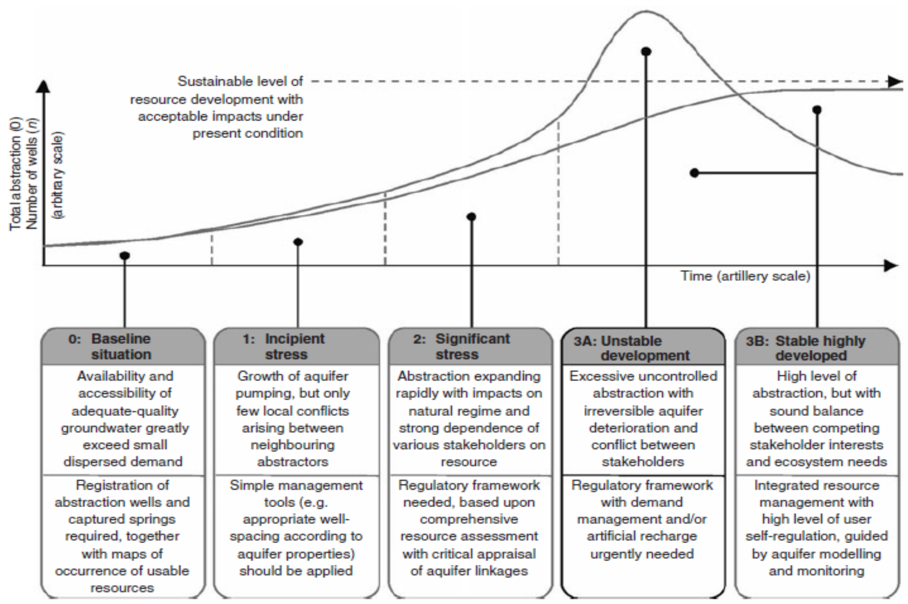

Figure 2.7. Stages of groundwater resource development in a major aquifer and their corresponding management needs (source: Kemper, 2007)

Following the principles of contingency theory which view every problem is context-dependent; it will be useful to explore various strategies and contexts embedded to them. Every region has their own strategies to overcome groundwater issues. Therefore, learning these various examples either their successfulness or failure can be very beneficial. Then suitable policy from other regions could be transferred from them. The concept of policy transfer will be described in the next section.

2.3. Policy Transfer

One of the main goals of this research is to give recommendation to improve the existing groundwater governance in Karo regency as borrower region. In doing so, comparative analysis will be used as a method as has been described in methodology section. By conducting comparison, the experience of other regions could be learned. The borrower learns not only what has worked in other regions but also can learn what not to repeat (Dolowitz and Marsh, 1996). In the policy perspective, Dolowitz and Marsh (1996) define this approach as policy transfer which means "a process in which knowledge about policies, administrative arrangements etc. in one time and/or place is used in the development of policies, administrative arrangements and institutions in another time and/or place" (p. 344). Moreover in doing policy transfer, a series of questions needs to address: Why do actors engage in policy transfer? Who are the key actors involved in the policy transfer process? From where are lessons drawn? What is transferred? What are the different degrees of transfer? What restricts or facilitates the policy transfer process?

There are two reasons why policy transfer is conducted, they are voluntary or coercive (Dolowitz and Marsh, 1996). First, voluntary transfer, it is conducted due to some form of dissatisfaction or problem with the existing condition. Second, unlike voluntary, coercive is conducted because there is a pressure from other such as government. Moreover, they identify six main categories of actors involved in policy transfer: elected official, political party, bureaucrats/civil servants, pressure groups, policy entrepreneurs/experts, and supra-national institutions. Objects that could be transferred by these actors include policy goal, structure and content, policy instruments, administrative techniques, institutions, ideology, ideas, attitudes and concepts, and also negative lessons. These objects could be learned either from within a nation such as central, provincial or local government or cross national such as international organizations and other nation including its central or local government.

Moreover, Rose identified five categories of policy transfer (as cited by Dolowitz and Marsh, 1996); copying, emulation, hybridization, synthesis, and inspiration (p. 351). Copying occurs when a country adopts a programme in use elsewhere without any changes. Emulation happens when a country accepts only a particular program that will be applied at home. Hybridization and synthesis involve combining elements of programmes found in two or more countries to develop a policy best-suited to the emulator. Finally, studying familiar problems in an unfamiliar setting can expand ideas and inspire fresh thinking about what is possible at home.

However, according to Dolowitz and Marsh (1996) and van Dijk (2006), there are four characteristics that should be noticed that make policy transfer is failed to be well implemented. The first is related to terminology, where the policy is misinterpreted by different localities. The second is jumping directly to a conclusion while problem’s core and instrument’s target have not matched yet. The next pitfall is in tailoring the procedure. It has to be concerned that an instrument is not one-size-fits-all. The implementation should consider local contexts. Finally, the assumption that views something new means better than the old ones frequently also leads to pitfall.

Chapter III

Groundwater Pressure and Current Groundwater Governance in Karo

Global concerns with the increased use of groundwater, the increased contamination of groundwater, and the associated problems of sustainability has necessitated renewed attention towards issues of groundwater governance. In doing so, several strategies such as regulatory or economic instruments have been advocated, mostly in the place where groundwater is extracted intensively. In spite of these measures, governing groundwater has proved intractable and in fact responses to intensive groundwater use are mostly not effective and have poor performance (see Giordano and Villholth, 2007; Shah, 2008; Theesfeld, 2010). In this chapter, such kind of groundwater issues will be explored deeply by taking Karo regency in Indonesia as case study.

Karo is selected due to some reasons. In Karo, groundwater is extracted intensively that more than 50 per cent of water demand supplied from groundwater resource. Besides that, groundwater in this region has contaminated due to human activities through domestic, industry and agriculture waste disposal. Consequently, groundwater depletion and degradation groundwater quality has become problems in Karo. In addition, due to high population growth (>1 %/year) and economic development (RGDP > 6%) in Karo, it is predicted that groundwater pressure will increase in the future. Unfortunately, this region only has limited policy and even recent strategies that have been implemented could not protect groundwater effectively.

3.1. Groundwater issues in Karo regency

The issues of groundwater depletion and contamination, as described in previous chapter, are generated by both natural pressure and also human intervention. On one side, hydrogeological conditions such as seasonal change and land topography or landscape characteristics could influence the availability of groundwater. On the other side, the human activities include groundwater withdrawal and waste disposal could cause groundwater level depletion and contamination respectively. In this chapter, those hydrogeological conditions, groundwater utilization, and human activities that could threat groundwater resources in Karo regency will be depicted. After that, the efforts that have been taken in order to protect its groundwater resources will be also described in this chapter.

3.1.1. Natural characteristics in Karo regency

Geography

Karo regency is located in North Sumatera province, Indonesia. The northern of Karo regency border are Langkat Regency and Deli Serdang Regency, the southern border are Dairi regency and Samosir regency, the eastern border are Deli Serdang regency and Simalungun regency and the western border is Nangroe Aceh Darusalam province. The area of this region is estimated 2,127.25 Km^2 and geographically is situated between 2^o 50’ to 3^o 90’ northern and 97^o 55’ to 98^o 38’ eastern (Figure 3.1). Karo regency consists of 17 districts and 262 sub districts. The widest district is Mardingding (267,11 Km^2 or 12,56% of regency area), but, the smallest district is Berastagi (30,5 Km^2 or only 1,43% of regency area). (BPS Karo, 2013).

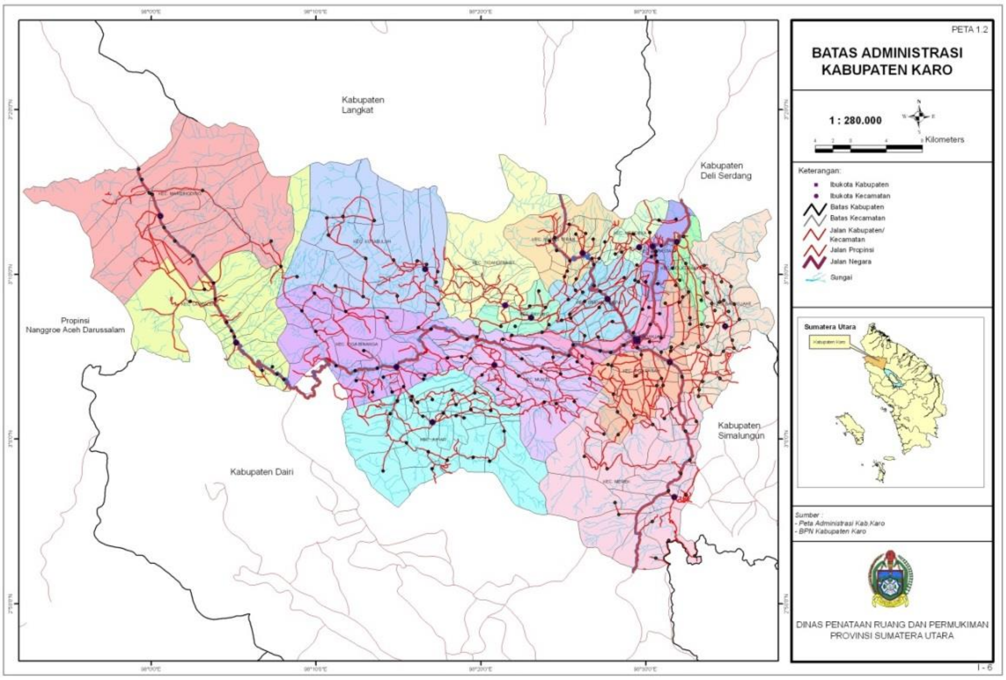

Figure 3.1. Administrative Map of Karo regency
Source: Pemerintah Kabupaten Karo (Government of Karo regency), 2013

Climate

Moreover, Karo is a tropical region, with two seasons; rainy season and dry season. Rainy season starts from August to January and from March to May, however, dry season comes in February, June and July (BPS, 2013). In 2012, the average rainfall in Karo is about 142.75 mm which reached a peak point about 268 mm on November, and on January reached a minimum point about 64 mm. Karo Regency is located on a plateau at an altitude from 600 to 1,400 metres above sea level (Figure 3.2), therefore, the temperature of this region relatively lower than other areas in North Sumatera. The air temperature in Karo is about 18.8ºC – 19.8ºC with the humidity average is about 84.66 percent.

Topography/landscape characteristics

Karo Regency is situated on the highland with varied highness from 280 to 1,420 above sea level. According to BPS (2013) and Pemerintah Kabupaten Karo (2013), about 46,462 Ha (21.84%) of Karo region is situated on the level of 280-500 m above sea level, and about 84,892 Ha (39.91%) and 70,774 Ha (33.27%) are lied on the level of 500-1,000 m and 1,000-1,400 m above sea level respectively. The rest of Karo region of 10,597 Ha (4.98%) lays on the level more than 1,400 m from sea level. In addition, the topography of Karo regency also varied; the flat area is about 23,900 Ha (11,24%), the slope area is about 74,919 Ha (35,22%), the aslant area is about 41,169 Ha (19,35%), and the cliff area is about 72,737 Ha (34,19%) (Figure3.2.) (BPS, 2013)

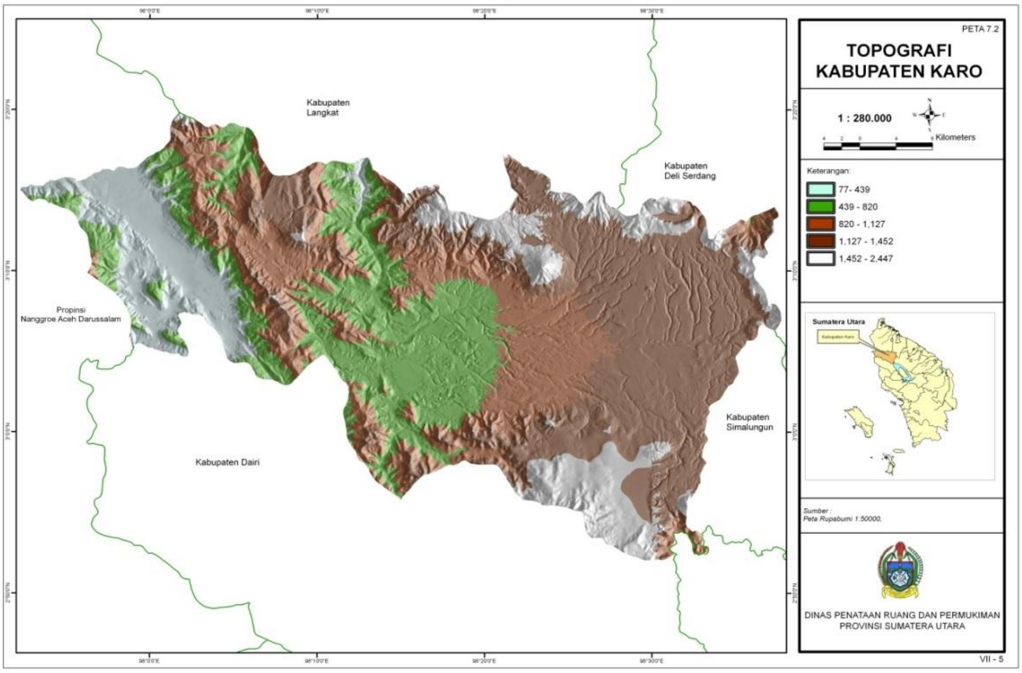

Figure 3.2. Topography map of Karo regency
Source: Pemerintah Kabupaten Karo, 2013

Groundwater aquifer characteristics

According to Badan Geologi (Geological Board of Indonesia) (2013), Pemerintah Kabupaten Karo (2013) and Distamben Propinsi Sumatera Utara (2014), based on its productivity, aquifer in Karo regency could be divided into four levels; scarce, little, local, and moderate (Figure 3.3). The productivity of scarce aquifer level is less than 10 litres per second. Most of Karo regency has this kind of aquifer; laid in the Mardinding district, a part of Lau Baleng district, Kutabuluh district, a part of Payung district, and a part of Juhar district. The second level is little aquifer, this kind of aquifer could produce 10 to 50 litres groundwater per second. Berastagi distric, Tigapanah district, Merek district and Munthe district has little aquifer level. The rest of Karo regions such as Barusjahe district have local aquifer level which could produce 50 to 100 litres ground water per second and a part of Laubaleng district has the moderate aquifer level; productivity 100 to 500 litres per second). However, these aquifers productivity is only the average number. In reality, the productivity of those aquifers depends on seasonal change. In dry season the productivity will decrease, but in wet season the productivity of aquifer will increase.

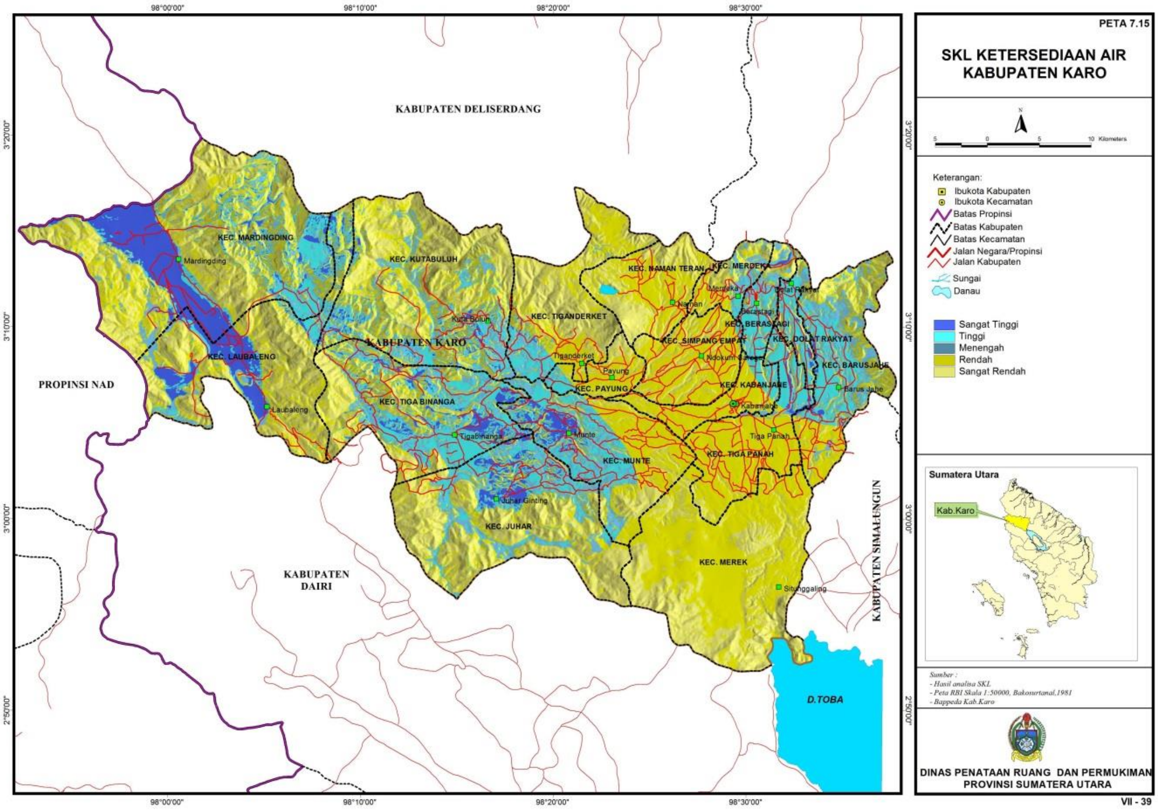

Figure 3.3. Groundwater availability map of Karo regency
Source: Pemerintah Kabupaten Karo, 2013

3.1.2. Threats on groundwater resources due to human activities in Karo regency

Groundwater Extraction

Groundwater is crucial to Karo regency (BPS, 2013). Groundwater is used not only for cooking, bathing or washing, but also useful for agriculture, as well as other sectors of the economy such as industries and animal husbandry. According to BPS (2013), most of people in Karo regency rely on groundwater as drinking, bathing and washing water supplier. They utilize different kinds of groundwater resources include deep well, shallow well and spring. Even, groundwater provided by water Tap Company (PDAM) is supplied from groundwater wells. In 2013, about 85.87 per cent villages in Karo use groundwater as their clean water suppliers (BPS 2013).

Even though, there are two water tap companies (*PDAM Tirtanadi and PDAM Tirtamelem)* in this region, they could not provide clean water to all of people in Karo (BPS, 2013). They only service about less than 25 per cent of people water demand. For instance, in 2013, only about 21,000 of 98.300 households in Karo get water from PDAM. As consequence, most of people rely on groundwater to supply their demand. According to Distamben Kabupaten Karo (Department of Mining and Energy of Karo regency) (2013), there are more than 200 individual deep wells in this region. This trend will increase correspondingly to population growth and economic development. According to BPS (2013), nowadays, the population number of Karo regency is more than 350.000. Based on population growth for the last decade, and also by considering the economic growth, it is predicted that population number in this region will about 400 thousands people, even it will reach 450 million people in 2040. Since, the clean water is not supplied by PDAM adequately; the pressure to groundwater resources will also increase significantly.

Besides population growth, the economic development also causes the increasing pressure on groundwater resources in Karo regency (Dinas Pertambangan dan Energi, 2013; BPS, 2013). Most of people in this region live as a farmer, and the main livelihood of Karo society is agriculture production, horticulture and society plantation. Although some of agriculture areas are wet land, most of agriculture lands in Karo are dry land. The agricultural activities Karo regency such as paddy, fruits, flowers, cassava, sweet potatoes, peanuts, soybeans, candlenut, coffee, coconut, tobacco, cocoa, oil palm, sugar palm, clove etcetera need much water especially in dry season. However, due to the lack of surface water availability, the farmers extract groundwater for watering their plants. According to BPS (2013), more than 90 percent of agriculture in Karo regency rely groundwater as sources of watering demand.

Land use change

Land use changes also influence groundwater availability (Heath, 1983; Aral and Taylor, 2011). As described in previous chapter, since the quantity of groundwater depends on amount of infiltration, the landscape characteristics where infiltration process occurs will influence the number of water trapped in aquifer. The settlement areas will reduce the infiltration process; in contrast, forest and vegetation cover could reduce runoff and increase infiltration. Therefore, the presence of forests and vegetation is very important as recharge areas. However, due to population growth and economic growth, many of recharge areas have changed to developed areas such as settlements or agriculture.

Data show that during last decade, the land use changes have been occurred intensively in Karo regency (Pemerintah Kabupaten Karo, 2013). In 2004, the forests areas cover 76,835 Ha or about 36.12 percent of total region area. However, in 2009, it has reduced to only 65,113 Ha or the forest has decreased about 15 per cent. Most of those forests are changed to settlements, and agricultural use. As consequence, the number of infiltration decreases, but the number of runoff increases in Karo regency.

Groundwater contamination

The contamination of groundwater is often derived from human activities. The pollutants could come from settlements, industrial activities, agricultural activities or other human activities. In Karo regency, for instance, most of groundwater pollutants are produced from settlements and agricultural areas (BPS, 2013).

Firstly, households' waste, septic tank and also landfill areas from settlement areas in Karo dispose to the environment without sufficient treatment (BPS, 2013). Most of household's waste as side products of cooking, bathing and washing is disposed freely. They dig hole as storage place, and leave waste alone to infiltrate to the soil. As consequence, the dangerous pollutants from household's waste such as detergent could find the aquifer and contaminate the groundwater. Moreover, as well as household's waste, most of household's septic tank is also constructed simply by digging hole in the permeable soil (BPS, 2013). The waste from water closet is disposed and stored in the hole, and let it infiltrate through the soil. Therefore, it could be possible for bacteria or other dangerous substances flow to the aquifer and poison the groundwater. Besides that, another source that produces groundwater pollutant is landfill. In Karo regency, landfill is located on valley and there is not properly constructed. The solid waste collected from settlements area is disposed and stored in landfill freely. This solid waste is left alone without further treatment. As consequence, the waste will be decomposed and generate leachate. This pollutant then contaminates soil, and finally could infiltrate to the aquifer and polluting groundwater. Leachate can contain high levels of bacteria, hazardous chemicals, metals, and ammonia.

Secondly, in Karo regency, the presence of industries also contributes to contaminate groundwater (BPS, 2013). The activities of industries such as tofu or other foods industries in this region produced hazardous waste. Unfortunately, most of these industries do not have proper waste treatment plant; they dispose the waste to environment freely. As consequence, these improper industrial waste disposals infiltrate through soil and can create groundwater pollution. Thirdly, groundwater contamination is also come from agricultural areas (BPS, 2013). To increase agricultural productivities, farmers in Karo regency use pesticides and chemical fertilizers intensively. Pesticides are used to protect the plants from pests attack and chemical fertilizers are used to increase soil fertility. However, like pesticides, misuse of fertilizers can cause groundwater pollution. Overuse can allow nitrates from fertilizer to seep into the water table. In sensitive groundwater areas, rainfall seepage can cause fertilizer to migrate and contaminate an aquifer.

Besides households, industries and agricultures, another source of groundwater pollutants could come from animal husbandry (BPS, 2013). In Karo, animal waste is disposed without treatment; they dispose animals' waste to lagoons directly. However, the lagoons used to trap animal waste if they leak or if the water table is too close to the land surface could cause groundwater contamination. This waste is the sources of bacteria and nitrates and could flow to groundwater aquifer.

3.2. Impacts of groundwater issues in Karo regency

3.2.1. Impacts of groundwater level depletion

The groundwater depletion as a result of over-pumping has been occurred in groundwater basin in Karo regency (Sumut Berita, 2012; Distamben Propinsi Sumatera Utara, 2013). This groundwater basin is inter- regency basin which lies from Karo regency to Medan, North Sumatera province. Even though the groundwater decline is caused by many factors, it is believed that well pumping contributes significantly. According to Distamben Propinsi Sumatera Utara, nowadays, the groundwater table declining in Karo has reached 2.5 metres.

Further, there are some consequences of groundwater depletion. Firstly, many of households well shallow have been dried (BPS, 2013, Dinas Pertambangan dan Energi Kabupaten Karo, 2014). Therefore, to get clean water, the well must be dug deeper and deeper. In Kabanjahe for instance, ten years ago, people still could get water through shallow well, however, nowadays, they must use deep well to find confined aquifer (Pemerintah Kabupaten Karo, 2013). To get clean water, people must drill the well up to 100 metres and it needs much money not only for construction but also for operational cost such as electricity. Secondly, although land subsidence is also triggered by natural activities such as earthquake, it is believed that groundwater depletion has contributed in causing land sinking in this region. Unfortunately, according to Pemerintah Kabupaten Karo, there are not quantitative data related to the rate of land subsidence in Karo. However, as comparison, according to Chaussard et al (2013), the rate of land subsidence in Medan which has the same groundwater basin with north side of Karo regency, is up to 8 cm/year (Figure 3.4).

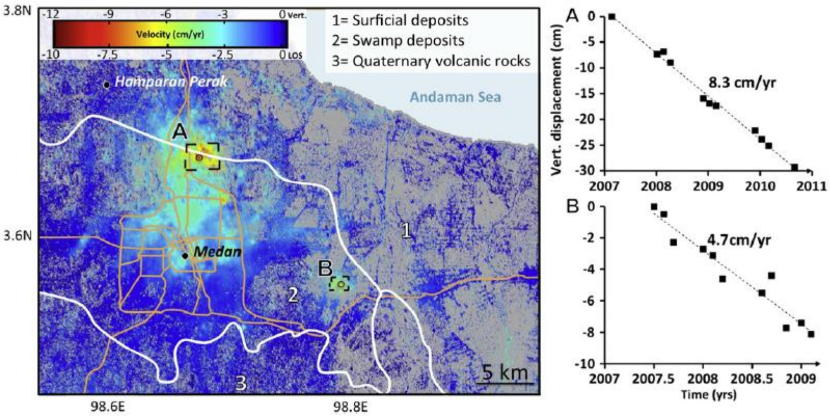

Figure 3.4. The rate of land subsidence in Medan
Source: Chaussard et al (2013)

3.2.2. Impacts of groundwater contamination

In areas where groundwater is relied to fulfil human demands, the contaminated groundwater will become a big problem (BPS, 2013). Consuming or using it to support human activities could cause health problems such as diarrhoea, hepatitis, typhoid, trachoma, and hookworm infection. In addition, fisheries and agriculture also will damage when using contaminated groundwater. Besides that, it also threatens ecosystems through eutrophication and is responsible for the loss of plant and animal species.

It is true that the full impacts of groundwater pollution on health, fisheries, agriculture and environment have not been assessed comprehensively (Pedley and Howard, 1997). The health problems, damages on fisheries, agriculture and environment are also associated with other factors such as human body immune and natural activities. Hence, data related to number of people, fisheries, agriculture and environment affected by contaminated groundwater is very difficult to find. However, the evidence shows that groundwater has been contaminated in some areas in Karo regency and also *Medan* groundwater basin (Pemerintah Kabupaten Karo, 2013). It is believed that groundwater pollution has contributed to cause some health problems, decreasing fisheries and agriculture productivity and also damaging environment.

3.3. Groundwater protection in Karo regency

As we have seen, groundwater issues in Karo regency are related to groundwater table depletion and contamination. The impacts of these issues further have caused land subsidence in some areas and also degradation of groundwater quality. In this part, how the groundwater in Karo is protected will be explored.

In Indonesia, groundwater protection involves many stakeholders and various laws (Tirtomihardjo, 2009; Badan Geologi, 2013). However, many of these laws and stakeholders were originally enacted to primarily regulate and manage the use and management of natural resources and the environment, rather than provide protection. To give a broader perspective in viewing groundwater protection, the discussion will be started by exploring historical development of water resources protection. From the history, it is expected that various strategies and policies that have been established and implemented can be well understood, include their strengths and also the failures. By learning from the past, it then implicates to the consideration that should be taken into account when new strategies are proposed.

3.3.1. Stakeholders in groundwater protection in Karo

Water resources protection in Indonesia has been initiated during the Dutch colonial period with the establishment of Department of Public Works (*Burgerlijke Openbare Werken/ BOW*) (Sugiyono, 2012). Through this organization, in 1936, formal regulation with regard water authorisation namely *Algemeen Water Reglement (AWR)* was established and approved by Volksraad (House of Representative). In this regulation, the authority and obligation of water resources belonged to central (colonial) government and the regulation only focused on surface water management such as sanitations, irrigations, and drainages.

After the independence proclamation in 1945, Soekarno took over political power in Indonesia) (Sugiyono, 2012). Similar to colonial principle, water management in this era was also controlled by central government. The policy related to water resources was enacted in Indonesia Constitution of 1945. However, this regulation only has general provisions on management of water resources. As stipulated on article (3) Paragraph 33, “Land and water and natural riches contained therein belong to and are controlled by the state and used for the welfare of the people". It means that the groundwater management became the authority of central government and the presence of groundwater in Indonesian must be used to meet the water demand for the benefit of the people. Further, in 1962 the government of Indonesia issued Law Number 5 Year 1962 which regulated the possibilities of local government company establishment (PDAM). This regulation became legal basis for the establishment of local water tap companies that were owned by local government called *Perusahaan Daerah Air Minum (PDAM)* in Indonesia.

The centralized government system in Indonesia continued in New Era of President Soeharto (Sugiyono, 2012). In this era Indonesia’s legal and administrative systems are extremely centralized. Most of the environmental policy decisions are created by central government. Governments for provinces, cities and other local municipalities are deemed to be local agencies of the central government, or organizations to implement the policies of the central government. Indonesia’s national policy and organizations on environmental conservation includes water resources protection was started in era of President Soeharto.

Even though, there were many development of environmental policy in this era, the most important thing was occurred in 1990. With the enactment of the 23rd Presidential Decree of 1990 (Pemerintah Indonesia, 1990), The Environmental Impact Management Agency (*BAPEDAL: Badan Pengendalian Dampak Lingkungan*) was inaugurated. Moreover, the Presidential Decree No. 77 of 1994 brought about a dramatic reorganization and strengthening of functions of BAPEDAL, which became an organization under the direct control of the President for environmental administration (Pemerintah Indonesia, 1994). This resulted in a system where the Ministry of Environment fulfils a coordination function for formulating policies on environmental problems, and BAPEDAL implements specific environmental conservation policies and pollution control measures.

BAPEDAL is actively promoting the measures to control water pollution, air pollution, hazardous and toxic waste, and the implementation of environmental impact assessment. Of these, water pollution control measures have particularly high priority. The river water quality improvement program called PROKASIH (water pollution control programme) is being implemented with the goal of preventing water pollution caused by business operations and improving river water quality. This program is attempting to reduce pollutants which flow into rivers by monitoring water quality in major rivers throughout the country, and strengthening on-site inspections of factories.

After the termination of Soeharto’s regime, decentralisation system was adopted in Indonesia government system. Indonesia has been undergoing a reform process. One of its features is the introduction of new decentralization guidance in 2001 under Law 22/1999 on regional governments and Law 25/1999 on fiscal balance between the central and regional governments and in 2004, they were replaced by Law 32/2004 and Law 33/2004 (Pemerintah Indonesia, 2004). With these laws, local governments include Karo regency receive large transfer of authority and decision-making discretion from central government to develop and to govern their own regions. Recently, there are three levels of government involve in water resources protection in Karo regency, namely central government, provincial government and local government. The authority of each level is described in Table 3.1.

Table 3.1.The authority of three level of government in water resources protection in Karo regency

Agency	Authority
National Level	
Ministry of Environment and Forestry	• Coordinating all activities related to water resources • Formulation of policy related to water resources issues • Compliance monitoring and supervision • Inquiry on and investigation of environmental criminal cases
Sector Ministries (Ministry of Health, Ministry of Public Work and Settlement, Ministry of Energy and Mineral Resources)	• Responsible for implementing water resources management policy in each sector/department • Issuing business licenses • Monitoring compliance with business licenses requirements • Managing supervision on business license requirements • Imposing administrative sanctions for violation of business license requirements
Provincial Level	
	• Responsible for implementing the water resources management policy in its territory for cross-regency/city water resources issues • Issuing permits related to water resources in its territory • Compliance monitoring • Managing supervision • Imposing administrative sanctions
Regency Level	
	• Responsible for implementing the water resources management policy in its territory • Issuing permits related to water resources in its territory • Compliance monitoring • Managing supervision • Imposing administrative sanctions

Source : Adopted from Pemerintah Indonesia, 2004 and Wangsaatmaja, 2006

3.3.2. Policy and regulations related to water resources protection in Karo regency

The principles of groundwater protection in Indonesia are accommodated in the Law Number 7 Year 2004 (Pemerintah Indonesia, 2004). This issue is specifically stated in the third chapter of the law consisting of six articles (article 20, 21, 22, 23, and 24). According to this law, water resources (both surface and groundwater) and environmental condition that is related to the quality of water resources such as catchment areas in the upstream, river banks, and so forth are supposed to be conserved in order to sustain the availability of water and prevent water-related issues either caused by human or nature.

Besides Law No. 7/2004, several regulations that related to groundwater protection have been established by central government, provincial government as well as Karo regency government (Tirtomihardjo, 2009; Badan Geologi, 2013). Generally, the regulation provides groundwater management plans, which contain data and information of groundwater used for the stipulation of groundwater conservation zones where activities on the protection and preservation of groundwater and on the control of groundwater contamination are carried out; requirements and procedures for obtaining groundwater use permits or groundwater exploitation permits; groundwater information systems for the storage, processing and dissemination of groundwater data and information to support groundwater management; empowerment, control and supervision on the management of groundwater; administrative sanctions; etc. The law enforcement through those regulations is expected could control the groundwater extraction and contamination. Regulations related to groundwater protection in Karo are shown in table 3.2.

Table 3.2. Regulations related to groundwater protection in Karo regency

Government Level	Regulations
National Level	Law No. 7/2004, concerning water resources management
	Law No. 26/2007, concerning spatial planning
	Law No. 18/2008, concerning waste management
	Law No. 32/ 2009, concerning environmental protection and management
	Government regulation No. 27/1999, concerning Environment impact assessment
	Government regulation No. 82/2001, concerning management of water quality and control over water pollution
	Government regulation No. 43/2008, concerning groundwater
	Government regulation No. 27/2012, concerning environmental permit
	Government regulation No. 81/2012, concerning waste management
	President regulation No. 33/2011, concerning national water resources policy management.
	Presidential decree No. 26/2011, concerning groundwater basins stipulation
	Ministry of Energy and Mineral Resources regulation No. 15/2012, concerning Efficiency of groundwater utilization
	Decree of Minister of Energy & Mineral Resources No. 1451K/10/MEM/2000, concerning Technical guidelines on groundwater management
Provincial Level	
	North Sumatera province government regulation No. 7/2003 concerning North Sumatera spatial planning
	North Sumatera province government regulation No. 4/2013 concerning groundwater management
Karo regency Level	
	Karo regency government regulation No. 3/2013 concerning groundwater taxation

Source: Adopted from Badan Geologi, 2013 and Pemerintah Kabupaten Karo 2013.

3.3.3. Groundwater protection in Karo regency

Basically there have been several policies established as guidance to protect groundwater In Karo regency. However, most of the policies were established by central government, only one of them was enacted by local government (see table 3.2). Since Indonesia has adopted decentralize government system, those central government regulations shall be translated into Karo context. Unfortunately, in fact, Karo only has one regulation which just regulates groundwater taxation. Karo still struggle to develop the other regulation such as groundwater license. This situation has become the main constraint to protect groundwater resources in this region (Pemerintah kabupaten Karo, 2013). In this section, the instruments that have been implemented in Karo to protect its groundwater resources and also its effectiveness will be described.

Regulatory instrument

Actually, the regulations as described in table 3.2 have accommodated general guide lines, related to groundwater in Indonesia as well as Karo regency. However, the implementation of those regulations is still not effective even is ignored by users. For instance, in Law No.7/2004, it has been stated that every groundwater well shall have permit from government, however, in Karo regency, many of private groundwater wells are unregistered. According to Pemerintah Kabupaten Karo (2013), more than 50 per cent of groundwater extraction in this region do not have permit. Several obstacles remain to implement the regulations. Until now, there is not local regulation in detail related to groundwater utilization in Karo such as obligation, right and sanction. Consequently, the implementation of the regulation is not effective (Pemerintah Kabupaten Karo, 2013). In addition, particularly in urban areas, there is no other water source alternative; hence, closing unregistered wells becomes dilemma. In one side, controlling groundwater utilization is very important for sustainability, in the other side, water is indispensable for people. To close unregistered wells in that area could then lead to cause social conflict (see Llamas & Martinez-Santos, 2005).

Economic instrument

Besides regulatory, Karo has also implemented economic approach in order to control groundwater extraction in this region (Pemerintah Kabupaten Karo, 2013). Even it has been had legal basis which is Karo regency government regulation no.3/2013 concerning groundwater charge. However, this instrument only implemented for industrial use commercial used. Therefore, in fact, most of groundwater users in Karo are used for domestic and agriculture. Besides that, groundwater is cheaper than water provided by local water company (PDAM), therefore, people prefer to use groundwater.

Other/supporting instruments

Besides regulatory and economic instruments, other efforts that have been implemented in Karo are groundwater inventory and monitoring. Groundwater inventory that have been done includes groundwater/ hydrogeological mapping, groundwater/ hydrogeological investigation (e.g. investigation which related to assessment on groundwater resource potential of the groundwater basin), groundwater/ hydrogeological research (e.g. groundwater quantification and modelling, use of isotope for delineating groundwater recharge area, etc.), groundwater exploration (e.g. exploration and development of groundwater for supplying water consumption in area of water shortage).

One of the results of this inventory was groundwater basin map in Karo regency (Badan Geologi, 2013) (Figure 3.5). According to figure 3.5, there are three kinds of groundwater basin in Karo regency, namely inter-province, inter-regency, and intra-regency groundwater basins. The orange one is inter-province groundwater basin. This basin lays in a part of Mardinding and Laubaleng district. The green one is inter-regency groundwater basin; it includes Berastagi district, Barusjahe district, a part of Tigapanah district and also a part of Namanteran District. However, the rest of Karo region is the blue one which means the groundwater basin in one region. This basin belongs to Karo regency responsibility.

Actually, groundwater data and information obtained from the above activities (groundwater inventory) are used to establish zone of groundwater conservation such as groundwater recharge area, and zone of groundwater use that consist of safe, buffer, critical, and damage zones. However, there is not follow-up action regard to this data (Pemerintah Kabupaten Karo, 2013).

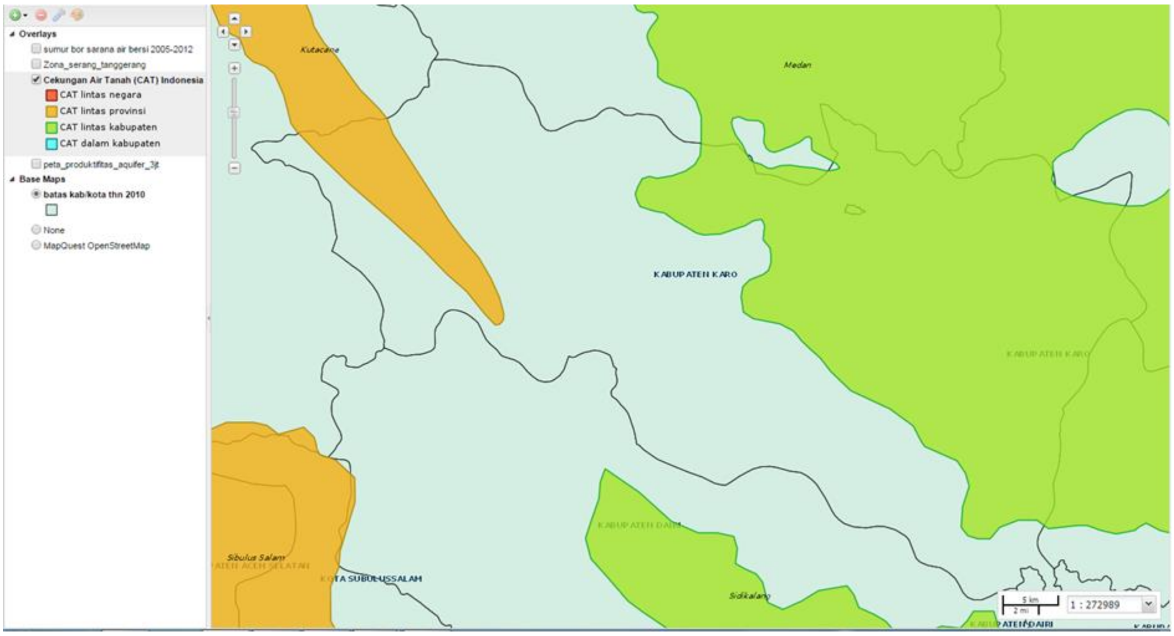

Figure 3.5. Groundwater basin map of Karo regency
Source: Badan Geologi, 2013

Moreover, groundwater monitoring has been performed in order to know the change of groundwater quantity and quality in a certain groundwater basin, and to be needed for supporting activities on groundwater conservation (Badan Geologi, 2013). Groundwater monitoring has been done at monitoring wells or production wells within the groundwater basin that include several items such as to measure and record groundwater level (phreatic and piezo metric levels), to measure and examine physical, chemical, biological parameters and radioactive constituent on groundwater, to record amount of groundwater use and to measure and record the change of groundwater environment, e.g. land subsidence phenomena. Unfortunately, this effort has not been done well and routinely, hence, data related to condition of groundwater in Karo regency either quantity and quality do not available (Pemerintah Kabupaten Karo, 2013). Lack of monetary and human resources are the main constraints to conduct this monitoring.

Table 3.3. Summary of groundwater protection in Karo regency

Instruments	Institutions	Leading stakeholder	Effectiveness	Obstacles
Regulatory approach				
Using of License	Law No. 7/2004, Government regulation No. 43/2008, Ministry of Energy and Mineral Resources regulation No. 15/2012, North Sumatera province government regulation No. 4/2013	- Central government for inter-provincial basin - Provincial government for inter-regency basin - Local government for intra-regency basin	Poor	- No local regulation yet - Weak in law enforcement - No water source alternative - Lack of budget - Lack of human resources
Closing Unregistered Wells	Law No. 7/2004, Government regulation No. 43/2008, Decree of Minister of Energy	- Central government for inter-provincial basin - Provincial government for	Poor	- No local regulation yet - Weak in law enforcement

	& Mineral Resources No. 1451K/10/MEM/2000, North Sumatera province government regulation No. 4/2013	inter-regency basin - Local government for intra-regency basin		- No water source alternative - Lack of budget - Lack of human resources
Economic approach				
Charging groundwater usage	Karo regency government regulation No. 3/2013	Local government	Poor	- No charge for domestic use - Groundwater is cheaper than PDAM
Voluntary/advisory approach				
Groundwater inventory	Law No. 7/2004, Government regulation No. 43/2008, Decree of Minister of Energy & Mineral Resources No. 1451K/10/MEM/2000	Local government	Poor	- Lack of monetary - Lack of human resources - No follow-up
Monitoring of groundwater table, land subsidence and groundwater quality	Law No. 7/2004, Government regulation No. 43/2008, Decree of Minister of Energy & Mineral Resources No. 1451K/10/MEM/2000	- Central government for inter-provincial basin - Provincial government for inter-regency basin - Local government for intra-regency basin	Poor	- Lack of monetary - Lack of human resources - Data is not up to date - No follow-up

Note :

Excellent: The existence of regulations to manage water in detail and there are no obstacles in implementation

Good: The existence of regulations to manage water in detail and there are few obstacle in implementation

Acceptable: The existence of regulations to manage water in general and few in detail, and still few problem found in implementation

Poor: The existence of regulations to manage water in general and few in detail, and many problems were found in implementation

Very poor: No regulation to manage water even though only in general

Table 3.3 provides summary of groundwater governance in Karo including the institutions, leading stakeholders, effectiveness and obstacles in implementation of existing instruments. This table shows two main messages. First, most of regulations in this region are central government regulations which only provide general rules and only one detail regulation was enacted by local government. Second, the performance of instruments that have been implemented was poor, due to the existence of regulations to manage water only in general and few in detail and many obstacles were faced in the implementation, hence improvement is a necessity. To improve groundwater governance in Karo, there might be conducted by learning from other regions. Experience in groundwater issues and groundwater protection in other regions will be depicted in the next chapter.

Chapter IV
Efforts to Protect Groundwater in Bandung, Bangkok and Tianjin

In the previous chapter, the issues related to groundwater resources in Karo regency have been described. Even though, to response that issues, government either central or local government has established many regulations to protect groundwater resources in Karo, those strategies are still not effective and has poor performance. Therefore, the improvement of current policy or even the development of new strategies is a necessity.

As has been described on previous chapter, in order to improve or to develop new policy, in this research, comparative analysis is used as a tool. Therefore, in this chapter, the discussion of groundwater governance in other relevant regions (references) will be elaborated; how their groundwater condition is and what their strategies in protecting groundwater are. However, to find the best and the most appropriate references, the process of selecting examples to be learned is crucial (Dolowitz and Marsh, 1996). Hence, in the beginning of this chapter, it will be discussed the considerations in selecting regions to be learned.

4.1. Considerations in selecting regions to learn from

It has been described on theoretical framework chapter that policy transfer can be distinguished into five categories namely copying, emulation, hybridization, synthesis, and inspiration. The difference of those categories is mainly on how host region manage the policy from donor region. In copying, policy is adopted without any change, but in last category, the policy from other regions is only used as inspiration about what is possible at home. It means that policy transfer actually could be conducted even borrower and lender (s) are not exactly 'match' or even truly different one each other. However, to make comparison meaningful, some obligatory prerequisites must be met by lender regions (see methodology).

In this research, other regions that are selected as lender regions are Bandung Indonesia, Bangkok Thailand and Tianjin China due to several reasons:

1. Bandung, Bangkok and Tianjin have had much experience related to groundwater issues. Data show that pressure on groundwater resources in these regions relatively

high since a last decade. Groundwater has been exploited intensively to meet people demand and also to support their activities, and groundwater quality in these regions has also decrease as result of waste disposal from people activities.

2. Besides that, these regions have also experienced the impacts of groundwater exploitation and contamination. For instance, Groundwater table decline followed by its further impacts such as infrastructure damage, groundwater contamination, even social conflict has been perceived in these regions.
3. These lender regions have had much experience in groundwater governance. They have had several strategies in groundwater governance including policy instruments, institutions, and stakeholders.

In addition, according to Dolowitz and Marsh (1996), in policy transfer, the more similar the both borrower and lender regions, the lesser obstacles that could be faced, Therefore, ideally, besides obligatory prerequisites, selected regions should have similar characteristics for both hydrological characteristics and socio-economic conditions. Unfortunately, due to limitation of data and time, in this research these criteria could not be met. Compared to Bangkok and Tianjin, Bandung is more similar with Karo in term of groundwater characteristics and socio economic. However, learning from abroad with different hydrogeological and socio-politic condition such as Bangkok and Tianjin will be also interesting. It will give broader understanding in groundwater governance and provide more option that could be learned and adopted.

4.2. Groundwater protection in selected regions

4.2.1. Groundwater protection in Bandung, West Java, Indonesia

Physical characteristics

Bandung is located in Bandung Basin and often referred to as Bandung Metropolitan (BPS Kota Bandung, 2014). Its elevation is about 768 metres above sea level and surrounded by Late Tertiary and Quaternary volcanic terrain. It has seven main tributaries and one of the biggest river on the island of Java namely Citarum river. Geographically, Bandung is located in West Java Province, Indonesia, with the latitude of the area is 7°19' - 6°24' south and the longitude is $106^{o}51'$ - $107^{o}51'$ east. The topography of this region is mountainous with latitude ranges from 500 to 1,200 metres above sea level and has humid and tropical climate.

Groundwater basin in Bandung is known as Bandung Basin and covers area of 1,370 km^2 include four administrative areas, a part of Bandung regency, Sumedang regency, Bandung city and Cimahi city (Wangsaatmaja et al, 2006; Chaussard et al, 2013; Widodo, 2013). In the north side, it is bordered by the Lembang fault; in the west, it is bordered by permeable tertiary rocks; and in the south and east lies surface water barriers. Moreover, the condition of groundwater in Bandung also has various potential in different locations. Based on groundwater quantity and quality, there are two areas of groundwater potential, in this region namely moderate potential of groundwater in shallow and deep aquifer and area with moderate potential of groundwater in shallow aquifer and low potential in deep.

Further, as tropical region, Bandung also has two seasons namely wet and dry season. (BPS Kota Bandung, 2014). The wet season extends from November to April and the dry season occurs from Mei to October. The average annual rainfall in the Bandung Basin varies from 1,000 mm in mid-regions to the south-east of Bandung City, to more than 3,500 mm in the north and less than 3,000 mm in the south. The yearly rainfall intensity ranges between 1,700 to 3,500 mm with a mean value of 2,195 mm. The average temperature is 22.6°C, and evapotranspiration value is 1,060 mm/year.

Socio-economic

The population of Bandung city was about 2.5 million in 2014 with population growth about 2.7 per cent per year (BPS Kota Bandung, 2014). The Regional Gross Domestic Product (RGDP) growth rate in the Bandung reached 15.66 per cent per year. According to current prices, the trade sector contributed around 31.91 % of total the city's RGDP, followed by industry (30.85 %), with communication ranking third followed by services at around 10.79 % (BPS Kota Bandung, 2014).

Groundwater Use

As well as Karo regency, the lack of clean water provided by the local water tap company has led to the increasing of groundwater extraction in Bandung (Wangsaatmaja et al, 2006). Based on data provided by PDAM Tirtawening (Bandung water tap company), in 2008, only about 64 percent of Bandung region has covered by PDAM Tirtaweing. As consequence, there were many people in Bandung relying on groundwater as their water supplier. The biggest users of groundwater in this area were domestic and industrial sectors. Even, in several areas, the local water tap company (PDAM Tirtawening) also used groundwater as a source for domestic water supply. In 2008, there were 32 wells used by PDAM as water sources. Besides that, another factor that causes the increase of groundwater extraction in Bandung was related to water price. Overall, the price of groundwater was cheaper compared to water provided by PDAM. (Gunawan, 1995; Wangsaatmaja et al, 2006). As consequence, many residents prefer to use groundwater rather than other sources.

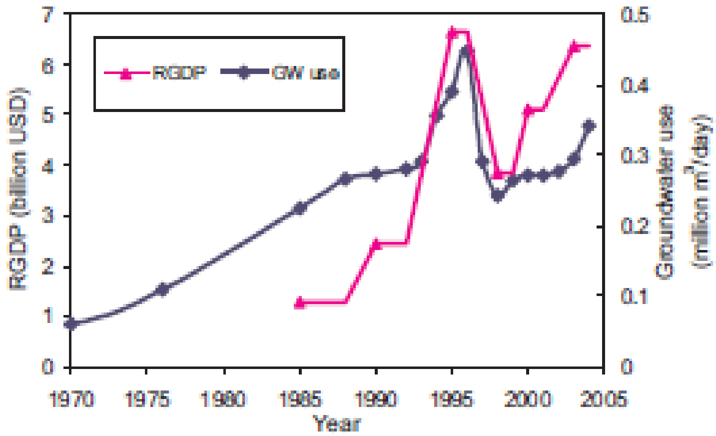

Figure 4.1 Groundwater use in Bandung
Source: Wangsaatmaja et al, 2006

Moreover, according to Directorate of Environmental Geology (1996), groundwater has been extracted and relied to fulfil domestics and other demand since 1900, even in 1997 reached the highest point (see Figure 4.1). Recorded data in 1993, groundwater exploitation reached about 0.3 million m^3 and tend to increase up to 0.45 million m^3 in 1997. However, due to economic crisis in 1998, many industries collapsed which resulted in decreasing in groundwater use. After the economy recovered and due to population growth and economic development, the trend of groundwater extraction has started to increase again (Wangsaatmaja et al, 2006). As consequences, the groundwater issues mainly water table depletion has been inevitable since a long time ago (Wangsaatmaja et al, 2006; Chaussard et al, 2013).

Groundwater issues

According to data from monitoring wells during some periods, there has been a significant decline in the groundwater table in the Bandung Basin (Wangsaatmaja et al, 2006;

Chaussard et al, 2013). For instance, in 1920, positive artesian identified in *Dayeuhkolot-Bojongsoang* area was +4.0 m above ground level, but in 1960 the water table declined to +3.9 m above ground level, even in the mid-1970s, the water table dropped to -2 m below ground level and had fallen to 40 to 80 m below ground level by 1990. Moreover, according to Directorate of Environmental Geology, the areas with the most severe depletion of the static groundwater level forming a cone of depression was *Cijerah, Cimanggung, Rancaeke and Leuwigajah.* In Cijerah, the groundwater table depletion exceeded 20 m during the period from 1997 to 2004, in *Cimanggung* the depletion of water table reached 60 m from 1994 to 2004, in *Rancaekek*, depletion has also exceeded 60 m over the past decade, and in *Leuwigajah* Industrial Estate, depletion reached 40 m over the period from 1994 to 2004. Some consequences of that water table decline are land subsidence, land subsidence that was occurred on *Cijerah, Cimanngung, Rancaeke and Leuwigajah*. In settlements and residential areas has caused the difficulty in extracting water from their dug wells. Moreover, groundwater depletion is also affecting Water Supply Enterprise where the volume of deep wells has declined from 550 liters/second in 1982-1983 to only 115 litters/second in 2004.

Besides groundwater table depletion, another issue related to groundwater in Bandung is groundwater contamination (Wangsaatmaja et al, 2006). The result of laboratory tests on 50 samples from various locations in the Bandung Basin in 2005 revealed that 78% of the samples did not meet the health quality standard and 70% exceeded the faecal coliform standard. Only one location had an absence of coliform bacteria, which was thought due to the fact that the well was quite deep. In fact, 90% of all dug wells sampled were relatively close to septic tanks. It is believed, therefore, that all the dug wells have been contaminated by septic tanks waste. Another reason for the high levels of coliform exceeding the standard is the poor state of sanitation around point at which the water is extracted.

Groundwater protection in Bandung and its effectiveness

Compared to Karo regency, Bandung has more regulations related to groundwater resources protection (Gunawan, 1995; Wangsaatmaja et al, 2006; Badan Geologi, 2013; Pemerintah Kota Bandung, 2015). Those regulations include national, provincial and also local government regulations. Although, the issues with regard to groundwater are still identified in some places, the implementation of those regulations such as Government regulation No. 43/2008 concerning groundwater, Decree of Minister of Energy & Mineral Resources No. 1451K/10/MEM/2000 concerning Technical guidelines on groundwater management and Government of Bandung Municipality regulation No. 03/2012 concerning groundwater management has been giving positive effect. Nowadays, most of groundwater well in Bandung has meter which could be used to measure volume of groundwater extraction as base for charging calculation.

While the establishment of the regulation has had positive impact in Bandung groundwater protection, the lack of clean water provided by local water company (PDAM Tirtawening) has become a big constraint (Gunawan, 1995; Wangsaatmaja et al, 2006; Badan Geologi, 2013; Pemerintah Kota Bandung, 2015). People who did not get adequate clean water provided by PDAM Tirtawening must seek the other alternatives of water resources. Unfortunately, most of them chose groundwater because it is cheaper, cleaner and easier than others sources such as rain water or river water. To tackle this issue, government of Bandung include PDAM Tirtawening has tried to revitalize the PDAMs infrastructure in order to minimize the water leakage during distribution process. The result, the PDAM Tirtawening coverage has increased from 63 percent in 2008 to about 72 per cent in 2012 and automatically it has contributed in decreasing groundwater extraction (PDAM Tirtawening, 2012). Besides that, to minimize groundwater exploitation, PDAM Tirtawening (financally supported by local government), also sought the other potential water resources. They developed new water treatment plant; therefore, PDAM could treat surface water resources from the river to restrict PDAM’s wells withdrawal (Wangsaatmaja et al, 2006; PDAM Tirtaweing, 2012; Pemerintah Kota Bandung, 2015).

Besides, inadequate clean water supplied by PDAM, the implementation of the regulations was also ineffective due to the bare minimum awareness of the stakeholders with regard to the importance of groundwater conservation, and also weak in law enforcement and monitoring. To tackle these issues, government has taken some interesting solutions (Wangsaatmaja et al, 2006). First, to increase the stakeholders’ awareness, government introduces tax compensation. Even though this approach has not implemented for households’ user, this approach could be categorized effective for industries. The industries that recycle their water use will get tax compensation. The result is that many industries become interested in water conservation, and contribute significantly in decreasing groundwater exploitation. Besides that, another approach that has been taken by government of Bandung was related to groundwater tariff particularly for industries. Simulated calculations concerning the costliest component indicated that the price that must be paid according to the last mechanism of water provision was much cheaper than the tariff released by PDAM. Therefore, the industries become more prefer to use groundwater resources than PDAM. However, nowadays, the tariff has been adjusted especially for industries where the groundwater tariff is much expensive that PDAM tariff. As result, many industries in Bandung leave groundwater extraction and use water supplied by PDAM.

Another effort that has been conducted by government in order to protect groundwater resources in Bandung area was related to groundwater recharge area (Heath, 1983; Aral and Taylor, 2011). An important factor that causes groundwater depletion in this region is cover land change in recharge area. According to the analysis by Geology and Environment Directorate (1996), concerning the recharge areas in the Bandung basin, there are 21 sites of recharge areas in the upstream of the Citarum watershed that are classified as the main recharge area accounting for 60,881.31 hectares or 26% of the total recharge area. The most important of groundwater recharge area for Bandung basin is located in the Bandung regency namely North Bandung Areas. However, due to population growth, economic development and cross administrative border, the land use management in North Bandung Area became complex (Wangsaatmaja et al, 2006; Pemerintah Kota Bandung, 2015). On one hand, in order to support the population growth and economic development, government of Bandung regency must provide land for development. On the other hand, Bandung city needs North Bandung area as recharge area to keep the availability of groundwater. To tackle this issue, West Java province government and central government took over to handle this issue. By conducting theoretical study, survey and also coordination among stakeholders, the final result is to stipulate the North Bandung Area as recharge area in new spatial planning document. As consequence, the new settlement development permit has been banned and even the settlements that violate spatial planning has been relocated or destroyed.

Table 4.1. Summary of groundwater protection in Bandung

Instruments	Institutions	Leading Stakeholders	Effectiveness	Obstacles
Regulatory approach				
Closing unregistered wells	- Government regulation No. 43/2008 - Decree of Minister of Energy & Mineral Resources No. 1451K/10/MEM/2000 - Provincial Regulation No.9 of 1995 - West Java Province Government issued Province Regulation Number 16/2001 - Government of Bandung Municipality regulation No. 03/2012	- Central government for inter-provincial basin - Provincial government for inter-regency basin - Local government for intra-regency basin	Poor	- Weak in law enforcement - No water source alternative - Limited awareness of groundwater users - Lack of personnel - Lack of budget
Stopping a new license for certain areas	- Local Regulation No. 43 of 1995 - Local Regulation Number 8/2002	Local government	Poor	- Weak in law enforcement - Limited awareness of groundwater users - No water source alternative. - Lack of personnel - Lack of budget
Domestic, industry and agriculture waste control and standard	- Law No. 18/2008 - Government regulation No. 82/2001	Community	Poor	- Weak in law enforcement - Minimum awareness of society - High cost
Zoning area 1. critical area 2. vulnerable area 3. safe area	- Minister of Mining and Energy Decree No. 02P/101/M.PE/1994 - Presidential decree No. 26/2011	Local government	Acceptable	- No follow-up - Minimum awareness of society
Controlling land use change	- Governor Decree No 181/SK.1624-Bapp/82 of 1982 - Bandung spatial planning regulation	Local government	Acceptable	- Weak in law enforcement - Minimum awareness of society
Economic approach				
Providing alternative water resources instead of groundwater	Local Government Rule No 16/2005	PDAM Tirtawening	Acceptable	- Lack of infrastructure of PDAM - High cost for treatment and distribution
Charging groundwater usage based on using purposes	Bandung City Government Rule Number 3 Year 1998	Local government	Acceptable	- No charge for domestic use - Groundwater is cheaper than PDAMs water - Not all wells have flow meter - Corruption in meter reading
Disincentive for groundwater users	- Local Regulation No. 43 of 1995 - Local Regulation Number 8/2002	Local government	Acceptable	- Only implemented for industry
Incentive for recycle and reuse technology	- Local Regulation No. 43 of 1995 - Local Regulation Number 8/2002	Local government, industries, community	Acceptable	- No incentive for domestic uses
Other/supporting approaches				
Monitoring of groundwater table, land subsidence, and groundwater quality	- Local Regulation No. 43 of 1995 - Local Regulation Number 8/2002	Local government	Acceptable	- Minimum monitor wells - Lack of personnel - Lack of budget
Conducting campaign related to the importance of groundwater conservation	- Local Regulation No. 43 of 1995 - Local Regulation Number 8/2002	Local government	Acceptable	- Lack of personnel - Lack of budget

Note :
Excellent: The existence of regulations to manage water in detail and there are no obstacles in implementation
Good: The existence of regulations to manage water in detail and there are few obstacle in implementation
Acceptable: The existence of regulations to manage water in general and few in detail, and still few problem found in implementation
Poor: The existence of regulations to manage water in general and few in detail, and many problems were found in implementation
Very poor: No regulation to manage water even though only in general

In conclusion, three main strategies have been implemented in Bandung either through policy or economic and campaign. Although the implementation of them has shown positive impact, however some constraints are still faced. Table 4.1 provides summary of groundwater governance in Bandung including the policy instruments, institutions, stakeholders, effectiveness and also obstacles in their implementation.

4.2.2. Groundwater protection in Bangkok, Thailand

Physical Characteristics

Bangkok is capital city of Thailand and located in Central Thailand. It covers an area of 1,568.73 square kilometres and situated in 13.45 north and the longitude 100.35 east. The topography of Bangkok is relatively flat and low-lying with latitude from 0 to 20 metres above sea level (Babel et al, 2006; Buapeng & Foster, 2008). Moreover, the climate of Bangkok is humid and tropical with annual average rainfall of 1,100 mm. The annual natural runoff of the city is estimated about 37,120 million m^3, concentrated during the wet season, but the river flow in the dry season decrease significantly (Gupta & Babel, 2005; Babel et al, 2006; Buapeng & Foster, 2008).

The most prominent geographical characteristic of the place is the Chao Phraya River that flows for 372 km, caressing the length of city. Geological characteristics of Bangkok is its soft to stiff dark grey to black clay, ranging in thickness from 20-30 m (Gupta & Babel, 2005; Babel et al 2006, Babel et al, 2012). Beneath the Bangkok Clay layer are unconsolidated and semi consolidated sediments intercalated by clay layers and containing large volumes of voids for water storage, which form several confined aquifers.

Socio-economic

In 2014, the population of Bangkok reached 8.5 million with population growth about 2.9 per cent per year (National Statistic Office of Thailand, 2014). The annual Regional Gross Domestic Product (RGDP) growth rate in this city was about 2.9 per cent. The retail trade sector contributed around 24 % of total the city’s RGDP, followed by manufacturing (14.3

%), and real estate, renting, and business activities with total at around 12.4 % (National Statistic Office of Thailand, 2014).

Groundwater use

In similar to Karo regency, in Thailand, groundwater is also primarily extracted for domestic, industrial and agricultural purposes (Babel et al, 2006). According to Babel et al (2006), an extensive use of groundwater in Bangkok has been begun since mid-1950s. At that time groundwater was primarily used to support inadequate surface water for public water supply. It was estimated that groundwater pumping in Bangkok and in the adjacent municipalities of *Nonthaburi and Samut Prakan* had reached about 937,000 m^3/day in 1976. The groundwater extraction in Bangkok tends to increase correspondingly to population growth and economic development, even in the learly-2000s, amounting to 2.5 million m^3 was pumped per day (Figure 4.2). Moreover, the usage of groundwater by private has generally continued to increase because the expansion of piped-water supply services by waterworks agencies lag behind urban development. In 2003, the total registered groundwater in the seven provinces of Bangkok, Nonthaburi, Samut Prakan, Pathumthani, Nakhon Pathom, Samut Sakhon, and Ayutthaya was extracted about 1.8 million m^3/day, and 92% of them were used by private users (Kasetsart University 2004).

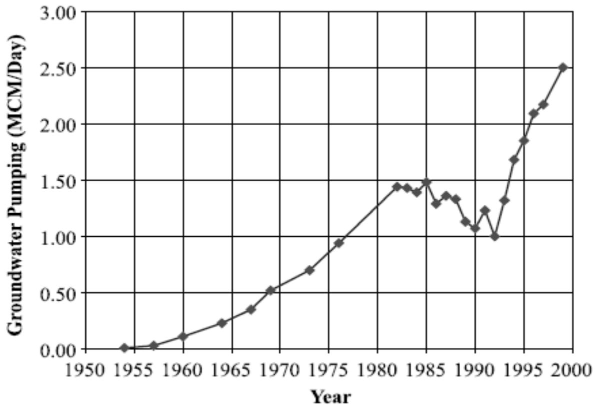

Figure 4.2. Groundwater pumping in the Bangkok area
Source : Gupta & Babel, 2005

Groundwater issues

In Bangkok City and the surrounding provinces, an intensive extraction and contamination of groundwater resources has caused serious environmental problems such as rapid groundwater depletion and quality deterioration. Further, that rapid groundwater level decline has led the land subsidence and the degradation of groundwater quality has caused health problems (Gupta & Babel, 2005; Babel et al, 2012; Aobpaet et al, 2013).

Firstly, land subsidence as a consequence of groundwater withdrawal has been a continuing problem in the Bangkok region for the past four decades (Gupta & Babel, 2005; Babel et al, 2012; Aobpaet et al, 2013). A survey conducted by of the National Environment Board (NEB) of Thailand in 1978-1981 showed irrefutable evidences of land subsidence due to deep well pumping in the Bangkok Area (Babel et al, 2006). The result showed that subsidence rates varied in different places, with the average rate of subsidence in Bangkok City at about 5 cm/year and subsidence rates of 10 cm/year were detected in the eastern part of Bangkok. Moreover, groundwater levels in the Bangkok Aquifer System have been also declining since the late 1960s, with water levels in the aquifers dropping a total of more than 40 to 50 m (Babel et al, 2006). Groundwater levels continued to decline until the late 1990s, especially in the Phra Pradaeng, Nakhon Luang, and Nonthaburi Aquifers.

Secondly, besides the drawdown of groundwater table, the groundwater in Bangkok also contaminated continuously (Gupta & Babel, 2005; Babel et al, 2012). In 2004, analysis of monitoring data from Department of Groundwater resources (DGR) has shown an increasing concentrations of chloride for the three most popularly used aquifers (Phra Pradaeng, Nakhon Luang, and Nonthaburi) especially in areas near the Gulf of Thailand in Samut Prakan province and along the Chao Phraya River (Kasetsart University 2004).

Groundwater protection and its effectiveness

Since the emergence of various problems associated with groundwater over extraction and contamination in the Bangkok the central government has implemented numerous strategies and approaches to protect it (Gupta & Babel, 2005; Babel et al, 2006; Babel et al 2012). The approaches or strategies that have been implemented can be classified into three categories; regulatory measures, economic measures, and other/supporting measures.

First of all, government established and implemented a comprehensive law related to groundwater. In 1977, a specific law concerning groundwater in Thailand was enacted namely Groundwater Act, B.E. 2520 (1977) and has been amended in 1992 and 2003

(JICA et al. 1999; Babel et al, 2006). This act contains provisions for controlling the exploration and drilling for groundwater, the use of groundwater, the recharging of aquifers through wells, and the protection and conservation of groundwater resources in the country. Under this act, the installation of wells and private groundwater use must get permit before the groundwater wells were operated and the violators will be sentenced (Babel et al, 2006). Even, in 1985, the installation of flow meter became obligatory in support of the use charges that the government started to levy from private users at that time. The implementation of this act was believed contributed to decrease the number of groundwater extracted in Bangkok (see Figure 4.3).

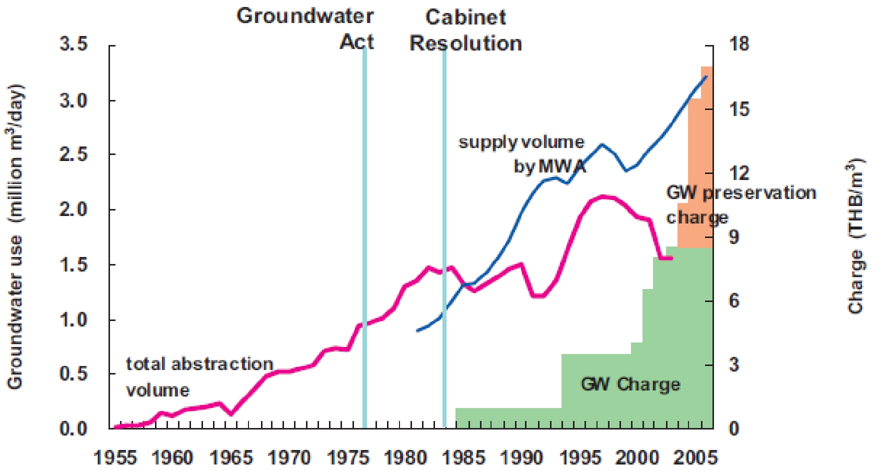

Figure 4.3. Groundwater Use Charge and Groundwater Abstraction in Bangkok
Source: Babel et al, 2012

Moreover, to control groundwater quality, in 2000 central government established Groundwater Act considering standards for the conservation of environmental quality. This regulation regulates the waste disposal generated from households' activities, and other activities such as industrial and agricultural. The waste disposes by these activities cannot exceed environmental quality standard that has been appointed in regulation. In doing so, some technical measures have been implemented. For instance, government has supposed that all of wells must be constructed well based on technical requirement, therefore, groundwater contamination which come from well could be minimized.

Besides that, another regulatory approach that has been introduced was critical zones (Babel et al, 2006). Government conducted survey and analysis to map the characteristics and condition of groundwater all over Thailand especially in the regions where the groundwater extraction was very intensive. The map is used as the basis for groundwater management. The area's most severely affected by groundwater issues such as land subsidence and groundwater depletion were appointed as the critical zones where more control over private and public groundwater activities were instituted. Through this strategy, groundwater protection includes environmental problems mitigation could be conducted effectively. Moreover, to mitigate the problems due to groundwater overexploitation, government has also implemented technical measures such as artificial recharge in critical zones (Babel et al, 2006).

Since regulatory instruments have been introduced, the alleviation of groundwater problems in Bangkok has been perceived (Gupta & Babel, 2005; Babel et al, 2006; Babel et al 2012). In fact, however, various interrelated factors hinder effective implementation of these policies and measures. First, a major barrier towards proper control over excessive and illegal use of groundwater resources in the Bangkok was lack of institutional thrust from concerned authorities resulting into ineffective implementation of laws and regulations. Despite the existence of laws requiring licenses for all private groundwater related activities in the country, illegal private wells still exist. Shortage in the number of Department of Groundwater Resources (DGR) inspectors and budgetary constraints limit the authorities' abilities to ensure that all private well users are registered with DGR. Many groundwater wells remain un-metered even with the existence of a regulation requiring the installation of meters for wells more than 15 m deep.

Second, lack of monetary as well as human resources add to the difficulties of the authorities in strictly enforcing groundwater management regulations, as they are unable to conduct proper monitoring of groundwater activities in the country (Gupta & Babel, 2005; Babel et al, 2006; Babel et al 2012). Regular inspections of registered wells and groundwater users could not be conducted as often as necessary. Moreover, some inappropriate legislation may also be considered as hindrances to effective implementation of regulatory measures (Gupta & Babel, 2005; Babel et al, 2006; Babel et al 2012). For instance, the legal definition of groundwater as being water occurring beneath the ground at depths exceeding 15, 20, or 30 m (depending on the region in the country), which still stands today even after two amendments of the Groundwater Act, keeps the use of groundwater from shallow aquifers all over the country largely unregulated.

Third, perhaps lack of discipline of groundwater users, which may be further encouraged by the weak resolve of the authorities to enforce regulations and impose penalties, is another factor that hinders the strict implementation of groundwater management measures in Bangkok. Punishment for lawbreakers range from a fine of not more than Bt 20,000 to six months of imprisonment, and penalties are charged for late payment of groundwater charges, but the effectiveness of penalties and fines imposed upon violators of regulations has been limited possibly due to the relatively meagre fines and that inspections for discovering violations and enforcing the penalties are not conducted enough (Gupta & Babel, 2005; Babel et al, 2006; Babel et al 2012).

Finally, another barrier to effective implementation of existing policies and the introduction of improved measures is lack of alternative sources of water that are suitable for the needs of industries, which are the largest groundwater users in the Bangkok (Gupta & Babel, 2005; Babel et al, 2006; Babel et al 2012). Sufficient and reliable piped-water supplies for domestic consumption are also lacking, especially in areas located far from city and town centres, such that private business and homeowners have no other option but to develop groundwater resources for their water supplies. This also limits the effectiveness of levying charges for groundwater use in controlling private groundwater abstraction since without alternative sources of water consumers have no choice but to continue using groundwater despite increased costs.

Second category was related to economic measures (Gupta & Babel, 2005; Babel et al, 2006). In 1985, central government implemented groundwater use charges in the six provinces including Bangkok. At the beginning, for every cubic meter of groundwater used was charged Bt1.00. However, it increased to 3.50 Bt/m^3 in 1994, and the government implemented it for groundwater use in the whole country. Even, in 2003, the Ministry of Natural Resources and Environment (MONRE) has recently imposed the groundwater preservation charge, that charge groundwater up to 8.50 Bt/m^3 in the critical zone. Due to this policy, the total cost per cubic meter of groundwater use in the critical zone has become relatively high, and has contributed in limiting the exploitation of groundwater in the area, especially those using large amounts such as industries.

The installation of meter has been obligatory for each groundwater well in Bangkok. This regulation is needed to make the quantification of groundwater use more accurate and to ensure that the users pay for exactly how much they extract and not exceed allowable amounts. However, the effectiveness of this control measure has been limited by the fact that not all registered users comply with it. Although groundwater users will have to pay for the full permitted amounts (even if they actually use less) when their wells are un-metered, this has not driven them to abide by the regulations, because perhaps the existing system of groundwater-use reporting, wherein well owners report their monthly use to DGR, who in turn bills them for their consumption, does not really incite groundwater users to do so.

Third category was supporting measures (Gupta & Babel, 2005; Babel et al, 2006; Bael et al, 2012). The Bangkok Groundwater Monitoring Network was established under the comprehensive study programme on groundwater and land subsidence from 1978-1981, and it is used to collect data on groundwater levels, land subsidence, and groundwater quality in the various aquifers in this region. The Groundwater Database System was established in 1995 through the JICA study on "Management of Groundwater and Land Subsidence in the Bangkok Metropolitan Area and its Vicinity" (JICA, 1995). The Groundwater Database System has allowed convenient access, by groundwater managers and decision-makers, to groundwater resources related information in the Bangkok Region necessary in assessing the status of the resource and formulating proper management measures. However, the full potential of the Groundwater Database System is currently not being realized due to lack of maintenance and updating. Budget constraints have also hindered the regular maintenance, rehabilitation, and expansion of the Groundwater Monitoring System.

Besides monitoring, a Department of Groundwater resource (DGR) has launched public awareness programmes. These programmes want to educate the population about the proper use of groundwater resources in the country through publication of various brochures and booklets. However, lack of monetary as well as human resources adds to the difficulties of the authorities in conducting these programmes regularly (Gupta & Babel, 2005; Babel et al, 2006; Babel et al 2012). Regular inspections of registered wells and groundwater users could not be conducted as often as necessary. The summary of groundwater governance in Bangkok is provided in table 4.2.

Table 4.2. Summary of groundwater protection in Bangkok

Instruments	Institutions	Leading stakeholders	Effectiveness	Obstacles
Regulatory approaches				
Control exploring , drilling, using, recharging, and metering groundwater	Groundwater Act, B.E. 2520 (1977)	Central government	Poor	- Weak in law enforcement - Lack of personnel - Lack of monetary - Lack of institutional trust - Inappropriate legislation - No alternative resources
Domestic, industry and agriculture waste control and standard	- Factories Act of 1992	Central government	Poor	- Weak in law enforcement - Lack of institutional trust - Lack of DGR inspectors - Lack of monetary
Well head protection	- Groundwater Act, B.E. 2520 (1977)	Central government	Poor	- Weak in law enforcement - Lack of institutional trust - Lack of DGR inspectors
Artificial recharge	Groundwater Act, B.E. 2520 (1977)	Central government	Acceptable	- Lack of monetary
Penalties for violations	Groundwater Act, B.E. 2520 (1977)	Central government	Acceptable	- Few environmental criminal prosecutions pursued or penalties levied
Zoning Area 1. Critical Area 2. Vulnerable Area 3. Safe Area	- Land Development Act of 2008 - The Town Planning Act of 1975	Central government	Acceptable	- Weak in law enforcement - Lack of institutional trust - Lack of DGR inspectors - Lack of monetary
Land use regulation	- Land Development Act of 2008 - The Town Planning Act of 1975	Central government	Acceptable	- Weak in law enforcement - Lack of institutional trust - Lack of DGR inspectors -
Economic approaches				
Groundwater usage charge based on location and availability	Groundwater Act	Central government	Acceptable	- Not all registered wells have meter - No charge for agricultural uses
Incentive and disincentive for groundwater users (Area which service by WSE pay more for groundwater)	The 2003 amendment of the Groundwater Act	Central government	Acceptable	- Not all people get water provided by local water system enterprise
Groundwater preservation charge	The 2003 amendment of the Groundwater Act	Central government	Acceptable	- Weak in law enforcement
Other/supporting approaches				
Establish Groundwater Database System	Groundwater Act	Central government	Acceptable	- Lack of maintenance and updating - Lack of budget
Monitoring of groundwater table, land subsidence and quality	Groundwater Act	Central government	Acceptable	- Minimum monitor wells - Lack of personnel - Lack of budget
Campaign related to the importance of groundwater conservation	Groundwater Act	Central government	Acceptable	- Lack of personnel - Lack of budget

Note :
Excellent: The existence of regulations to manage water in detail and there are no obstacles in implementation
Good: The existence of regulations to manage water in detail and there are few obstacle in implementation
Acceptable: The existence of regulations to manage water in general and few in detail, and still few problem found in implementation
Poor: The existence of regulations to manage water in general and few in detail, and many problems were found in implementation
Very poor: No regulation to manage water even though only in general

4.2.3. Groundwater protection in Tianjin, China

Physical Characteristics

Tianjin is located in the Northeast area of the China. Geographically, this city is situated between 38°33′57″ - 40°14′57″ north latitude and 116°42′05″ - 118°03′31″ east longitude with its boundary bordering on the Hebei Province and the Beijing (Bai, 2001; He and Lei, 2006; Dong et al et al, 2013). Tianjin has a total area about 11, 919.7 km^2, comprising 15 districts and 3 counties. It lies at the northern end of the Grand Canal of China, which connects with the Yellow River and Yangtze River. The topography of the city is generally flat, and swampy near the coast, but hilly in the far north, where the Yan Mountains intrude into northern Tianjin with latitude from 0 to 1,000 metres above sea level. As for climate, Tianjin lies in the temperate zone with a semi humid and continental monsoon climate which has four different seasons and relatively low rainfall (about 540 mm/year) (Zhou, He and Lei, 2006).

Based on its hydrogeological characteristics, Tianjin region has two types of groundwater demarcation, namely the mountain area with crevice water in bedrock and alluvial plain area (Bai, 2001; He and Lei, 2006; Dong et al et al, 2013). Mountain areas with crevice water lie in the north mountain areas of Jixian County, and cover the area about 727 km^2. The alluvial plain, further, can be divided again into two areas which are the interstitial (between clay and sand) with whole fresh groundwater and the interstitial with deep freshwater, which is covered by salty water on the surface.

Socio-economic

Compared to Bandung and Bangkok, the population of Bangkok was the most populous which about 14.7 million in 2014. The population growth in this region was also high which reached 4 per cent per year (China Statistical Yearbooks Database, 2014). However, the annual Regional Gross Domestic Product (RGDP) growth rate in this city was also the highest that about 12.6 per cent. The secondary industry sector contributed a half of total the city's RGDP, followed by service and trade (40 %), and agriculture in third place at around 10 % (China Statistical Yearbooks Database, 2014).

Groundwater use

Groundwater plays an important role in the economic development of Tianjin (Bai, 2001; He and Lei, 2006; Dong et al, 2013). It supplies for about 70% in the whole water demand in Tianjin. The groundwater is mainly used for agriculture use with more than a half of total groundwater extraction volume, followed by domestic use, industrial and ecological use respectively. According to He and Lei (2006) and Dong et al (2013), the extraction of groundwater resource increased continuously and significantly due to economic development, the scale of the city, and the increase in population density. For instance, in 1990, the average volume of groundwater exploitation was about 748.2 million m^3, however, it rose up to 90.45% in 2002 (He and Lei, 2006).

Moreover, data show that the exploitation of groundwater resources in Tianjin region has been in alarming stage (Bai, 2001; He and Lei, 2006; Dong et al, 2013). Based on water balance calculation, many of districts in this region has exploited their groundwater resources exceeded the maximum limit. It means that the groundwater extraction more than the groundwater recharge. Such kind of condition has occurred in Beichen, Jinnan, Xixing, Dong et alli, Dagang and Tanggu district. Even though the groundwater overexploitation has not happened in district of Jixian County, Baodi District, Ninghe County and Jinghai County, data show that the groundwater only had a little surplus (He and Lei, 2006).

Groundwater issues

In similar with other regions discussed before, the groundwater issues in Tianjin are also related to land subsidence and contamination (Changming et al, 2001; Bai, 2001; He and Lei, 2006; Dong et al, 2013). The ground subsidence in this region is mainly caused by long-term overexploitation on its groundwater. The extraction of groundwater intensively for long time in most of districts in Tianjin has caused the land subsidence such as Tanggu District, Hangu District, Dagang District, and the industrial areas in lower reaches of Hai River which cover about 3,876.597 km^2 (He and Lei, 2006; Dong et al 2013).

Besides land subsidence, the contamination for both shallow and deep groundwater resources also has become a big issue in Tianjin city (Changming et al, 2001; Bai, 2001; He and Lei, 2006; Dong et al, 2013). Firstly, the groundwater pollutants found in Tianjin city come mainly from pollution caused by the unreasonable emission of industrial waste, farmland irrigation, long-term fertilizers and pesticides, as well as from the arbitrary emission of city garbage and living sewage (Dong et al, 2013). For instance, in Wuqing County, it has been practicing the sewage irrigation for a long time so that the shallow groundwater is greatly polluted. Secondly, the deep groundwater contamination is caused by two reasons, which are the poor quality of wells and the abandoning wells (He and Lei, 2006). In the first case, the poor quality of wells especially close to the coastal area, could cause sea water intrude to the well and mix salty water and freshwater. In the second case, the abandoning wells which has contaminated by salty water, naturally, entering into the deep aquifers and contaminating the aquifer. The statistics shows that the accumulative total number of abandoned wells is 35,746 up to 1997, hereinto 34,246 wells located in suburbs for agriculture use (He and Lei, 2006).

Groundwater protection and effectiveness

The groundwater protection in Tianjin has begun since 1980s (Changming et al, 2001; He and Lei, 2006). For instance, in 1987, the government of Tianjin was enacted regulation namely ‘Temporary Regulation on Groundwater Resource Management in Tianjin’ which is still used at present (He and Lei, 2006). Accompanying with this regulation, another supporting regulation came out at the same time, namely ‘Regulations on Levying Groundwater Fee in Tianjin’. At that time, the groundwater protection was mainly conducted through law enforcement and could decrease the expanding of groundwater extraction (see Figure 4.4).

However, this regulation has been serving nearly two decades and has lagged behind the development of the groundwater management itself. The groundwater extraction has increased significantly, and the contamination of this resource has been also more severe than before. Further, the Tianjin Municipality condition has changed a lot, however, this regulation has not changed (He and Lei, 2006). As consequence, this regulation could not deal with the current groundwater situation. For instance, some articles themselves in regulation have problems. It prescribed that the groundwater for agriculture and oil field was free of charge and there is no measuring device for exploited volume. Therefore, this regulation is less effective on agriculture. To improve the effectiveness of this regulation, Tianjin Water Conservancy Bureau has been amending the current temporary regulation since 2001 and now has been revised (see Figure 4.4) (He and Lei, 2006).

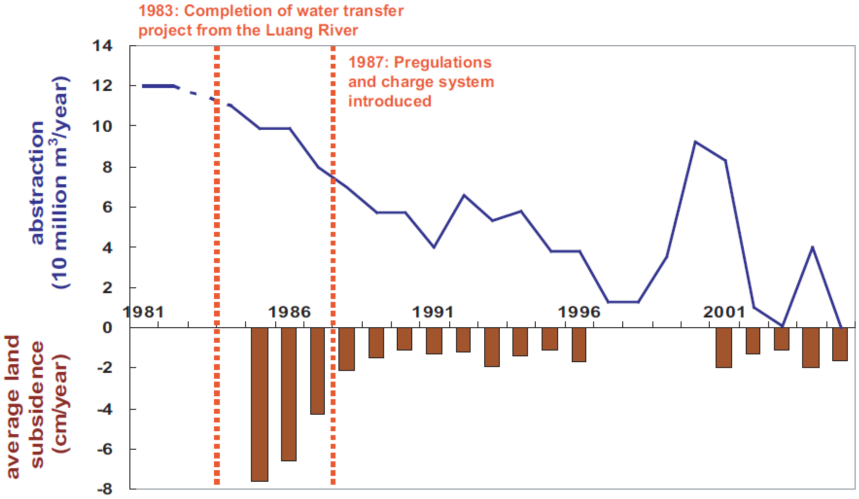

Figure 4.4. Groundwater extraction and land subsidence in Tianjin
Source: He and Lei, 2006

In addition, since then, the regulation has also regulated engineering construction standard of groundwater exploitation and the management on abandoned wells. The wells quality depends on the scientific engineering design and higher-level constructer. So the construction organization that will construct or maintain the groundwater project must have the related qualification, and it must not overstep its business scope covered by the qualification (He and Lei, 2006).

Moreover, with related to regulation, the combination of different policy measures has been proposed and it could optimize the effectiveness of groundwater protection in Tianjin (Bai, 2001; He and Lei, 2006; Dong et al, 2013). Nowadays, the laws and regulations related to groundwater are not established and designed specifically and exclusively, but also considering the influence of the other regions and also the other interests. This integrated regulation has been contributed for effectiveness of groundwater protection in this region. For instance, Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) have been implemented at all levels on water resource exploitation and utilization. In addition, groundwater exploitation plan has been synergy with urban planning and be an integral part of urban planning. Urban planning has incorporated measures to conserve groundwater in urban development plan (He and Lei, 2006).

An economic approach has been also implemented in China as well as Tianjin city. Before, groundwater extraction fee was obviously low (Changming et al, 2001; Bai, 2001; He and Lei, 2006; Dong et al, 2013). For instance, groundwater fee for industrial using was far lower than tap water, which has undoubtedly encouraged groundwater exploitation. Therefore, to control groundwater exploitation, the Tianjin municipality adjusted the groundwater fee. In addition, nowadays, water fee has been different between different using purposes (Changming et al, 200; He and Lei, 2006; Geng and Yi, 2006). For example, to encourage shallow groundwater and salty water utilization in salty water areas, fees on exploiting these kinds of water has been adjusted lower, and tap water for ground recharging has also been adjusted. Now tap-water fees contain an item of wastewater treatment fee. This fee is 0.6 Yuan per m^3 for domestic user and 1.00 Yuan per m^3 for the other users (He and Lei, 2006). The recharging is mainly depending on the tap water, but users who use tap water for recharging has to pay the same as other users. Since they do not generate wastewater, they don't have to pay the fee covering cost of wastewater treatment.

Besides regulatory and economic approaches, another effort to protect groundwater that have been taken by Tianjin city was water saving and inner water transfer from North to South within Tianjin (Changming et al, 2001; Bai, 2001; He and Lei, 2006; Geng and Yi, 2006; Dong et al, 2013). Firstly, water saving is an effective way to mitigate the conflict between water supply and demand in Tianjin. It's estimated that there is water-saving potential with about 150 million m3 in Tianjin. Water saving could be implemented successfully greatly depends on the basic infrastructure construction, such as rebuilding former water supply facilities to reduce the wasting, and building new facilities supporting the utilization of reclaimed water and rainwater etc. Secondly, in the north there is fresh groundwater with exploitable potential, but in the south there is salty water covered with badly overexploitation, focusing on the deep fresh groundwater. So the groundwater resource should be balanced firstly within Tianjin through transferring water from north to south Tianjin. The summary of groundwater governance including policy instruments, institutions, stakeholders, effectiveness and also obstacles faced in implementing current groundwater protection instruments in Tianjin is provided in Table 4.3.

Table 4.3. Summary of groundwater protection in Tianjin

Instruments	Institutions	Leading stakeholder	Effectiveness	Obstacles
Regulatory approaches				
Control drilling and using groundwater	Tianjin Water Management Bureau (1996)	Local government	Poor	- No alternative resources
Domestic waste treatment	Tianjin Water Management Bureau (1996)	Communities	Acceptable	- Lack of operating funds
Industrial waste treatment	Tianjin Water Management Bureau (1996)	Industries	Acceptable	- Many industries have not waste treatment plant - Lack of operating funds
Controlling the using of pesticide and fertilizers	Tianjin Water Management Bureau (1996)	Farmers	Acceptable	- Weak in supervision - Lack of operating funds
Zoning Area 1. Critical Area 2. Vulnerable Area 3. Safe Area	Local formal regulation	Local government	Acceptable	N/A
Introducing EIA and SIA	Local formal regulation	Local government	Acceptable	- Lack of monetary
Economic approaches				
Water transferring	Tianjin Water Management Bureau (1996)	Local government	Good	- Lack of infrastructure
Groundwater usage charge based on using purposes	Local formal regulation	Local government	Good	- Agricultural use, which is the major beneficial use, is not regulated by pumping regulations, nor any charges imposed.
Water saving	Local formal regulation	Groundwater users	Good	- Infrastructure
Effluent charge	Local formal regulation	Local government	Good	- Weak in law enforcement
Other/supporting approaches				
Monitoring of groundwater table, land subsidence and groundwater quality	Local formal regulation	Local government	Acceptable	- Minimum monitor wells - Lack of personnel - Lack of budget
Campaign related to the importance of groundwater conservation	Local formal regulation	Local government	Good	- Lack of personnel - Lack of budget

Note:
Excellent: The existence of regulations to manage water in detail and there are no obstacles in implementation
Good: The existence of regulations to manage water in detail and there are few obstacle in implementation
Acceptable: The existence of regulations to manage water in general and few in detail, and still few problem found in implementation
Poor: The existence of regulations to manage water in general and few in detail, and many problems were found in implementation
Very poor: No regulation to manage water even though only in general

Over all, as well as Karo regency, Bandung, Bangkok and Tianjin have also had experience of groundwater issues including groundwater table depletion and also degradation of groundwater quality. However, compared to Karo regency, they have much experience in groundwater protection either through regulatory, economic or other supporting measures. Further, comparing groundwater issues as well as groundwater protection in Karo and Bandung, Bangkok and Tianjin will be interesting. It is expected that through comparison, suitable policy that have been implemented in those donor regions could be selected and transferred in order to develop and to improve existing groundwater governance in Karo.

Chapter V

Seeking Suitable Strategy to Improve Groundwater Governance in Karo

In the previous chapter, the issues related to groundwater resources in Karo regency as host region and Bandung, Bangkok, and Tianjin as donor regions have been described. In this chapter, those information and data will be analysed by using comparative method. Key elements that will be compare can be distinguished in three main categories include natural characteristics, groundwater issues, and groundwater governance. In addition, the socio economic condition in each city will be also provided. After comparing, the suitable strategy recommendations selected from donor regions' experience will be provided.

5.1. Causes of groundwater issues

5.1.1. Natural characteristics

The geography of case study regions could be distinguished into two characteristics, mountainous and coastal areas. Karo is similar to Bandung; located in equator zone with mountainous topography and high latitude (Figure 5.1, Table 5.1). However, with two others, Karo is different where Bangkok and Tianjin located in coastal area with low-lying topography. Moreover, the hydrology of all case study regions except for Tianjin is influenced by a monsoon climate. As these cities have clear rainy and dry seasons, and the annual precipitation of the first three regions is relatively high compare to Tianjin that has a very low precipitation.

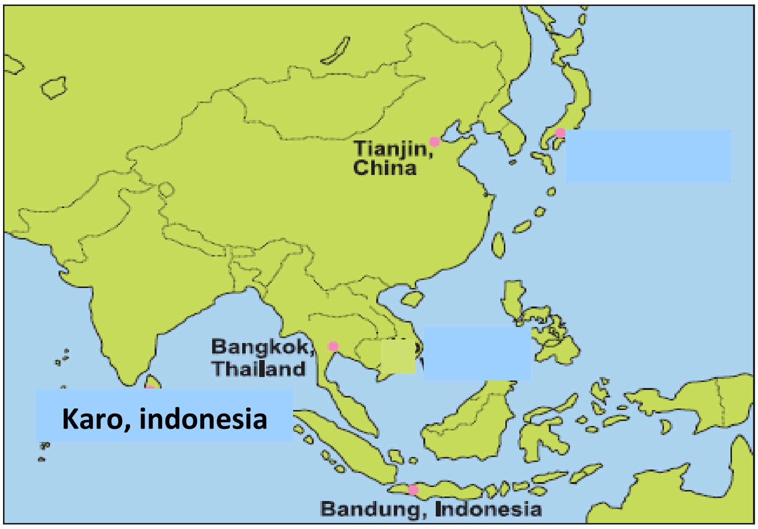

Figure 5.1. Location of case study regions
Source : Adopted from Wangsaatmaja et al, 2006

With regard to aquifer conditions, there are two types that important to be compared. First, Karo is very similar to Bandung, Bangkok and Tianjin in term of covered area. All of regions have relatively large aquifers and lye in cross jurisdiction administrative borders which mean that their aquifer are also influenced and utilized by other regions. In addition, the case study cities share a similar aquifer setting of semi- or un-consolidated alluvial sediments, and geological characteristic of tertiary rock is dominated in these regions except Bangkok. Although rainfall in Karo, Bandung and Bangkok is relatively high, however, groundwater extraction in two later regions is much more than Karo (see table 5.3). In contrast, Tianjin only has a little rainfall, but the extraction is high (see table 5.3).

Table 5.1. Geography, hydrology and aquifer condition

No.	Criteria	Karo	Bandung	Bangkok	Tianjin
A.	*Geography*				
1.	Location on the earth	Equator zone between 2^{o} 50’ to 3^{o} 90’ northern and 97^{o} 55’ to 98^{o} 38’ eastern	Equator zone with the latitude of the area is 7°19' - 6°24' south and the longitude is 106o51' - 107o51' east.	Equator zone with the latitude 13.45 north and the longitude 100.35 east	North side between 38°33′57″ ~40°14′57″ north latitude and 116°42′05″~118° 03′31″ east longitude
2.	Area	2,127.25 km2	2,340.88 km2	1,568.7 km2	11,919.7 km2
3.	Topography	Mountainous	Mountainous	Flat and low-lying	Generally flat but hilly in the north side
4.	Latitude	600 to 1,400 metres above sea level	500 to 1,200 metres above sea level	0 to 20 metres above sea level	0 to 1,000 metres above sea level
B.	*Hydrology*				
1.	Climate	Humid and tropical climate	Humid and tropical climate	Humid and tropical climate	Semi humid and continental monsoon climate
2.	Season	Two seasons	Two seasons	Two seasons	Four seasons
3.	Average annual rainfall	1,600 mm	1,500 mm	1,100 mm	540 mm
4.	Temperature	15 – 28 ^{o}C	18 - 30 ^{o}C	10 – 35 ^{o}C	5 – 30 ^{o}C
C.	*Aquifer*				
1.	Area	Large and cross administrative border : inter provincial, inter regency and intra regency	Large and cross administrative border : inter provincial, inter regency and intra regency	Large and cross administrative border	Large and cross administrative border
2.	Geology	Most of region is covered by volcanic tertiary rock and semi- or un-consolidated alluvial sediments	In the north side, it is bordered by the Lembang fault; in the west, it is bordered by permeable tertiary rocks; and in the south and east lies surface water barriers.	Soft to stiff dark grey to black clay, unconsolidated and semi consolidated sediments intercalated by clay layer and containing large volume s of voids for water storage	Has two types groundwater demarcation : mountain area with crevice water in bedrock and alluvial plain area

5.1.2. Human intervention

Socio economic

The common feature of Karo and the other lender regions is the rapid increase of population (Table 5.2). The population of Bandung and Bangkok doubled in 30 years, and the increase characterizes the trend of urban sprawl. The population number and the growth rate in Tianjin is the highest (14, 7 million people and growth rate about 4% per year) followed by Bangkok, Bandung and Karo respectively.

As developing regions, the economic development of Karo is relatively high, it reaches more than 6 per cent which higher than Bangkok, although still lower than Tianjin and Bandung. The main activities contributed to Regional Gross Domestic Product (RGDP) of Karo are agriculture, in Bandung and Bangkok is trade, and in Tianjin is industry. However, as well as Karo, industrial sector has a big contribution in Karo, Bandung and Bangkok (Table 5.2).

Due to their different number of population, the water demand to consume and to support their activities is also different (Table 5.2). Totally, Karo is estimated only need water about 14 million m3/year, however, Bandung, Bangkok and Tianjin consume use water about 900, 1,700 and 2,500 million m3/year respectively. The water is provided by local water supply and groundwater as two main sources besides surface water such as river.

Table 5.2. Socio economic condition

No.	Criteria	Karo	Bandung	Bangkok	Tianjin
1.	Population	0.5 million (in 2014)	2.5 million (in 2014)	8.5 million (in 2014)	14.7 million (in 2014)
2.	Population growth rate	1.07 % per year	2.7 % per year	2.9 % per year	4 % per year
3.	RGDP growth rate	6.34 % per year	15.66% per year	2.9 % per year	12.6 % per year
4.	Percentage of main economic activities for RGDP	Agriculture 60.98, services and industry 13.91, trade, hotels and restaurants : 11.49	Trade 31.91% , industry 30.85%, transportation and communication 11.64%, and services 10.79 %	Retail trade 24%, manufacturing 14.3%, real estate, renting and business activities 12.4%	Secondary industry 50%, service and trade 40%, agriculture 10%
5.	Estimated water demand	14 million m3/year	900 million m3/year	1,750 million m3/year	2,500 million m3/year
6.	Water supplier	Local government (Local water tap company)	Local government (Local water tap company)	Local government (Local waterworks authority)	Local government (Local water tap company
7.	Water resources	Groundwater, Lau Biang river	Groundwater, Citarum river	Groundwater, Chao Phraya river	Groundwater, Luan river

Groundwater extraction

The purposes, reasons and the number of groundwater extracted are shown in table 5.3. Groundwater has contributed to the development of both borrower and lender regions as an important source for consuming and supporting their economic activities. In the case of Karo, where groundwater is mainly used for domestic use is similar to Bandung and Bangkok, except Tianjin which mainly used for agriculture need. In Karo and Bandung, groundwater even contributes more than 50 percent as water sources. In addition, it is believed that the number of groundwater abstracted in Tianjin is the highest that the other regions due to the population number. Besides that, due to the lack of water provided by local water tap company and due to the fact that groundwater is cheaper and has better quality than surface water are the main reasons why groundwater is exploited in these regions.

Table 5.3. The purposes, reasons and the number of groundwater extracted

No.	Criteria	Karo	Bandung	Bangkok	Tianjin
1.	Main purposes (respectively)	Domestic, agriculture, industry, and animal husbandry	Domestic, and industry	Domestic, industry, and agriculture	Agriculture, industry, and domestic
2.	Reasons	The lack of water provided by local water tap company, Groundwater is cheaper and has better quality than surface water	The lack of water provided by local water tap company, Groundwater is cheaper and has better quality than surface water	The lack of water provided by local water tap company, Groundwater is cheaper and has better quality than surface water	Scarcity of surface water particularly in dry season, Groundwater is cheaper and has better quality than surface water
3.	Estimated volume	8 million m3/year	500 million m3/year	600 million m3/ year	750 million m3/ year
4.	Estimated groundwater contribution	57%	60%	34%	30%

Groundwater contamination

Groundwater quality deterioration has been identified in Karo as well as the other regions (Table 5.4). Although there is not report data related to groundwater contamination in Karo, it is predicted that groundwater pollutants come from domestic waste, landfill, septic tank, and agriculture. The pollutants differ from place to place, and are even site specific, but salinization due to sea water intrusion, chemical pollutants produced by industrial or agricultural activities and coliform contamination caused by domestic waste water have been identified. Due to the pollution, in some places the concentration of pollutants has exceeded quality standard.

Table 5.4. Groundwater contamination

No.	Criteria	Karo	Bandung	Bangkok	Tianjin
1.	Sources	Domestic waste, landfill, septic tank, agriculture	Septic tank, domestic waste, industrial waste, land fill	Sea water intrusion, industrial waste	Sea water intrusion, surface water pollution and the domestic and industrial sewage
2.	Main Pollutants	Coliform, NO3, Mn, Fe	Coliform, NO3, Mn, Fe	Cl, Mn, F, NO3, Fe	As, Cl, Hg
3.	Concentration of pollutants	High in some places	High, in many places has exceeded health quality standard 100/100 ml.	High, in some places has exceeded health quality standard especially in areas near the Gulf of Thailand along the Chao Phraya River	High, in some places has exceeded health quality standard

In conclusion, comparing groundwater characteristics in Karo as host region with Bandung, Bangkok and Tianjin as donor regions reveals that they have similarities and differences. The important similarities of these regions are in terms of rapid population growth, rapid economic growth, and overwhelming dependence on groundwater and have experienced similar groundwater issues such as groundwater table depletion and contamination. However, there are essential differences, first in the scale of the population number and volume groundwater extracted and second, in the hydrogeological characteristics particularly with Tianjin. While Karo has only 0.5 million population, which withdraw 8 million m3 of groundwater annually, the figures for Tianjin are staggering at 14 million population and 750 million m3 of groundwater abstraction. Besides that, as Karo, and Bandung are located in mountainous area, Bangkok and Tianjin are situated in low-lying coastal area. In addition, Karo, Bandung, Bangkok has tropical climate with high precipitation, in contrast, Tianjin has semi humid and continental monsoon climate with four seasons and low precipitation.

5.2. Impacts of groundwater issues

5.2.1. Impacts of ground water table depletion

Intensive extraction of groundwater resulted in depletion of the resource, which is often associated with other problems such as land subsidence, construction damage, groundwater well deepening and salt water intrusion. As table 5.5 shows, because of intensive abstraction of groundwater, all of the regions suffered from severe water table drawdown associated with land subsidence. Although varied in different places, the depletion rate reaches 100, 10 and 40 cm per year in Bandung, Bangkok and Tianjin respectively. As consequence, it has caused land subsidence, construction damage, and sea water intrusion which then could lead social conflict.

Table 5.5. Impacts of groundwater depletion

No.	Criteria	Karo	Bandung	Bangkok	Tianjin
A.	The depletion rate	Varied in different places, up to 2.5 cm per year	Varied in different places up to 10 cm per year	Varied in different places from 5 cm to 10 cm per year	Varied in different places from 10 cm to 40 cm per year
B.	Impacts				
1.	Land subsidence	Yes	Yes (up to 2 cm/year)	Yes (2 – 5 cm/year)	Yes (0.5 – 1 cm/year)
2.	Construction damage	Yes	Yes	Yes	Yes
3.	Sea water intrusion	No	No	Yes	Yes
4.	Groundwater well deepening	Yes	Yes	Yes	Yes

5.2.2. Impacts of groundwater contamination

Table 5.6 provides the impacts caused by groundwater contamination. Due to pollution, groundwater cannot be used directly, therefore, treatment is required and consequently, people must spend their money for this treatment process. This phenomenon has existed in those of Karo, Bandung, Bangkok and Tianjin. In addition to conventional pollutants such as fluorine, chlorine and coliforms can be future hazards to human health. Although quantitative data related health impacts could not find, information from secondary data showed that groundwater pollution has contributed to cause diseases such as diarrhoea, skin diseases and etcetera.

Table 5.6. Impacts of groundwater contamination

No.	Criteria	Karo	Bandung	Bangkok	Tianjin
1.	Condition	In some places unsafe to consume directly	In some places unsafe to consume directly	In some places unsafe to consume directly	In some places unsafe to consume directly
2.	Treatment requirement	Yes in some places	Yes in some places	Yes in some places	Yes in some places
3.	Health problem	Diarrhoea, cholera, skin diseases etc.	Diarrhoea, cholera, skin diseases etc.	Diarrhoea,cholera, skin diseases etc.	Diarrhoea, cholera, skin diseases etc.

5.3. Groundwater governance

To tackle the groundwater related issues, measures to restrict groundwater use and contamination have been taken by Karo, Bandung, Bangkok and also Tianjin region. In doing so, these regions have implemented several policy instruments that can be distinguished into three categories; regulatory, economic and other/supporting. The comparison between groundwater protection in Karo regency and those three donor region will be summarized in this section. Indeed, the effectiveness of the measures that have been taken will be also compared include the explanation why such measures is effective or not.

5.3.1. Regulatory Instruments

On the whole, compared to Karo, a governance structure for managing groundwater has been much stronger in Bandung, Bangkok and Tianjin. While Bandung, Bangkok and Tianjin have implemented several regulatory instruments to protect their groundwater resources, Karo regency only has limited. Karo only has one local regulation related to groundwater charge. Moreover, Karo still struggles to develop its groundwater institutions. Hence, local government has limited legal aspect to control groundwater extraction or to close unregistered wells. The establishment of regulation is not an easy task in Karo, which adopted democratic government system, where power is in the hand of community. Numerous stakeholders must be involved to develop new regulation. In contrast, China as well as Tianjin is a hard state, with arms of government and the party stretching to local region. Every region has a region leader and a region Communist Party leader with strong authority sanctioned by higher echelons of the government and the Communist Party. Therefore, to establish and to implement regulation will more difficult in Karo and Bandung compared to Tianjin.

In Bandung, Bangkok and Tianjin, principally, groundwater rights are not attached to the land, therefore landowner cannot extract groundwater even in their own land as much as desired. The resource belongs to the state in trust for the public. However, even when the state claims ownership rights to a body of groundwater, individual or collective users may nevertheless hold abstraction and use rights. To keep its sustainability, groundwater utilization will be controlled and managed by government. In doing so, a user must apply to the state to get rights as groundwater license in order to extract groundwater. This includes use and quantity limitations, drilling permits, special zones of conservation, and reporting and registering requirements.

Moreover, groundwater governance in Bandung, Bangkok and Tianjin has changed from that of being highly fragmented to that of being more institutionalized. However, the water-related jurisdiction involves many stakeholders and their authority is not clear in many cases. For instance, in Bandung, groundwater is managed by central government, provincial government and also local government according to its authority, but surface water is controlled by central government including Ministry of Public Work, Ministry of Energy and Mineral resources. In similar to Bandung, in Tianjin, surface water is in central districts jurisdiction but groundwater in suburban prefectures are managed by the water resources bureau, while the groundwater in central districts is under the control of the Urban Construction Committee of the city. Consequently, water resources in the city cannot be planned and managed as a whole.

To decrease groundwater pressure, Bandung, Bangkok and Tianjin have developed critical zones base on groundwater condition all over the region. Areas most severely affected by groundwater issues such as groundwater depletion and contamination have been appointed as the critical zones where more control over private and public groundwater activities were instituted, even if needed there will not new license given there. The areas where groundwater recharge exceeded groundwater extraction were determined as safe areas. In these areas, the control is not as strict as critical zones, but monitoring related to groundwater table depletion and quality were conducted routinely. Although this policy is very useful particularly in critical zones, in some area this policy could not implement effectively. The main reason is due to lack of water provided by local water entrepreneur, hence, community do not have other alternative instead of groundwater. To tackle this issue, those regions have different solution. Bandung tries to improve the service of local water company or even has planned to relocate the industries in critical zones. Bangkok implemented technical measures by artificial recharge. In different, due to the potential water in the north side of region, Tianjin transferred water from north to critical zones.

As recharge areas is a crucial for infiltration, to protect recharge area is very important to conserve groundwater resources. In doing so, Bandung, Bangkok and Tianjin have established spatial planning regulation in order to manage land use in their region. In this spatial planning, locations of recharge area have been determined. Consequently, in this area, the development has been restricted or even could not be developed. The different is rest in which level of government, while Bandung and Tianjin land use is managed by local government, in Thailand as a whole it is controlled by central government.

With regard to groundwater contamination issue, those donor regions also have introduced regulatory approach namely waste management. The most common sources of groundwater pollutants in those Bandung, Bangkok and Tianjin are municipal and industrial wastewater, septic systems, and use of fertilizers in agricultural lands. In Bandung and Bangkok, safeguarding groundwater resources from pollution has been achieved by aquifer protection. As a basis for protection groundwater, several important regulations and standards have also been promulgated or established including wastewater disposal standard for domestic; industrial effluent standards; and inland aquaculture. However, weak in law enforcement, lack of budget and personnel seem to be major problems for these regions. In different, Tianjin tries to reduce groundwater contamination through technical approach by developing waste treatment plant. In order to minimize groundwater contamination, the city plans to improve its wastewater treatment capacity by expanding existing plants and constructing new plants. However, due to a lack of operating funds, the plants usually cannot be operated at full capacity.

Moreover, in implementation of instruments, Bandung, Bangkok and some in Tianjin, most of obstacles faced is perhaps lack of discipline of groundwater users, which may be further encouraged by the weak resolve of the authorities to enforce regulations and impose penalties. To tackle this issue, Bangkok introduced penalty for violators. Punishment for lawbreakers is in the form of fine and imprisonment. In addition, penalties are also charged for late payment of groundwater charges. However, the implementation of this policy also remains another obstacle. The effectiveness of penalties and fines imposed upon violators of regulations has been limited possibly due to the relatively meagre fines and that inspections for discovering violations and enforcing the penalties are not conducted enough.

5.3.2. Economic Instruments

Economic instruments to protect groundwater resources have been implemented in Karo, Bandung, Bangkok, and Tianjin. Unlike in three other regions, in Tianjin the price of water is not decided by free-market forces, but local government often involve fixing the water price, which ensures that private contractors cannot earn excessive profits, that is, profits over and above the costs of extraction. Thus, water selling is not a profitable business in Tianjin. This condition is totally different with Karo, Bandung and Bangkok, where many private groundwater wells are developed as business purpose. They extract groundwater as much as they want and sell it according to negotiation with community buyer. Even, such kind of business has become interesting because the increase of water demand due to inadequate water supplied by local water enterprise.

Those three donor regions have introduced groundwater use charge as disincentive in order to minimize groundwater extraction. However, in Bandung and Tianjin, groundwater price is cheaper than water supplied by local water enterprise. Consequently, there is no incentive for domestic, industries and also farmers to shift to the public water supply as a water resource. Even, in Bandung, domestic users are exempted from the groundwater charge. Therefore, in these regions, the charge instrument to control groundwater extraction does not function effectively for domestic use. But, different approach has been implemented for industry in Bandung. To increase the industries awareness, government introduces tax compensation. The industries that recycle their water use will get tax compensation. The result is that many industries become interested in water conservation, and contribute significantly in decreasing groundwater exploitation.

However, slightly different with Bandung, in Bangkok and Tianjin, an additional charging scheme in addition to regular groundwater uses charge, which known as groundwater preservation charge in Bangkok or effluent charge in Tianjin has been introduced to optimize groundwater protection. Unlike in Bandung, where the charge is inserted to local revenue, in Bangkok and Tianjin, this charge is used only for groundwater conservation purposes. The charge covers the administration cost of the licence, the monitoring costs for compliance sampling, the costs related to wastewater treatment, cleaner production and relevant research activities. Monitoring costs are related to the contents of the discharge and the type of water received. The change in groundwater charges is expected to promote the shift from groundwater use to the public water supply.

Moreover, as groundwater conditions including the magnitude of the impact of intensive groundwater use, availability of other water resources that can substitute for groundwater use, and scarcity of the resources are different in different places, regionally differentiated charging schemes have been introduced in Bangkok. The more severe groundwater issues, the higher groundwater price will be charged. This approach has also implemented in

Tianjin. In this region, where generally groundwater charge is lower that water price provided by local water supply, in exception, it is not applied to industries. As industries are one of the main groundwater users Tianjin, groundwater charge for industrial uses has been assigned higher than water tap price.

5.3.3. Other/supporting Instruments

One important factor that must be known as a basis to develop groundwater policy either regulatory or economic is data. These supporting data including groundwater table, groundwater quality and also land subsidence. In doing so, the regions of Bandung, Bangkok and Tianjin have conducted monitoring activities to collect data related to groundwater table depletion, land subsidence and also groundwater quality. However, this activity need much funds, many human resources and must be conducted regularly. As those regions have limited budget, limited personnel, they also involve industries to support their existing effort. For instance, in Bandung, local government has policy that industry must have groundwater well monitor. In different, Tianjin gives additional charge for industry that will be used for monitoring activities. Even in Bangkok, the Bangkok Groundwater Monitoring Network was established which has obligation to collect data of groundwater levels, land subsidence, and groundwater quality in the various aquifers in Bangkok. These data, then, are input to the Groundwater Database System.

In addition, those data are used in campaign in order to increase the community awareness to protect groundwater resources. Groundwater users who have known what the conditions of their resource are will be willing to sacrifice their current income to preserve groundwater. Moreover, they will know that overexploitation is going to hurt them in the foreseeable future. Such thing has conducted by Bangkok, through Department of Groundwater Resources (DGR) which has launched public awareness programmes to educate the population about the proper and the wise use of groundwater. DGR publish it through various brochures and booklets.

5.4 Strategy recommendation for Karo Regeny

After comparing and evaluating the aquifer characteristics, groundwater issues, and groundwater governance in Karo, Bandung, Bangkok and Tianjin, in this sub chapter possible strategy that might be useful to be adopted for Karo regency context will be proposed. The strategy recommendations are learned from experienced in Bandung, Bangkok and Tianjin. It is true that recommendation provided in this research perhaps will not “the perfect strategy”, however, this new strategy is believed could improve the current strategy in order to achieve sustainable development in Karo regency.

Actually, as it has been described in theoretical framework chapter, there are numerous strategies for groundwater governance as have been implemented in Bandung, Bangkok and Tianjin. The increased of those multiple governance either theoretically or practically have created a wide range of possible governance options that can be chosen. However, according to Kemper (2007), the groundwater governance challenges vary, of course, from country to country and between regions within countries. The manageability of groundwater will depend on complexity of groundwater issues faced. Consequently, not all of strategies that have been implemented in Bandung, Bangkok and Tianjin could be implemented directly in Karo context. What kind of instruments that could be adopted in Karo, what challenges will be faced and how to deal with the challenges will be described in this chapter.

5.4.1. Groundwater condition in Karo, Bandung, Bangkok, and Tianjin

According to Kemper (2007), in developing groundwater governance, many factors including groundwater condition (e.g. aquifer characteristics such as the size of aquifers, aquifer yields, and storage capacity, human intervention such as number of abstraction and level of contamination), various stakeholders to be involved, and socio economic of the region must be considered. It is true that there is not a comprehensive data which can describe current condition in both case study and donor regions completely and perfectly. However, in this research, considering data availability (see table 5.1, 5.2, 5.3, 5.4, 5.5, 5.6), generally it can be concluded that current condition in Karo and donor regions is different particularly in term of groundwater condition. Compared to donor regions, the pressure on groundwater resources in this region is less than those in Bandung, Bangkok and Tianjin. The estimated volume of groundwater extracted for instance, with have similar area and annual rainfall, Karo only extract about 8 million m3/year, but Bandung extract it up to 500 million/year, even more in Bangkok and Tianjin.

5.4.2. Proposed groundwater governance in Karo regency

Learning from Bandung, Bangkok and Tianjin experience, there are some instruments options that could be transferred to improve current groundwater governance in Karo. Moreover, considering the five categories of policy transfer, (Dolowitz and Marsh,1996), the policy from donor regions can be conducted by copying, emulation, hybridisation, synthesis and inspiration. However, due to the reasons that Karo and donor regions are not similar particularly in term of groundwater condition, the best approach chosen in this research is hybridisation/synthesis and inspiration.

Hybridisation/synthesis approach involves combining elements of strategies found in donor regions to develop a policy best-suited in case study. However, the failure of donor regions could be learned as inspiration to develop better policy. The categories that will be chosen depend on suitability in Karo region by considering the groundwater condition and the stage where the groundwater development is (see model developed by Kemper (2007) (see table 2.1 and figure 2.7). Therefore, in this section, the policy that could be transferred will be described. However, as well as donor regions, the proposed policy instruments are also distinguished into three categorised; regulatory, economic and other/supporting.

Regulatory instruments

Learning from Bandung, Bangkok and Tianjin, to implement each of instruments, institution including regulation and organization is very important. Institutions are needed because instruments can only implement when organization and regulation have been developed (Kemper, 2003, 2007). Actually, Karo has had organizations which responsible for groundwater governance including in national, provincial and regency level (see table 3.1). Unfortunately, only national level established groundwater regulations, however, only one regulation exist in local level and this regulation only regulate concerning groundwater charge (see table 3.2). However, the elements in this regulation should be adjusted based on current groundwater condition in Karo.

To control groundwater extraction, that regulation should regulate groundwater exploring and drilling. Such kind of regulation has been implemented in Bandung, Bangkok and Tianjin. This regulation could be developed in Karo by combining elements from donor regions (hybridisation). As Karo and Bandung is located in same country, exploration and drilling rule could be adopted from Bandung, therefore, political and cultural obstacle could be minimize. However, to increase the awareness of groundwater user, the punishment should be stated clearly in this regulation as has been implemented in Bangkok.

Moreover, unlike in Bandung, Bangkok and Tianjin that have tried to stop a new groundwater extraction license for a certain area, Karo still can establish a new license especially in areas where are no other alternative sources such as river or lake. Consequently, such kind of regulation is not needed in Karo. However, for a new well, groundwater user must register his/her wells before it is developed. In addition, it is fact that there are many unregistered groundwater wells in Karo. As long it is extracted for domestic use, currently, local government do not need to close these wells. Because to close existing unregistered wells is very risky. Since people could not get adequate water from local water company, or even they do not have another water source, closing their wells could lead further problems such as social issues. The most important thing, all of these unregistered wells must be recorded to get the real number of groundwater wells and to know the volume of water extracted. These data are useful as base to develop groundwater policy for the long term.

Besides groundwater conditions, important information that should be known in Karo is charging area locations. Charging area could be determined by conducting hydrogeological survey and analysis. Such kind of study has been conducted in Bandung which determined the North Bandung Area as one of catchment area. In Bandung, data from this study, then, are input for spatial planning. This spatial planning is used as legal aspect to control land use change. Government should restrict the development in this charging area or even stop the development in this area. This strategy could be adopted by Karo regency. However, in doing so, coordination among stakeholders is a necessity in order to particularly when catchment area is located in transboundary.

In similar with Bandung, Bangkok and Tianjin, Karo should have regulations which regulate waste management. Learning from those donor regions, it has been revealed that the increasing of groundwater contamination is due to uncontrolled waste disposal produced by domestic, industry and also agriculture. The regulation manages domestic, industrial and agricultural waste including waste disposal standard and also sanction for violators as has been implemented in this regions. It is expected that through this regulation, these polluters become aware and not dispose their waste freely without treatment. As well as groundwater regulation, this regulation could be adopted from donor regions. The principle waste management could be adopted from Bandung. In Bandung, this regulatory approach is integrated with economic measures. Incentive for polluters is given in the form of charge compensation when they recycle or reuse their water waste. However, to increase the effectiveness of this regulation, penalty as has been implemented in Bangkok could be also implemented.

Economic instruments

In order to control groundwater extraction, economic instruments such as groundwater charge and incentive/disincentive could be implemented in Karo. Although, Karo has implemented this strategy, the charge only applied for industry and commercial use. Unfortunately, the other groundwater users, which are the highest consumers in this region, such as domestic use and agriculture use, are still free. Consequently, they extract groundwater as they desired. To anticipate this issue, Karo could adopt the strategy from Bangkok and Tianjin which applied disincentive principle. Groundwater is charged based on groundwater condition and higher charge is applied in areas where people can find the other water source such as river or lake.

Moreover, one of the main reasons that caused regulatory instruments could not function effectively in Bandung, Bangkok and Tianjin is lack of water provided by public water company or even people do not have other options. This issue has been faced in Karo since a long time ago. It is predicted that groundwater regulation that established in short term will also not effective since this obstacle cannot be resolved. Therefore, government must provide adequate water for people especially in vulnerable and critical zone. The strategy that has been implemented in Bandung could be also applied in Karo. As Karo had has local water company (PDAM Tirtamalem and PDAM Tirtanadi), government should support this company either through finance or even policy, hence, they can improve their service in order to meet water demand of people throughout the region. Since surface water is much in Karo, actually, PDAM has adequate raw water and to increase their current production capacity.

Other/supporting instruments

It is true that Bandung, Bangkok and Tianjin have also monitored their groundwater conditions. However, they were not conducted it regularly. Consequently, the groundwater condition was not update. In addition, although they have known the groundwater condition, this information was not followed-up. However, according to Kemper (2003, 2007), groundwater data including water table, land subsidence and groundwater quality are very important, because these data will be useful as basis to develop sustainable groundwater governance. Therefore, monitoring should be conducted regularly in Karo regency. To conduct this monitoring, Karo can establish organisation such has been implemented in Bangkok (Bangkok Groundwater Monitoring Network). However, the failure in Bangkok should not be repeated. Groundwater condition should be monitored regularly and the monitoring result must be followed up to determine zoning area. When Karo has had zoning area, groundwater governance should be developed based on existing condition and based on priority area rather than universally apply the measures. For instance, once one region has been vulnerable, government should stop establishing a new license there, or even relocate industry in a place once there has been known as critical zone.

While in regulatory instrument controlling groundwater contamination is engaged for industrial and agricultural sector through economic measure, in the future, integrated waste management should be introduced. In doing so, some possible strategies could be applied. First, develop integrated waste management including solid waste, especially liquid waste as has been implemented in Tianjin. Recently, Karo does not have appropriate solid waste management; waste from domestic, industry and agriculture is disposed freely to environment. For instance, liquid waste from domestic and industry is disposed freely to drainage system or even to surrounding areas. As solution, Karo should develop an integrated waste management system including developing its institution. However, this approach needs integration and synchronization between agencies which has interest in groundwater management (Kemper, 2007). Second, it is true that waste generation is inevitable in human activities; therefore, appropriate available technology for recycling can be implemented. Consistency and support from the government in the implementation is the key to the success of this programme. Besides can reduce groundwater contamination, water from treatment plant can be also reuse to minimize groundwater exploitation.

Most of the water-related conflicts in Bandung, Bangkok and Tianjin, such as water pollution and water scarcity, mostly result from the ‘scientific management shortage’ rather than ‘resource shortage’. In those regions, many stakeholders get involved in the water affairs. Different bodies take charge of different parts. For instance, although we are discussing groundwater, the other sectors such as environment, industry, agriculture or even surface water need to be considered. Whether or not the groundwater resource can be used rationally has close relationship with rational management of those sectors. This experience should become an inspiration to develop groundwater governance in Karo. So in future, Karo need the highly efficient and integrated groundwater management system is eagerly needed. This strategy is in line with the current believe as has been describe by Lemos & Agrawal (2006); Jänicke & Jörgens, (2006).

Moreover, another inspiration that could be learned from Bandung, Bangkok and Tianjin experience is related to public participation. Lack of public participation in groundwater governance has caused the implementation of policy ineffective. They do not aware that groundwater governance is important for sustainable development. Therefore, to develop groundwater governance in Karo, it is recommended to involve public. They must be given opportunities to actively participate in the development and enforcement of solutions to problems resulting from groundwater use. Local community capacities must be developed, possibly through the conduct of seminars and trainings (see Lemos & Agrawal, 2006; Jänicke & Jörgens, 2006).

Chapter VI
Conclusion

After providing theoretical review related to groundwater issues and groundwater governance, followed by providing empirical data and comparison analysis, in this last chapter, conclusion will be provided. In conclusion, general finding to answer the research question, *'What kinds of governance should be established, comparatively, to protect the groundwater resources in the context of Karo regency?*' will be drawn based on theoretical review, empirical data and analysis in previous chapter. In addition, in the last part of this chapter, the general reflection of this research will be provided.

6.1. Conclusion

As groundwater is essential to a region's economy, environment, and public health and as it has more advantages than other sources, groundwater will be exploited as main water supply. Further, the pressure to groundwater resources will be increase due to with population growth, economic growth, uncertainty around surface water deliveries, and changes in land use practices. Such kind of groundwater issues have been revealed in this research either in Karo as case study or in Bandung, Bangkok and Tianjin. The groundwater in all of these regions has been exploited intensively to meet people demand, even it has contaminated through human activities. Consequently, as has been experienced in those regions, the continuous and high pressure on groundwater has caused groundwater issues such as water table depletion and groundwater contamination. However, the groundwater issue either its impacts or its level varies in each region depends on complex factors including aquifer characteristics, hydrogeological conditions and human interventions.

Concerning the increased use of groundwater and the associated problems has necessitated renewed attention towards issues of groundwater governance. In doing so, Bandung, Bangkok and Tianjin, have viewed governing groundwater with seriousness and have made legal provisions for the same, while Karo is still grappling with basic issues such as developing and enacting a groundwater regulation. The experience of Bandung and Bangkok bring to the fore the fact that while making regulation is not very difficult, enforcing one is a challenge. Many obstacles faced in all of the regions as has been discussed above. The implementation of regulation became more ineffective due to the fact that condition for law enforcement are likely to happen in regions such as Bandung and Bangkok where direct dependence on groundwater is very high, economic condition of users is still low and political situation unstable. Even, in Tianjin, where has hard state, with arms of government and the party stretching to local region, the violation still occur. Governing groundwater has proved very difficult since only relied on law enforcement.

Unlike direct regulatory, better performance have been experienced in Bandung, Bangkok and Tianjin when the economic measures were implemented. Implementation of economic instruments such as groundwater usage charge and disincentive or incentive in groundwater use had better performance than law enforcement for alleviating groundwater stress. However, all these are being used with varying mechanisms in different regions, and experience of Bandung, Bangkok and Tianjin are quite well documented. In Bandung, for instance, as industry is the main groundwater use, industry is charged higher than other purposes. In different, Bangkok and Tianjin charge groundwater uses based on groundwater condition in that region. Groundwater in critical zones is charged higher than that in safe zone. Furthermore, although groundwater protection through economic approach has better performance than direct regulation, in fact, the implementation of this instrument was also faced several obstacles. People who have no other alternatives instead of groundwater, the charge mechanism cannot control groundwater exploitation. Moreover, weak in law enforcement has also become obstacle to implement economic instrument effectively.

After conducting comparison and evaluation and to answer the main research question, groundwater strategy proposed in Karo is also distinguished into three categories: regulatory, economic and other/supporting instruments (see table 6.1). These strategies are transferred from donor region experience through hybridisation or synthesis approach. For regulatory instruments, Karo should establish a comprehensive groundwater regulation including groundwater permit, zoning area, and land use. However, unlike donor regions, recently Karo do not need to stop a new license or to close unregistered wells (see chapter 5). For economic instruments, the experience from Bandung, Bangkok and Tianjin could be adopted. The implementation of incentive and disincentive approach perhaps could control groundwater extraction in Karo. In addition, to support regulatory and economic instruments, monitoring of groundwater table, land subsidence and groundwater quality should be conducted regularly in Karo. The summary of strategy recommendations for groundwater governance in Karo regency is provided in Table 6.1.

Table 6.1. Strategy recommendations for groundwater governance in Karo regency

Instruments	Leading stakeholder	Donor regions	Explanation
Regulatory instruments			
Establishing groundwater regulation which regulate groundwater exploring and drilling	Local government	Bandung	- No need to stop new groundwater permit - No need to close unregistered wells, but registration should be conducted
Penalties for violations	Local government	Bangkok	- It is needed to increase the stakeholders awareness
Land use regulation	Local government	Bandung, Bangkok and Tianjin	- Consist of charging areas, critical areas, vulnerable areas and safe areas.
Controlling the waste disposal	Local government	Bandung, Bangkok and Tianjin	- Establish waste regulations including for domestic, agriculture and industry - Is integrated with economic instrument
Economic instruments			
Groundwater charge	Local government	Bangkok and Tianjin	- Groundwater is charged based on groundwater condition - Not only for industries, but implemented for all groundwater users - Groundwater price is higher than PDAM's water
Providing water source alternatives	Local government	Bandung, Bangkok and Tianjin	- Improve local water company services - Restrict the using of groundwater
Other/supporting approaches			
Monitoring of groundwater table, land subsidence and groundwater quality	Local government	Bandung, Bangkok and Tianjin	- Conducted regularly - Is followed –up to in developing groundwater management
Integrated waste management		Tianjin	- Need integration and synchronisation among related agencies - Develop waste recycling technology
Integrated water management	Local government	Bandung, Bangkok and Tianjin	- Involve related stakeholders

Finally, typical of groundwater issues in Karo, Bandung, Bangkok and Tianjin case reveals that to develop groundwater governance, many factors interacting. The developing sustainable groundwater management includes three phenomena in relation to groundwater resources – escalating groundwater demand, escalating groundwater issues and increasing stakeholders' involvement. All of these phenomena can be found in the case of Karo, Bandung, Bangkok and Tianjin, and become more sophisticated due to rapid economic growth and population growth in these regions. The most important lesson to be learned through these cases is that groundwater governance cannot be carried out within the regulatory or economic approach alone, but rather requires a comprehensive systems approach. Groundwater condition, socio-economic condition and inter-stakeholders relationships are three major issues which need to be addressed to develop groundwater governance policy. Concerning the latter issue, the necessity of cooperation between appropriate institutions has been recognized, and there seems a proneness to create institutions that facilitate cooperation. In the case of Bandung, Bangkok and Tianjin, the groundwater institutions including regulation, organizations and instruments exists, but its administrative power is too weak to take on coordinating responsibility.

6.2. Reflection

Based on the empirical findings, summarised in the previous section, some general reflections of this research are made here.

a. Ideally, the selected case study and donor regions should have very similar groundwater characteristics, because according to (Dolowitz and Marsh, 1996), the more similar case study and donor, the less obstacles will be faced in conducting policy transfer. However, in this research, two out of three selected donor regions are different in term of topography (Bangkok and Tianjin) and climate (Tianjin). Consequently, although the policy has good performance in donor regions, it could not be adopted. For instance, to decrease groundwater extraction, Tianjin desalinated seawater to substitute groundwater. However, it is impossible adopted in Karo which located far from sea.

b. Moreover, in this research, donor regions are selected from developing country. It is true that they have more experience than case study; however, the policy options provided by these donor regions mostly focus on classic approaches. In fact, this research has revealed that to develop sustainable groundwater governance, these regions faced many obstacles. Therefore, as has been described in in literature review, it will be very interesting to select donor regions from those who have implemented different governance strategy which has shifted to more communicative approach.

c. This research focuses strongly by considering aquifer characteristic and human intervention. Consequently, the recommendations proposed in this research are only mainly based on aquifer characteristics. However, actually, according to Kemper (2003, 2007), social, economic and political condition are also have important role which should be considered in developing groundwater governance. Unfortunately, due to data availability, socio-economic condition of the region, either in case study or in donor regions is considered only limited. Therefore, it is suggested to consider these factors in the future research.

d. This research has not discussed the consequences of proposed strategies when they are implemented. It is expected that the recommendation strategies will give positive impacts, however negative impacts should be considered. Therefore, continuing this research by exploring possible consequences of each strategy in the field of environment, economics, social, etc. can widen the perspective in understanding groundwater issue

e. Understanding groundwater issue is very important before developing groundwater governance (Kemper, 2003, 2007; Bredehoeft and Durbin 2009; Giardano, 2009; Theesfeld 2010). In doing so, in this research, groundwater issues are framed clearly by describing and providing factors that could cause groundwater issue. The possible factors are gathered and studied from literature review. In this research, groundwater issue is framed by dividing it into two categories namely causes and impacts. Causes consist of natural factors including hydrogeological characteristics such as climate and aquifer conditions and human factors such as groundwater extraction and contamination. In this research, such kind of approach is implemented in case study and also donor regions. By conducting this framing, the groundwater issue in those regions could be known clearly. It is clear then, that groundwater issue in specific region is unique depends on interrelated relationship between groundwater characteristics and human interventions. Although amount of groundwater extracted is similar in two different regions, the groundwater issues perceived by them could be different depends on hydrogeological characteristics in their region and vice versa. Consequently, strategies to protect groundwater resources will therefore have to be developed uniquely too.

f. By developing this approach, perhaps this research contributes for planning practice particularly to develop groundwater governance in other regions. To understand the unique of groundwater issue in other regions, such kind approach could be implemented before developing groundwater governance in their regions. However, by considering the other important factors such as social, economic and political condition and also inter-stakeholders relationships. Moreover, since comparative analysis is used to develop groundwater governance such kind of approach is very important. Because, according to Dolowitz and Marsh (1996), to avoid policy transfer failure, the unique of case study and also donor regions must be understood well before policy is transferred.

g. In general, the approach that has been implemented to frame groundwater issues perhaps could be implemented in other environmental issues such as surface water pollution and air pollution. To make surface water and air pollution issues well understand, framing issues including its causes and impacts is very useful. Then, appropriate and suitable solutions could be developed to reduce air pollution. Moreover, as well as groundwater, surface water and air pollution are ‘transboundary resources’, which means that the causes and the impacts could come from other point and could be recognized in different point. Therefore, the strategies that have been implemented for groundwater issues perhaps could be also applied for air pollution issues.

References

Alexander, E. R. (2005). Institutional transformation and planning: from institutionalization theory to institutional design. *Planning Theory*, 4(3), 209-223

Aral, M.M, and Taylor, S.W, (2011) Groundwater quality and quantity management, Environmental and Water Resources Institute of the American Society of Civil Engineers,Virginia, USA.

Aobpaet, A., Cuenca, M.C., Hooper, A., & Trisirisatayawong, I., (2013) InSAR time-series analysis of land subsidence in Bangkok, Thailand, *International Journal of Remote Sensing*, 34:8, 2969-2982, DOI: 10.1080/01431161.2012.756596.

Braadbaart, O. and Braadbaart, F. (1997). Policing the urban pumping race: industrial groundwater overexploitation in indonesia, *World Development*, Vol. 25(2), pp 199-210.

Bai, X., and Imura, H., (2001), Towards sustainable urban water resource management: a case study in Tianjin, China, *Sustainable Development* Vol. 9, pp. 24–35

Blomquist, W. and Ingram, H., (2003), Boundaries seen and unseen: resolving transboundary groundwater problems, *Water International* 28, pp. 162-169.

Bradley, Robert M., (2004), Forecasting Domestic Water Use in Rapidly Urbanizing Areas in Asia, *Journal of Environmental Engineering*, Vol. 130(4), pp. 465 - 471.

Babel, M.S., Gupta, A.D., and Sto. Domingo, N.D., (2006), Groundwater resources management in Bangkok, Sustainable groundwater management in Asian city.

Buapeng, S. & Foster, S., (2008), Controlling Groundwater Abstraction and Related Environmental Degradation in Metropolitan Bangkok – Thailand, The World Bank global water partnership associate program.

Baxter, P and Jack, S., (2008), Qualitative case study methodology: study design and implementation for novice researchers, *The Qualitative Report*, Vol. 13 (4), pp. 544-559

Biesbroek, G.R., Swart, R.J. & van der Knaap, W.G.M. (2009). The mitigation-adaptation dichotomy and the role of spatial planning. *Habitat International*, Vol. 33, pp. 230-237

Bredehoeft, J., Durbin, T., (2009) Ground water development: the time to full capture problem. *Ground Water*, Vol. 47, pp. 506–514

Babel, M.S., Rivas, A.A., Gupta, A.D., & Kataoka, Y., (2012) Improving Groundwater Quality Management for the Sustainable Utilization of the Bangkok Aquifer System, *International Journal of Water Resources Development*, 28:2, 355-371, DOI: 10.1080/07900627.2012.668645

Badan Pusat Statistik (BPS) Kabupaten Karo (2013), Kabupaten Karo Dalam Angka, Kabanjahe, Indonesia accessed on 7-10-2014 via http://www.karokab.bps.go.id/?hal=publikasi_detil&id=153

Badan Geologi (2013), Sistem informasi air tanah, Bandung Indonesia, accessed via http://pag.bgl.esdm.go.id/siat/

Badan Pusat Statistik (BPS) Kota Bandung, (2014), Kota Bandung Dalam Angka 2014, Bandung, Indonesia

Changming, L., Jingjie, Y., & Kendy, E., (2001) Groundwater exploitation and its impact on the environment in the north china plain, *Water International*, Vol. 26(2), pp. 265-272, DOI: 10.1080/02508060108686913

Chaussard, E, Amelung, F, Abidin, H, Hong, S, (2013), Sinking cities in Indonesia: ALOS PALSAR detects rapid subsidence due to groundwater and gas extraction, *Remote Sensing of Environment*, Vol. 128, pp. 150–161

China Statistical Yearbooks Database, (2014), Tianjin statistical yearbook, accessed via http://tongji.cnki.net/overseas/engnavi/YearBook.aspx?id=N2011110058&floor=1 on 2 -6-2015.

Dolowitz, David and David Marsh, (1996), Who learns what from whom: a review of the policy transfer literature, *Political Studies*, Vol. 54, pp. 343-357.

Dolowitz, David and David Marsh, (2000), Learning from abroad: the role of policy transfer in contemporary policy-making, Governance, Vol. 13, pp. 5-24.

Direktorat Tata Lingkungan Geologi dan Kawasan Pertambangan (DTLGKP)(Directorate of Environmental Geology) and Badan Perencanaan Daerah Propinsi Jawa Barat (BPDPJB) (Planning Board of West Java Province) (1996), Identifikasi dan pengendalian pembangunan di daerah resapan (Identification and control of development in recharge area). Final report. Bandung: Departemen Pertambangan dan Energi, Direktorat Jenderal Geologi dan Sumberdaya Mineral

Dinas Pertambangan dan Energi Kabupaten Karo, (2013), Data sumur bor di Kabupaten Karo, Kabanjahe, Indonesia.

Dong et al, D., Sun, W., Zhu, Z., Xi, S., & Lin, G., (2013), Groundwater Risk Assessment of the Third Aquifer in Tianjin City, China, *Water Resource Management*, DOI 10.1007/s11269-013-0342-z

Distamben Propinsi Sumatera Utara (2014), Potensi air tanah, Medan, Indonesia accessed on 22-04-2015 via http://distamben.sumutprov.go.id/index.php/data/potensi-air-tanah

Ebraheem, A.M., Garamoon, H.K., Riad, S., Wycisk, P., Seif El Nasr, A.M., (2003). Numerical modeling of groundwater resource management options in the East Oweinat area, SW Egypt. *Environmental Geology* , Vol. 44, pp. 433-447

Evans, M. and Davies, J., (1999), Understanding policy transfer: a multi-level, multi-disciplinary perspective, Public administration, Vol. 77, pp. 361-386.

Evans, M., (2009), Policy transfer in critical perspective, *Policy Studies*, Vol. 30(3), pp. 243-268.

European Environmental Agency (2009), Water resources across europe- confronting water scarcity and drought, EEA Report No.2/2009. Copenhagen.

Feeny, D., Berkes, F., McCay, B. J., and Acheson, J. M., (1990), The tragedy of the commons: Twenty-two years later. *Human Ecology*, Vol. 18 (1), pp. 1–19.

Food and Agriculture Organization of The United Nations (FAO)(2003), Groundwater Management, *The Search for Practical Approaches*, Rome, Italy

Feng, Liu, Meng, Fu, Zhang, H., Zhang. K.(2008), Land subsidence induced by groundwater extraction and building damage level assessment — a case study of Datun, China, *Journal of China Univ Mining & Technology*, Vol. 18 pp. 0556–0560

Gunawan, H. 1995. Analisis terhadap pokok-pokok pertimbangan dalam rangka perumusan kebijakan pengelolaan dan pemanfaatan air tanah: Kasus Cekungan Bandung (Policy analysis on groundwater management and usage: Case study of Bandung Basin). Master's thesis. Bandung: Bandung Institute of Technology.

Gupta, A.D. & Babel, M.S., (2005) Challenges for Sustainable Management of Groundwater Use in Bangkok, Thailand, *International Journal of Water Resources Development*, Vol. 21 (3), pp. 453-464, DOI: 10.1080/07900620500036570.

Geng, Y., & Yi, J., (2006) Integrated water resource management at the industrial park level: A case of the Tianjin Economic Development Area, *International Journal of Sustainable Development & World Ecology*, Vol. 13 (1), pp. 37-50, DOI: 10.1080/13504500609469660.

Giordano, M., and Villholth. K, (2007) The Agricultural Ground Water Revolution: Opportunities and Threats to Development. Wallingford, Oxon, UK: CABI.

Giordano, M., (2009) Global groundwater? Issues and solutions. Annual Rev Environ Resources, Vol. 34, pp. 153–178

Ge, L., Li, X., Chang, H., Hayman Ng, A. H., Zhang, K., & Hu, Z., (2010) Impact of ground subsidence on the Beijing–Tianjin high-speed railway as mapped by radar interferometry, *Annals of GIS*, Vol. 16 (2), pp. 91-102, DOI: 10.1080/19475683.2010.492125

Heath, R. C., (1983), Basic ground-water hydrology: U.S . Geological Survey Water-Supply Paper 2220, 86 p.

He, X., and Lei, Z., (2006), Groundwater resources management in Tianjin, Sustainable groundwater management in Asian city.

Japan International Cooperation Agency (JICA), Department of Energy Development and Promotion (DEDP) and Japanese Institute of Irrigation and drainage (JIID), (1999), Water Resources Laws in Thailand. Bangkok, Thailand

Jordan, A., Wurzel, R.K.W., and Zito, A.R., (2005) The rise of 'new' policy instruments in comparative perspective: has governance eclipsed government? *Political Studies*, Vol.53 (3), pp. 477-496

Jänicke, M., Jörgens, H. (2006) New Approaches to Environmental Governance. In: Jacob, K. M. Jänicke (eds.) Environmental Governance in Global Perspective: New Approaches to Ecological and Political Modernisation, Freie Universität Berlin, Berlin

Jordan, A. (2008). The governance of sustainable development: taking stock and looking forwards. *Environment and Planning C*, 26(1), pp. 17-33.

Kasetsart University, (1998), English Informations. Water Resources Information of 25 River Basins of Thailand, accessed via http://www.eng.ku.ac.th/~irre/E25BASIN.HTM on 22-05-2015

Kraemer, R. A., Choudhury, K., Kampa, K., (2001), Protecting water resources: Pollution prevention, International Confrence on Fresh Water, Bonn

Kemper, K.E., (2003), Rethinking groundwater management. In Figures, Caroline, and Rockstrom, Johan, eds. Rethinking Water Management: Innovative Approaches to Contemporary Issues. London, GBR: Earthscan, 2003. ProQuest ebrary. Web. 21 June 2015.

Kamel, S., Dassi, L., Zouari, K., (2006), Hydrogeological and hydrochemical approach for hydrodynamic exchanges between deep and shallow aquifers in the Djerid basin, Tunisia. *Hydrological Sciences Journal* Vol. 5, 713e730 (in French).

Kemper, K. E., (2003), Rethinking groundwater management. In: Figueres, C., Rockstrom, J. and Tortajada, C. (eds) *Rethinking Water Management: Innovative Approaches to Contemporary Issues*. Earthscan, London.

Kemper, K. E., (2004), Ground water—from development to management. *Hydrogeology Journal*, Vol. 12, pp. 3–5

Kemper, K.E, (2007), Instruments and institutions for groundwater management. In: Giordano M (ed) Agricultural groundwater revolution: opportunities and threats to development. CABI, Cambridge, MA, pp 153–172

Ken'ichi, N., and Yuwana, D. A., (2012), Groundwater sustainability in Bandung, Indonesia.

Kementerian Pekerjaan Umum (2013), Pola Pengelolaan Sumber Daya Air Wilayah Sungai Toba Asahan, Jakarta Indonesia.

Lafferty, W.M., E. Hovden (2003) Environmental Policy Integration: Towards an Analytical Framework. *Environmental Politics*, Vol.12 (3), pp. 1-22.

Llamas, M. R., and Martinez-Santos P., (2005), Intensive groundwater use: silent revolution and potential source of social conflict, *Journal of Water Resources Planning and Management* Sep/Oct, 337-341

Lemos, M. C., A. Agrawal (2006) Environmental governance. Annual Review of Environment and Natural Resources, 31 (3), pp. 297-325

Lerner, D. N., Harris, B., (2009), The relationship between land use and groundwater resources and quality, Land Use Policy, Vol. 26S, pp. S265–S273

Loorbach, D. (2010). Transition management for sustainable development: a prescriptive, complexity-based governance framework. *Governance*, Vol. 23(1), pp.161-183

Li, X., Li, G., and Zhang , Y., (2014), Identifying Major Factors Affecting Groundwater Change in the North China Plain with Grey Relational Analysis, *Water*, Vol. 6, pp. 1581-1600; doi:10.3390/w6061581

Mukherji A, Shah T (2005) Groundwater socio-ecology and governance: a review of institutions and policies in selected countries. Hydrogeology Journal, Vol. 13, pp. 328–345

Merriam, S., (2009). Qualitative research: A guide to design and implementation. San Francisco, CA: Jossey-Bass.

Martínez, J.P, Marín, M.H, Burbey,T.J, Cervantes,N.G, Lozano,A.O, De-Leon,E.Z, Pinto, A.S, (2013) Land subsidence and ground failure associated to groundwater exploitation in the Aguascalientes Valley, México, *Engineering Geology,* Vol.164, pp. 172–186

Modoni, G, Darini, G, Spacagna, R.L, Saroli, M, Russo, M, Croce, P.,(2013), Spatial analysis of land subsidence induced by groundwater withdrawal, *Engineering Geology*, Vol. 167, pp. 59–71

North, D. (1990*)*, Institutions, Institutional Change and Economic Performance, Cambridge: Cambridge University Press.

National Statistic Office of Thailand, (2014), Statistical tables 2014, accessed via http://web.nso.go.th/en/survey/bts/datafiles/2014_KST_Statistical%20Tables.pdf on 2-6-2015.

Pemerintah Indonesia, (1990), Keputusan Presiden Republic Indonesia no.23 tahun 1990 tentang Badan Pengendalian Dampak Lingkungan, Jakarta, Indonesia.

Pemerintah Indonesia, (1994), Keputusan Presiden Republik Indonesia no.77 tahun 1994 tentang Badan Pengendalian Dampak Lingkungan, Jakarta, Indonesia.

Pemerintah Indonesia, (2004), Undang-undang Republik Indonesia no.07 tahun 2004 tentang Pengelolaan sumber daya air, Jakarta, Indonesia.

Pemerintah Indonesia, (2004), Undang-uandang Republik Indonesia no.32 tahun 2004 tentang Pemerintah Daerah, Jakarta, Indonesia.

Pemerintah Indonesia, (2008), Keputusan Presiden no.43 tahun 2008 tentang Air tanah, Jakarta, Indonesia.

Pfeiffer, L., Lin, C. (2009), Groundwater pumping and spatial externalities in agriculture, *Journal of Environmental Economics and Management*, Vol. 64, pp 16–30

Pemerintah Indonesia, (2009), Undang-undang no.32 tahun 2009 tentang Perlindungan dan pengelolaan lingkungan hidup, Jakarta, Indonesia.

Pessali, Huascar (2011), Public Policy Design in Developing Societies Beyond Transplantation, *Journal of Developing Societies*, Vol. 27 (1), pp. 11 - 28.

Pemerintah Kabupaten Karo, (2013), Rencana tata ruang wilayah Kabupaten Karo, Kabanjahe, Indonesia.

PDAM Tirtawening, (2015), Pelanggan air minum PDAM Tirtaweing, Bandung Indonesia. Accessed on 21-05-2015 via http://www.pambdg.co.id.

Sophocleous, Marios (2002), Interaction between Groundwater and Surface Water: the State of the Science, *Hydrology Journal*, Vol 10, pp. 52 – 67.

Shah, T., (2008), Taming the Anarchy: Groundwater Governance in South Asia. Washington, DC: Resources for the Future Press.

Shiqin, W., Xianfang, S., Qinxue, W., Guoqiang, X., Changming, L., Jianrong, L., (2009), Shallow groundwater dynamics in North China Plain, *J. Geogr. Sci.*, Vol. 19, pp. 175-188 DOI: 10.1007/s11442-009-0175-0

Sheng, Z., Li, J., King, P. J., and Miller, W., (2011), Development of groundwater resources, Groundwater Quantity and Quality Management. Reston, VA, USA: ASCE, 2011. Accessed via ProQuest ebrary. Web, on 20 June 2015.

Sugiyono (2012), Improving strategies in dealing with water supply fulfilment and groundwater conservation: learning from successful policies and practices, Master Thesis ITB-RuG.

Sumut Berita (2012), Sumur bor marak tanah akan amblas bisa menimbulkan korban jiwa, Kabanjahe, Indonesia, accessed on 7-10-2014 via http://www.sumutberita.com/2012/09/09/sumur-bor-marak-tanah-akan-amblas-bisa-menimbulkan-korban-jiwa/

Tirtomihardjo, H., (2009), Groundwater Potency in Indonesia and Their Management, Bandung, Indonesia,

accessed via http://wenku.baidu.com/view/4acd432c0066f5335a81211d on 25-5-2015.

Theesfeld, I., (2010) Institutional challenges for national groundwater governance: policies and issues. *Ground Water*, Vol. 48, pp. 131–142

USGS, (2015), The water cycle, accessed via http://water.usgs.gov/edu on 25-5-2015.

Van Dijk, Terry (2006), Transplanting instruments that work: four practical lesson on eliminating assumptions, *Planning Theory and Practice*, Vol 7 (4), pp. 421 - 442.

Wangsaatmaja, S., Sutadian, A. D., and Maria A. N. Prasetiati, M.A.N, (2006), Groundwater resources management in Bandung, Sustainable groundwater management in Asian city.

Warner. W. (2010) Ecological modernisation theory: towards a critical ecopolitics of change? Environmental Politics, 19 (4), 538-556

Widodo, L.E., (2013), Estimation of Natural Recharge and Groundwater Build up in the Bandung Groundwater Basin Contributed from Rain Water Infiltration and Interaquifer Transfer, *Procedia Earth and Planetary Science* , Vol. 6, pp.187 – 194

Zhou, Y., Vulnerability and adaptation to climate change in North China: the water sector in Tianjin, Research unit Sustainability and Global Change, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg, Germany, accessed via http://www.start.org/Program/advanced_institute3_web/Final%20Papers/Zhou_paper%28revised%29.pdf on 24 -05-2015

Zuidema (2013) Post-contingency: stimulating local environmental policy, Ashgate, Farnham.