A STUDY ON ECONOMIC EVALUATION OF BENEFICIARY PAYS PRINCIPLE IN WATER RESOURCE MANAGEMENT: THE CASE OF NAMYANGJU IN KOREA

By

Jaehyun Yoon

THESIS

Submitted to

KDI School of Public Policy and Management

in partial fulfillment of the requirements

for the degree of

MASTER OF DEVELOPMENT POLICY

2014

A STUDY ON ECONOMIC EVALUATION OF BENEFICIARY PAYS PRINCIPLE IN WATER RESOURCE MANAGEMENT: THE CASE OF NAMYANGJU IN KOREA

By

Jaehyun Yoon

THESIS

Submitted to

KDI School of Public Policy and Management

in partial fulfillment of the requirements

for the degree of

MASTER OF DEVELOPMENT POLICY

2014

Professor Tae Yong Jung

A STUDY ON ECONOMIC EVALUATION OF BENEFICIARY PAYS PRINCIPLE IN

WATER RESOURCE MANAGEMENT:

THE CASE OF NAMYANGJU IN KOREA

By

Jaehyun Yoon

THESIS

Submitted to

KDI School of Public Policy and Management

in partial fulfillment of the requirements

for the degree of

MASTER OF DEVELOPMENT POLICY

Committee in charge:

Professor Tae Yong JUNG, Supervisor ____________

Professor Taejong KIM ____________

Professor Insoo JEONG ____________

Approval as of May, 2014

ABSTRACT

A STUDY ON ECONOMIC EVALUATION OF BENEFICIARY PAYS PRINCIPLE IN WATER RESOURCE MANAGEMENT: THE CASE OF NAMYANGJU IN KOREA

By

Jaehyun Yoon

Using hedonic price method, this study analyzes the impact of restriction for water quality protection on property value with officially announced prices of reference land in the city of Namyangju in 2012. The analysis results show that there is statistically significant evidence that supports the land price difference between the restricted area and the unrestricted area of Namyangju caused by the restriction for water quality protection. In specific, under the semi-log model, the loss rate that the restricted area experience is 15.0% of the land price of the unrestricted area. Under the double-log model, the rate is estimated to be 19.8%.

Based on the results from the regression analyses of the models, the total compensations for the city of Namyangju are estimated to be in the range between 6.5 and 8.6 trillion won. Under the perpetuity compensation scheme at the discount rate of 10 %, the estimated annual compensation is in the range between 0.7 and 0.9 trillion won. This is more than Water Use Fee collected in 2012 for the Han River, which is approximately 0.5 trillion won. Considering the size of the restricted area of the Paldang area, which is more than 18 times of that of Namyangju, the rate of Water Use Fee, which is based on beneficiary pays principle and imposed on the residents of the downstream area, needs to be increased to sufficiently compensate the economic loss caused to the upstream areas of the Han River.

ACKNOWLEDGEMENT

I first would like to express special gratitude to my thesis supervisor, Professor Tae Yong JUNG. His guidance and advices allowed me to build a sense of academic research and practicality. In addition, both his compliments and criticism stimulated me to navigate through touch challenges and ultimately find the finish line of this thesis. I also would like to sincerely thank my second thesis supervisor, Professor Taejong KIM. Through his lectures and comments, I was able to gain confidence in econometric analysis and to complete the quantitative analyses of this thesis. I also would like to express my appreciation to Professor Insoo JEONG for the evaluation comments on the thesis and Professor Jaejin BYUN for his advices, which helped me design the structure of this thesis at the initial stage.

I cannot fail to thank Mr. Han Gook KIM and Ms. Sun Young HWANG of BIZ-GIS. Through the generous support program of BIZ-GIS, they provided me technical assistance regarding the data collection and allowed me to take advantage of GIS technology. Without the assistance of BIZ-GIS, I would not have been able to conduct the analyses for this thesis. I also would like to thank Mr. Chanil JUNG of KDI School for his assistance at the early stage regarding data mining, which allowed me to continue the research of this thesis.

Lastly and most importantly, I would like to thank my family for their support and encouragement.

TABLE OF CONTENTS

Abstract i
Acknowledgement iii
List of Tables v
List of Figures vii

1. Introduction 1

2. Background Information and Literature Review 3
2.1. Beneficiary Pays Principle 3
2.2. Water Use Fee for the Han River in Korea 4
2.3. Officially Announced Price of Reference Land 9
2.4. The Paldang Area and the City of Namyangju 9
2.5. Development Restriction for Water Quality in the Paldang Area 12
2.6. Hedonic Price Method 16

3. Research Method and Data Analysis 18
3.1. Research Method 18
3.2. Data Analysis 22
3.2.1. Descriptive Analysis 22
3.2.2. Regression Analysis 27
3.2.3. Border Analysis 32
3.3. Limitations 39

4. Conclusion and Implications 40

Reference 44

Appendix A. Results of Robust Regression 47

Appendix B. Results of Quantile Regression 49

LIST OF TABLES

Table 2-1 Areas required to pay Water Use Fee in the region of the Han River........................5

Table 2-2 Recipient areas of Han River Watershed Management Fund...................................5

Table 2-3 Water Use Fee for the region of the Han River 8

Table 2-4 Total Water Use Fee collected in the region of Han River 8

Table 2-5 Land composition of Namyangju 11

Table 2-6 Development restriction for water quality protection in the Paldang area (Water Supply Source Protection Area and Water Source Special Policy Area) 12

Table 2-7 Development restriction for water quality protection in the Paldang area (Water-pollutant Buffering Zone)..14

Table 2-8 Development restriction for water quality protection in the Paldang area (Nature Protection Area)...15

Table 2-9 Summary of the literature review on hedonic price method...................................17

Table 3-1 Hedonic price models used...19

Table 3-2 Definitions of the variables used 19

Table 3-3 Number of the sample observations used 23

Table 3-4 Sample area and actual area of Namyangju..23

Table 3-5 Descriptive statistics of the sample data used (excluding dummy variables) 23

Table 3-6 Descriptive statistics of the sample data used (dummy variables) 24

Table 3-7 Descriptive statistics of the sample data used sorted by restriction (excluding dummy variables)..25

Table 3-8 Descriptive statistics of the sample data used sorted by restriction (dummy variables) 26

Table 3-9 Area-weighted average land price of the samples used..27

Table 3-10 Regression results for Namyangju (semi-log model) 28

Table 3-11 Regression results for Namyangju (double-log model)..29

Table 3-12 Loss rates for the restricted area of Namyangju 30

Table 3-13 Estimated total compensation for water quality protection in Namyangju 31

Table 3-14 Estimated perpetuity compensation for water quality protection in Namyangju .. 31

Table 3-15 Number of the sample observations used (border analysis) 33

Table 3-16 Area-weighted average land prices of the samples in Namyangju (border analysis) 33

Table 3-17 Descriptive statistics of the sample data used sorted by restriction (excluding dummy variables) (border analysis) 34

Table 3-18 Descriptive statistics of the sample data used sorted by restriction (dummy variables) (border analysis) 35

Table 3-19 Regression results for Namyangju (semi-log model) (border analysis) 36

Table 3-20 Regression results for Namyangju (double-log model) (border analysis) 37

Table 3-21 Loss rates for the restricted area of Namyangju (border analysis) 38

Table A-1 Robust regression results for Namyangju (semi-log model) 47

Table A-2 Robust regression results for Namyangju (double-log model) 48

Table B-1 Quantile regression results for Namyangju (semi-log model) 49

Table B-2 Quantile regression results for Namyangju (double-log model) 50

LIST OF FIGURES

Figure 2-1 Rate adjustment process for Water Use Fee for the region of the Han River 7

Figure 2-2 Map of Namyangju - 1 10

Figure 2-3 Map of Namyangju - 2 11

Figure 3-1 Map of the samples used 22

Figure 3-2 Map of the samples used (border analysis) 32

1. Introduction

Beginning in 1999, Korea has adopted Water Use Fee for the upstream region of the Han River, which is Korea's major river and crosses the country's capital, Seoul. The principle behind the fee is beneficiary pays principle, which levies the surcharge on the residents of the downstream area, who benefit from the freshwater supplied from the upstream area, in order to compensate the loss caused to the residents of the upstream area, who are restricted to develop their areas due to the water quality protection. In fact, Water Use Fee is collected to form Han River Watershed Management Fund, which is used to provide financial assistances to the residents in the upstream areas and to support the purification of contaminated water.

Despite the clear logic of beneficiary pays principle, the fee levied on the residents of the downstream area is still in question as there is no direct method to value the cost associated with the services of freshwater using direct market prices. In specific, unlike commodities or financial products, there is no market for freshwater from the river, and market prices are not readily available for the freshwater. This means the cost of the ecosystem services of freshwater cannot be calculated using a direct valuation method based on market prices.

The objective of this study is to estimate the cost of the services from freshwater of the Han River and to evaluate beneficiary pays principle in the case of the Han River. For the estimation, due to the fact that there is no market price available for the freshwater from Lake Paldang, this study will utilize hedonic price method using officially announced price of reference land of the city of Namyangju, which is attached to Lake Paldang, in the year of 2012. In fact, Lake Paldang is an artificial lake created by a dam in the Han River and is the main water resource for the residents of the downstream area, and the area around Lake Paldang is subject to heavy restrictions in order to protect the water from contamination.

Through the analyses on the land price of the city of Namyangju, the economic loss caused by the restriction for water quality protection will be analyzed, and the current beneficiary pays principle for the Han River, which is funded through Water Use Fee, will be tested. In fact, the city of Namyangju has both restricted area (42.6%) and unrestricted area (57.4%) within its administrative district, and the analysis on Namjangju allows a cross-sectional analysis using hedonic price method to compare the land prices with respect to restriction for water quality protection.

The results of the cross sectional analysis on the city of Namyangju suggest that there is statistically significant evidence for the economic loss caused by water quality protection. In addition, the total amount of compensation estimated by the results of the cross sectional analysis suggests that the current Han River Watershed Management Fund is not sufficient, and Water Use Fee needs to be increased.

After the introduction chapter, Chapter 2 presents background information and literature review, which include topics on beneficiary pays principle, hedonic price method, Water Use Fee system in Korea, the Paldang area and the city of Namyangju, and development restriction for water quality protection in the Paldang area.

Chapter 3 presents the research method used and the results of the data analyses conducted, which include both descriptive and regression analyses. In addition, the results of a customized border analysis on the samples around the borderline between the restricted area and the unrestricted area in Namyangju will be presented. The limitations of this study will be also covered.

In Chapter 4, the conclusion and policy implications for this study will be presented with the list of reference followed. Lastly, Appendix A and B present supplementary information that support the results of this study.

2. Background Information and Literature Review

This chapter provides background information on the concepts that are used in this study to estimate the economic loss caused to the city of Namyangju and to evaluate beneficiary pays principle in the Han River. This chapter also presents literature review on hedonic price method, which is chosen as the research method for this study.

2.1. Beneficiary Pays Principle

Beneficiary pays principle is based on the concept that those who benefit from a service should be responsible for the cost of the service that they consume. Under beneficiary pays principle, those who benefit from a service should pay for the cost regardless of whether they caused harm to the service. In case of water resources, under beneficiary pays principle, those who consume the freshwater pay for the cost associated with keeping the freshwater from pollution. From this sense, beneficiary pays principle is quite different from polluter pays principle, which states that those who produce pollution should pay for the cost of the service.

Korea's Water Use Fee in the region of the Han River, which imposes surcharge on the residents of the downstream area of the Han River, is based on beneficiary pays principle as Water Use Fee is collected to form Han River Watershed Management Fund. Han River Watershed Management Fund is used to support the upstream area of the Han River where development activities are restricted to protect the water quality of the Han River, and the upstream area residents experience significant economic loss from potential development. Based on beneficiary pays principle, Water Use Fee is utilized to compensate for the economic loss that the upstream residents of the Han River experience to provide clean water to the downstream areas. More detailed information on Water Use Fee will be discussed in the following section.

2.2. Water Use Fee System for the Han River in Korea

On February 8, 1999, "Act on the Improvement of Water Quality and Support for Residents of the Riverhead of the Han River System" was passed, and the Korean government introduced the water use fee system in the Han River, which is the first surcharge based on beneficiary pays principle for water resource management in Korea.

Water Use Fee was originally introduced to support the residents in the upstream area of the Han River. The upstream area has been under strict regulations in terms of development in order to protect the water quality of the Han River. Due to the regulations, the residents in the upstream areas had to give up the potential economic benefit from development. As an effort to compensate the economic loss caused to the upstream areas, Water Use Fee is imposed on the final user of the freshwater from the Han River on a usage basis. Following the principle, Water Use Fee is imposed to the downstream areas of the Han River that include 27 cities including Korea's capital, Seoul, as shown in Table 2-1.

<Table 2-1> Areas required to pay Water Use Fee in the region of the Han River

City of Seoul (25 Districts)	City of Incheon (8 Districts and 2 Counties)	Province of Gyeonggi (25 Cities)
All areas in the city of Seoul	All areas in the city of Incheon (including partial areas of counties of Ganghwa and Wongjin)	Suwon, Seongnam, Uijeongbu, Anyang, Bucheon, Gwangmyeong, Pyeongtaek, Ansan, Goyang, Gwacheon, Guri, Namyangju, Osan, Siheung, Gunpo, Uiwang, Hanam, Yongin, Gimpo, Anseong, Hwaseong, Yangju, Dongducheon, Paju (partial), Pocheon (partial)

Source: Han River Watershed Management Committee of Korea (2013)

Water Use Fee collected from the downstream areas is used to form Han River Watershed Management Fund, which is used to support the upstream areas including 34 cities and counties as shown in Table 2-2.

<Table 2-2> Recipient areas of Han River Watershed Management Fund

City of Seoul (3 Districts)	Province of Gyeonggi (11 Cities and Counties)	Province of Gangwon (14 Cities and Counties)	Province of North Chungcheong (8 Cities and Counties)
Gangdong, Songpa, Gwangjin	Guri, Namyangju, Hanam, Yongin, Icheon, Anseong, Gwangju, Yeoju, Pocheon, Gapyeong, Yangpyeong	Chuncheon, Wonju, Gangneung, Taebaek, Samcheok, Hongcheon, Hoengseong, Yeongwol, Pyeongchang, Jeongseon, Hwacheon, Yanggu, Inje, Goseong	Cheongju, Chungju, Jecheon, Cheongwon, Boeun, Goesan, Eumseong, Danyang

Source: Han River Watershed Management Committee of Korea (2013)

Han River Watershed Management Fund is used for the following projects in the recipient areas:

1) Support projects for the residents of the recipient areas.

2) Establishment and operation of environment facilities

3) Purchase of land and projects for maintenance of the riparian area

4) Environment friendly projects

5) Projects for water quality improvement

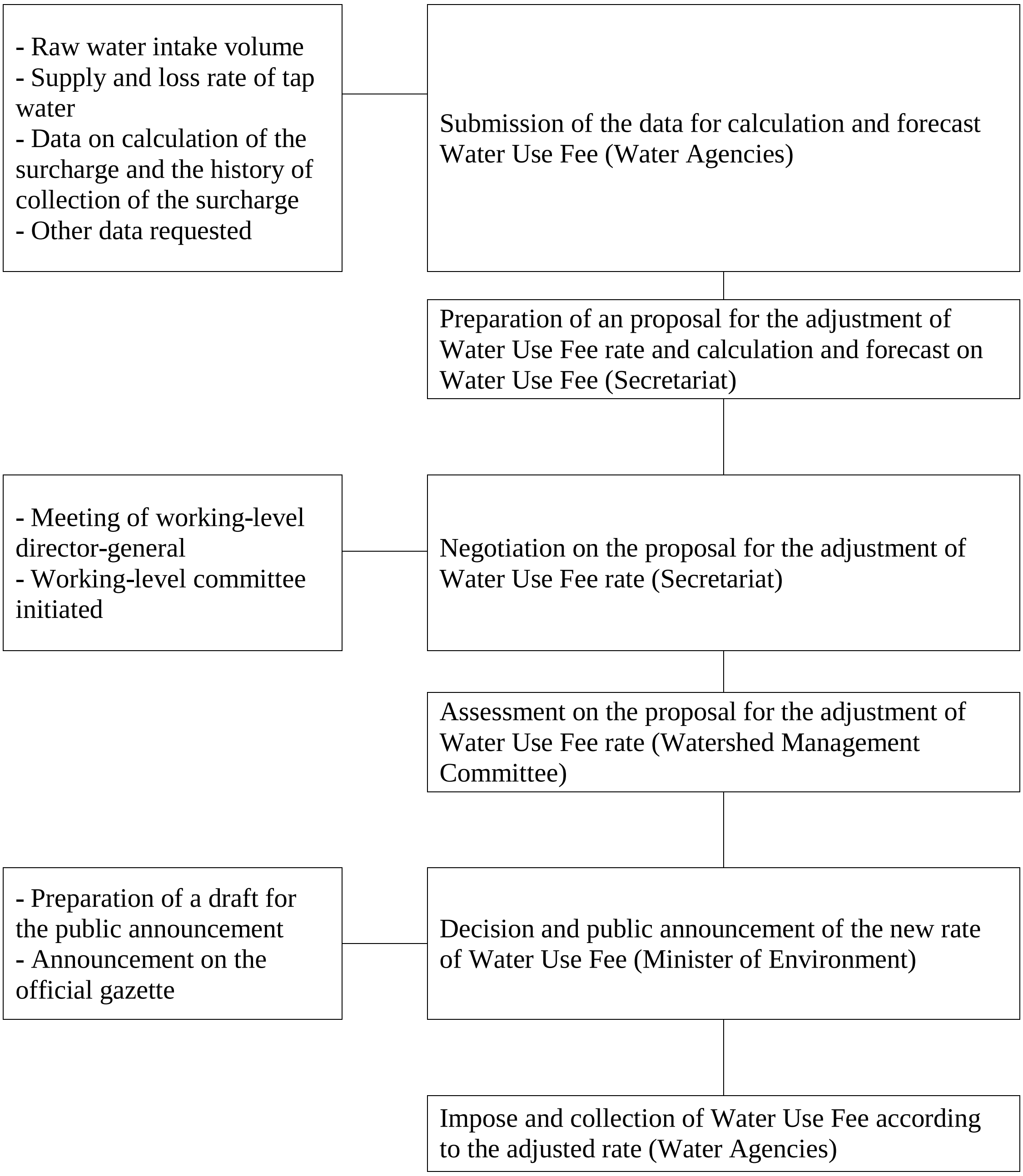
6) Projects for reduction of nonpoint source pollution

7) Projects for total pollution load management

8) Administrative fees for the operation of the fund

The rate of Water Use Fee is adjusted every two year by Han River Watershed Management Committee and promulgated by the Minister of Environment. The adjustment process of Water Use Fee is described in Figure 2-1.

<Figure 2-1> Rate adjustment process for Water Use Fee for the region of the Han River



Source: Han River Watershed Management Committee of Korea (2013)

Following the process described above, the rates of Water Use Fee for the Han River have been increased from 80 won/ton in 1999 to 170 won/ton in 2012. In the period between 1999 and 2012, the rates of Water Use Fee have been adjusted as shown in Table 2-3.

<Table 2-3> Water Use Fee for the region of the Han River

(won/ton)

Year	1999	2000	2001	2002	2003	2004	2005
Water Use Fee	80	80	110	110	120	120	130
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Water Use Fee	140	150	160	160	160	170	170

Source: Han River Watershed Management Committee of Korea (2013)

From 1999 to 2012, the total Water Use Fee collected is estimated to be 4.3 trillion won, and the amounts of annual collection of Water Use Fee are shown in Table 2-4.

<Table 2-4> Total Water Use Fee collected in the region of the Han River

(1 billion won)

Year	1999	2000	2001	2002	2003	2004	2005	2006
Total Water Use Fee Collected	28	175	231	247	269	284	304	338
Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Total**	
Total Water Use Fee Collected	363	386	398	404	431	492	4,300	

Source: Ministry of Strategy and Finance of Korea (2013)

Table 2-4 shows that since 1999, the total amount of Water Use Fee collected has been increased. Despite the increase, there has been aggressive demand from the upstream areas of the Han River to increase the rate of Water Use Fee for adequate compensation for the economic loss caused by the restriction for water quality protection.

2.3. Officially Announced Price of Reference Land

According to Korea's "Public Notice of Values and Appraisal of Real Estate Act," officially announced price of reference land is the price per unit area of reference land, which the Ministry of Land, Infrastructure and Transport (MLIT) has surveyed, assessed, and made public. Officially announced price of reference land is surveyed and assessed every year by MLIT and serves as an indicator for general land transactions. In addition, it provides a criterion for the cases where the central and local government estimate the land price or an appraisal business operator conducts valuation of an individual land.

In this study, officially announced price of reference land is used as the dependent variable to test the economic impact of development restriction on property value. In fact, officially announced price of reference land is used as the reference data which serve as bases for various taxes and surcharges including development charge, inheritance tax, capital gain tax, etc. From this point of view, the officially announced price of reference land can serve as reliable dependent variable which can be used to estimate the compensation for the economic loss caused by water quality protection in the region of Namyangju.

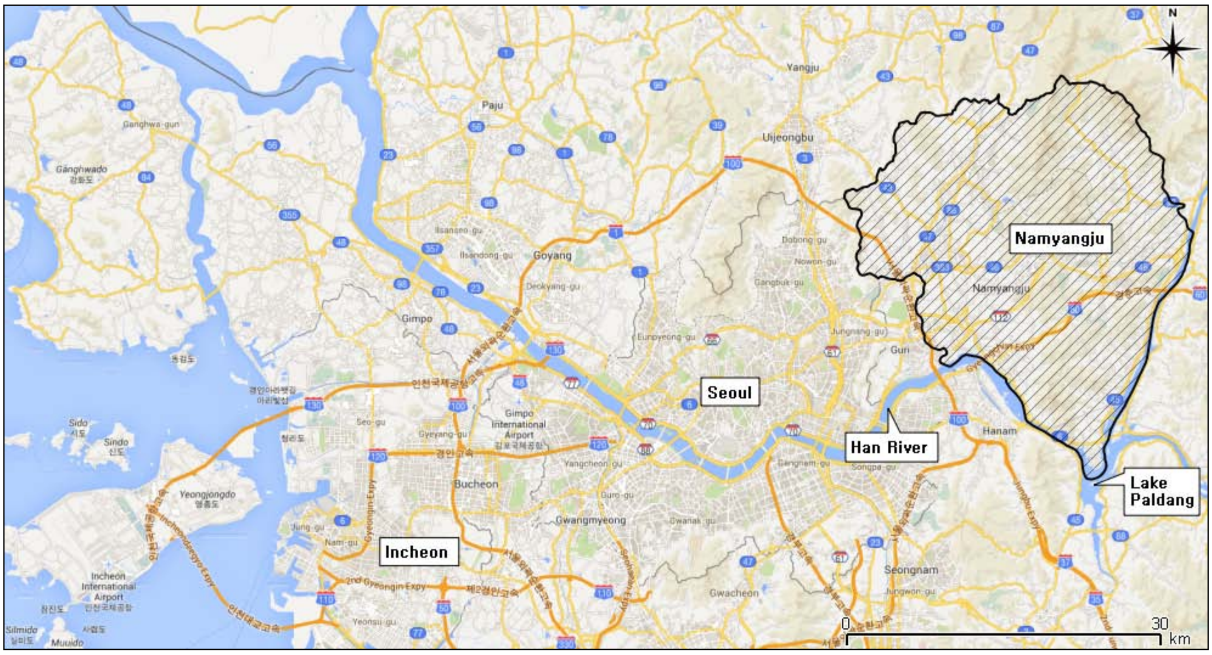
2.4. The Paldang Area and the City of Namyangju

The Paldang area refers to the watershed area around Lake Paldang, which is a man-made lake in the Han River. Built by an artificial dam, Lake Paldang has the reservoir capacity of approximately 2.4 million tons and can supply water to the downstream areas of the Han River, which include the capital of Korea, Seoul, up to 7.8 million tons/day. In fact, Lake Paldang is the main water supply source and has been environmentally protected to ensure the water quality.

Due to the efforts to protect the water quality, since 1993, the Lake Paldang has maintained its BOD (biochemical oxygen demand) level under 2 ppm; BOD level shows the amount of dissolved oxygen needed by aerobic biological organisms to break down the organic material in the water. The water with BOD level of under 3 ppm is safe for bathing and swimming and can be transformed into drinking water after purification process. From this point view, the restriction on the upstream areas have contributed in maintaining the water quality of the Han River and providing the services of the freshwater.

Namyangju is a city in the Paldang area with the population of 604,864 as of the end of 2012. The city is located east of Seoul and touches Lake Paldang as shown in Figure 2-2.

<Figure 2-2> Map of Namyangju - 1



Source: Google Map generated by QGIS 2.0.1-Dufour

The total area of Namyangju is approximately 458.1 km^2, and 194.9 km^2 of the total land is under restriction to protect the water quality of the Han River, which is about 42.6% of the total area as shown in Table 2-5

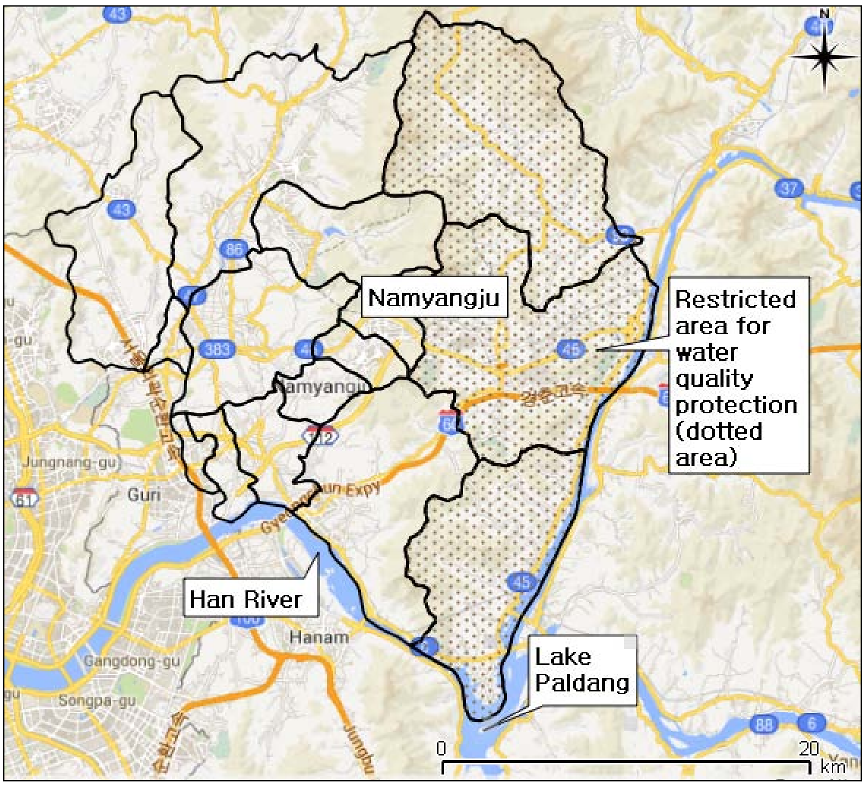
<Table 2-5> Land composition of Namyangju

Total area	Area under restriction	Percent of area under restriction
458.1 km^2	194.9 km^2	42.6 %

Source: Government of Gyeonggi Province of Korea (2013)

The districts that are under the restriction for water quality protection in Namyangju are Hwado-eup, Sudong-myeon, and Joan-myeon, which are located on the eastern side of the city as shown in Figure 2-3. Considering Namyangju's restrictions, which limit the development of the restricted area, it is apparent that the city is experiencing significant economic loss due to the restrictions associated with water quality protection.

<Figure 2-3> Map of Namyangju - 2



Source: Google Map generated by QGIS 2.0.1-Dufour

2.5. Development Restriction for Water Quality in the Paldang Area

The Paldang area is under various restrictions for water quality protection. The four major types of restriction areas include Water Supply Source Protection Area, Water Source Special Policy Area, Water-pollutant Buffering Zone, and Nature Protection Zone. The detailed restrictions are describe in the following tables according to the types of restriction areas:

<Table 2-6> Development restriction for water quality protection in the Paldang area (Water Supply Source Protection Area and Water Source Special Policy Area)

	Water Supply Source Protection Area	**Water Source Special Policy Area**	
		Area I	**Area II**
Factory	Not Allowed	- Facilities that produce designated pollutants are not allowed * Designated facilities that outsource all the waste water treatment are allowed. - Facilities that produce more than 200 m^3 of waste water are not allowed	- Facilities that produce designated pollutants are not allowed * Designated facilities that outsource all the waste water treatment are allowed. - Facilities that produce more than 200 m^3 of waste water are allowed if all the waste water is treated at BOD level that is lower than 30 ppm or treated by sewage treatment facility
Hotel	Not Allowed	- Buildings with gross floor area of over 400 m^2 are not allowed. * Allowed if all the waste water is treated by sewage treatment facility.	- Allowed if all the waste water is treated by sewage treatment facility or treated at BOD and SD level of lower than 20 ppm
Restaurant	Not Allowed	- Buildings with gross floor area of over 400 m^2 are not allowed. * Allowed if all the waste water is treated by sewage treatment facility.	- Allowed if all the waste water is treated by sewage treatment facility or treated at BOD and SD level of lower than 20ppm
Livestock	Not Allowed	- Facilities subject to authorization are not allowed: * Cowshed: Over 450 m^2 Pigsty: Over 500 m^2 - Facilities subject to registration can be allowed * Cowshed: Less than 450 m^2 Pigsty: Less than 500 m^2	-

Fish farm	Not Allowed	- New facilities and license extension are not allowed.	- New facilities and license extension are not allowed.
Fishery, Shipping	Only authorized long-line and off-shore gill net fishery allowed	- New facilities, license extension, and expansion of the current facilities are not allowed.	-
General Construction	Not Allowed	- Buildings with gross floor area of over 800 m^2 are not allowed. * Allowed if all the waste water is treated by sewage treatment facility. * Public welfare facilities are allowed if all the waste water is treated at BOD and SS level of lower than 20 ppm	- Allowed if all the waste water is treated by sewage treatment facility or treated at BOD and SD level of lower than 20ppm
Waste Treatment Facility	Not Allowed	- Landfill, waste treatment, waste recycle facilities are not allowed * Domestic waste, porcelain recycle, and lumber waste treatment facilities are allowed if all the waste water is treated by sewage treatment facility.	- Landfill, waste treatment, and waste recycle facilities are not allowed * Domestic waste, porcelain recycle, and lumber waste treatment facilities are allowed if all the waste water is treated by sewage treatment facility.
Golf resort and range	Not Allowed	- Not allowed * Artificial grass golf range is allowed	- Not allowed * Natural grass golf range can be allowed only after installment of waste reduction system * The new construction is possible if it is included in total pollution load management plan.
Mining and quarrying	Not Allowed	- Not allowed * Local government's quarrying is possible after prior authorization.	- Not allowed * Local government's quarrying is possible after prior authorization.
Cemetery	Not Allowed	- New cemetery facilities (both public and private) are not allowed	- New cemetery facilities (both public and private) are not allowed

Source: Han River Watershed Management Committee of Korea (2013)

<Table 2-7> Development restriction for water quality protection in the Paldang area (Water-pollutant Buffering Zone)

	Water-pollutant Buffering Zone	
	Within the Water Source Special Policy Area	Within the Water Source Special Policy Area
Factory	- Not Allowed	
Hotel	- Not allowed * Can be allowed outside the water source special policy area if the waste water is treated to BOD and SS level of lower than 10 ppm, respectively	
Restaurant	- Not allowed * Can be allowed outside the water source special policy area if the waste water is treated to BOD and SS level of lower than 10 ppm, respectively	
Livestock	- Not allowed * Can be allowed outside the water source special policy area if all excrement of livestock is treated at public facility or produced into fertilizers.	
General Construction	- Community housing is not allowed * Can be allowed if the waste water is treated to BOD and SS level of lower than 10 ppm, respectively.	

Source: Han River Watershed Management Committee of Korea (2013)

<Table 2-8> Development restriction for water quality protection in the Paldang area (Nature Protection Area)

		Nature Protection Area
Factory		- Large enterprises cannot build new factory or expand the current ones - For small and medium enterprises, * High-technology sector: new factory or expansion of the old one is allowed (within 1,000 m^2) * Urban type: new factory or expansion of the old one is allowed (1,000 ~ 3,000 m^2)
Standard on Factory		- New building or expansion of factory, which is over 500 m^2 is regulated by total factory location limit (Office and warehouse are not included in the floor are of factory).
Development Project		- Under the assumption that total pollution load management is in effect, * Tourist sites and large scale development projects are allowed * Expansion of city/regional development projects (1) Projects of over 100,000 m^2 in city area (residence, business, and factory) are allowed after review (2) Projects between 100,000 m^2 and 500,000 m^2 are allowed after review * Factory: projects of 30,000 m^2 and 60,000 m^2 are allowed after review
University	New	- Not allowed * New building or expansion of professional college, graduate school, and small college with 50 or less students (those that are less than 8 year old) and new building or expansion of college due to merger of another college are allowed.
	Relocation	- Partially allowed (Nature protection area to nature protection area or professional/graduate program university under 50 personnel)
	Expansion	- The expansion is regulated under the total volume control system.
Large Building - for sales, 15,000 m^2 - for business, 25,000 m^2 - for multi-purpose, 25,000 m^2		- The large building are allowed in the cities and counties that implement total pollutant load management system.
Training facility - total floor area of over 3,000 m^2		- Not allowed (The old ones are allowed for expansion within 10%)

Source: Han River Watershed Management Committee of Korea (2013)

In the case of Namyangju, the entire restricted area for water quality protection, estimated to be 194.9 km^2, is designated as both Water Source Special Policy Area and Nature Protection Zone. Of the total restricted area for water quality protection, 42.4 km^2 is designated as Water Supply Source Protection Area and 8.1 km^2 as Water-pollutant Buffering Zone.

The types of restriction area for water quality protection in Namyangju show that the region is under multiple restrictions, which do not allow large-scale development that could have brought economic benefit to the restricted area.

2.6. Hedonic Price Method

Hedonic price method is a valuation method that statistically estimates the relationship between a property's characteristics and its value. Hedonic price method was highly influenced by the characteristic theory of value, which is based on the works by Lancaster (1966) and Rosen (1974). According to the characteristic theory of value, a value of a good can be defined by a set of implicit or hedonic prices of attributes. In this sense, using hedonic price model, a price of a property can be expressed as follows

$$p = p(z1, z2, \ldots, zn), \text{ where } p \text{ is a price of property and } z \text{ is an attribute}$$

In addition, a hedonic price of an attribute, which represents economic value of an attribute, can be expressed as follows,

$$\text{Hedonic price of an attribute } (zi) = \partial p/\partial z_i = p_i$$

The hedonic price method allows us to calculate how much the price of a good or service differs due to a specific attribute. For this reason, hedonic price models can be used to estimate the impact of an environmental attribute controlling other factors. Once the price differential due to the environmental attribute is determined, the hedonic price models can be used to estimate willingness-to-pay for the specific environmental attribute.

A number of studies have been conducted regarding the impact of environmental attributes on the property values using hedonic price method. The summary of the literature review on hedonic price method is presented in Table 2-9.

<Table 2-9> Summary of the literature review on hedonic price method

Paper	Attribute	Impact on property value
Murdoch & Thayer (1988)	Air pollution	Negative
Chattopadhyay (1999)	Air pollution	Negative
Zabel & Kiel (2000)	Air pollution	Negative
Lake, I. R. et al. (2000)	Noise	Negative
Kendree & Rauch (1990)	View	Positive
Rodriguez & Sirmans (1994)	View	Positive
Wolverton (1997)	View	Positive
Benson et al. (1998)	View	Positive
Sirpal (1994)	Neighboring facility (Shopping facilities)	Positive
Jeong and Park (2003)	Neighboring facility (Waste facility)	Negative
Kim and Jung (2012)	Neighboring facility (Landfill site)	Negative

The summary of literature review suggests that hedonic price method can be utilized to isolate the economic impact of a specific environment attribute by analyzing the change in property values, controlling impacts of other factors using regression analyses.

3. Research Method and Data Analysis

In order to test the economic impact of restriction for water quality protection in the city of Namyangju, hedonic price method is used in this study. Among the valuation methods for non-market valuation, which include travel cost method and contingent valuation method, hedonic price method is chosen due to the availability of land price data in Namyangju. For comprehensive analyses, this study presents both descriptive and regression analyses on the land prices and independent variables that affect the land prices and estimates the land price difference caused by the restriction for water quality protection. In addition, a customized border analysis on the samples around the borderline between the restricted area and unrestricted area will be conducted. For the regression analyses, STATA/IC 11.1 is used.

3.1. Research Method

For the estimation of the compensation for the economic loss caused to the restricted area of Namyangju, the economic impact of restriction on the land price will be analyzed using hedonic price models. For the land price, which will be the dependent variable, the officially announced prices of reference lands of Namyangju in the year of 2012 are used, and the two types of hedonic price models, semi-log model and double log model, are chosen as described in Table 3-1.

<Table 3-1> Hedonic price models used

Type	Function	Remarks
Semi-log model	$\ln(Y) = a + \beta_1 X_1 + \sum_{i=2}^{7} \beta_i X_i + \sum_{i=8}^{20} \beta_i X_i + \varepsilon$	Y: dependent variable (land price) a: constant X_1: independent variable (restriction for water quality protection)(dummy variable) X_i (i= 2, 3, ･･･,7): independent variables (accessibility and land size variables) X_i (i= 8, 9, ･･･,20): independent variables (isolation and land type variables)(dummy variables)
Double-log model	$\ln(Y) = a + \beta_1 X_1 + \sum_{i=2}^{7} \beta_i \ln(X_i) + \sum_{i=8}^{20} \beta_i X_i + \varepsilon$	

The dependent and independent variables that are used in the hedonic price models of this study are defined in Table 3-2 as follows:

<Table 3-2> Definitions of the variables used

Variable	Attribute	Measurement
Dependent Variable		
Land price	Officially announced price of reference land	won/m^2
Independent Variables		
Restriction variable		
Restriction	Development restriction for water quality	If restricted =1, If not restricted = 0
Accessibility variables		
Primary school	Distance to the closest primary school	km
Hospital	Distance to the closest hospital	km
Convenience store	Distance the closest convenience store	km
Seoul	Distance to the center of Seoul	km
Road	Distance to the closest road	km
Isolation	The sample land does not have direct access to road (the land cannot be accessed by automobile)	If yes = 1, If no = 0

Land size variable			
Land size		The land size of the sample	m^2
Land type variables			
In comparison to building site	Dry field	The type of land is dry field	If yes = 1, If no = 0
	Factory	The type of land is factory site	If yes = 1, If no = 0
	Forest	The type of land is forest land	If yes = 1, If no = 0
	Gas station	The type of land is gas station site	If yes = 1, If no = 0
	Orchard	The type of land is orchard	If yes = 1, If no = 0
	Paddy field	The type of land is paddy field	If yes = 1, If no = 0
	Pasture	The type of land is pasture	If yes = 1, If no = 0
	Religion	The type of land is religious site	If yes = 1, If no = 0
	River	The type of land is stream area	If yes = 1, If no = 0
	Sports site	The type of land is sports site	If yes = 1, If no = 0
	Warehouse	The type of land is warehouse site	If yes = 1, If no = 0
	Misc.	The type of land is miscellaneous land	If yes = 1, If no = 0

"Land price" represents officially announced price of reference land measured in won per square meter (won/m^2) in 2012 and is the dependent variable. "Restriction" is a dummy variable that shows whether the sample observations are under development restriction for water quality protection, and the value of variable is 1 if the sample is a land sample that is under restriction for water quality protection and is 0 if the sample is not under the restriction. The coefficient of this variable will be used to estimate the land price loss rate. "Primary school" is direct distance between a sample land and the closest primary school. The data are as of end of 2012 and are the public data announced by Ministry of Education of Korea.

“Hospital" shows the direct distance between a sample land and the closest hospital. The hospitals include upper-level general hospitals, general hospitals, dental hospitals, dental clinics, oriental hospitals, and oriental clinics. The data are the public data announced by Health Insurance Review and Assessment Service (HIRA), and the ones used in this study are updated in 2012.

“Convenience store” is the direct distance between a sample land and the closest convenience store. The convenience stores in this study include the stores of major convenience store franchises in Korea: Seven Eleven, Buy the Way, CSPACE, CU, Ministop, and GS25. The data are collected from the websites of the above mentioned convenience stores and Korea Association of Convenience Stores, which are undated as of the end of the year 2012.

“Seoul” represents the direct distance from the center of Seoul to the sample points. The coordinates of the center of Seoul in this study have the latitude of 37.573 degree and the longitude of 126.985 degree. “Road” demonstrates the direct distance between a sample land and the closest road. "Land size" represents the size of the sample lands. The data are announced by Ministry of Land, Infrastructure and Transport of Korea.

"Isolation" is a dummy variable that shows whether a sample land is directly connected to a road. If the sample land is directed connected, the value is 0, and if not, the value is 1. In addition, there are 13 dummy variables according to the types of land. The types of land include dry field, factory, forest, gas station, sports site, orchard, paddy field, pasture, religion, river, building site, warehouse, and miscellaneous. The mentioned 13 dummy variables are analyzed in comparison to the samples of which type of land is building site.

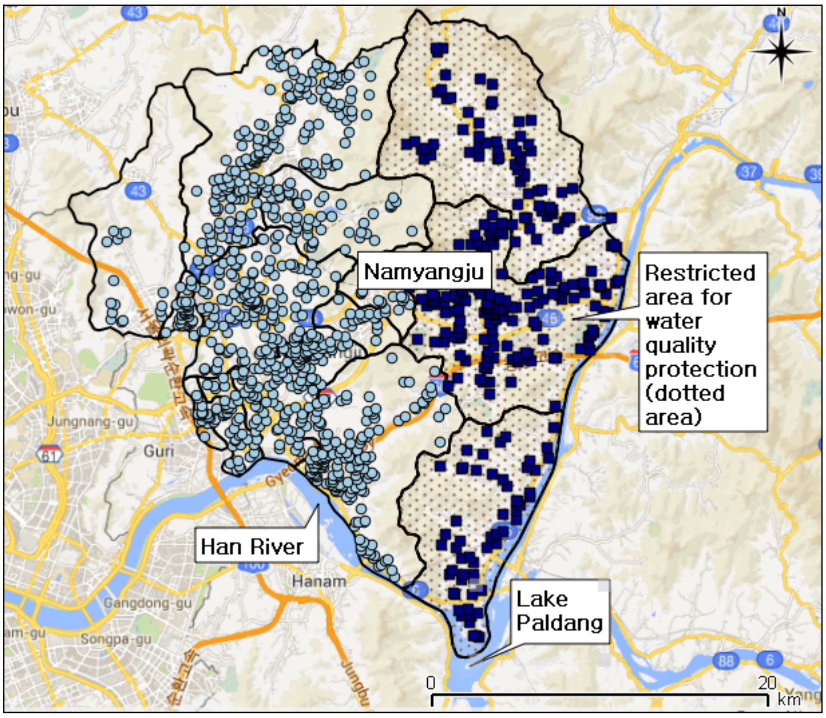
3.2. Data Analysis

To estimate the economic loss caused to the city of Namyangju in terms of land price, using hedonic price method, regression analyses were conducted on the samples of officially announced prices of reference land in Namyangju in the year of 2012.

3.2.1 Descriptive Analysis

Using two hedonic price models, semi-log model and double-log model, the data analyses on the land prices of Namyangju were conducted. All the data used in this study are those in the year of 2012. As shown in Figure 3-1, 1,081 data points were analyzed for this study.

<Figure 3-1> Map of the samples used



Source: Google Map generated by QGIS 2.0.1-Dufour

Among the total data points used, 286 represent the areas under restriction for water quality protection, and 795 represent the area without the restriction as presented in Table 3-3.

<Table 3-3> Number of the sample observations used

Number of observations		
Restricted area	**Unrestricted area**	**Total**
286	795	1,081

The data points are randomly chosen in a way to represent Namyangju's proportion of the areas under the restriction and those without the restriction. The actual area and sample area are presented in Table 3-4 as follows:

<Table 3-4> Sample area and actual area of Namyangju

	Restricted area	Restricted area (%)	Unrestricted area	Unrestricted area (%)	Total
Sample area (km^2)	3.0	42.6%	4.1	57.4%	7.1
Actual area (km^2)	194.9	42.6%	263.1	57.4%	458.1

The descriptive statistics of the total sample data analyzed are described in Table 3-5 and Table 3-6 as follows:

<Table 3-5> Descriptive statistics of the sample data used (excluding dummy variables)

Variable	Mean	SD	Min.	Max.
Land price (won/m^2)	511,882	755,479	1,300	6,150,000
Primary school (km)	1.1	0.8	0.1	3.8
Hospital (km)	1.1	1.0	0.0	4.9
Convenience store (km)	1.0	0.9	0.0	5.4
Seoul (km)	23.8	5.3	13.4	36.5
Road (km)	0.2	0.3	0.0	2.5
Land size (m^2)	6,593	32,373	73	869,225

<Table 3-6> Descriptive statistics of the sample data used (dummy variables)

Dummy Variables	Number of variable with the value = 1	
	Number of Observations	%
Total Observations	1,081	100
Isolation	186	17.2
Dry field	210	19.4
Factory	39	3.6
Forest	150	13.9
Gas station	1	0.1
Orchard	2	0.2
Paddy field	232	21.5
Pasture	24	2.2
Religion	1	0.1
River	1	0.1
Building site	380	35.2
Sports site	4	0.4
Warehouse	1	0.1
Misc.	36	3.3

Table 3-5 shows that the range for sample land prices is between 1,300 won/m^2 and 6,150,000 won/m^2. The direct distances to the closest primary school are between 0.1 km and 3.8 km. The main land types are building site (35.2%), paddy field (21.5%), and dry field (19.4%). 17.2% of the samples do not have direct access to road.

The descriptive statistics of the sample data sorted by restriction show that the mean value of the land price in the unrestricted area, which is a simple average value, 605,121 won/m^2, is more than two times greater than that of the restricted area, 252,703 won/m^2. For other variables like the direct distance to primary schools, hospitals, convenience stores, Seoul, and roads, the restricted area has greater values. Lastly, the average land size of sample lands in the restricted area, 10,627 m^2 is more than two times greater than that of the unrestricted area, 5,142 m^2. The detailed data are shown in Table 3-7 and Table 3-8.

<Table 3-7> Descriptive statistics of the sample data used sorted by restriction (excluding dummy variables)

Variable	Mean	SD	Min.	Max.
Unrestricted area				
Land price (won/m^2)	605,121	824,675	1900	6,150,000
Primary school (km)	1.1	0.7	0.1	3.6
Hospital (km)	0.9	0.8	0.0	4.2
Convenience store (km)	0.9	0.7	0.0	3.3
Seoul (km)	21.3	3.5	13.4	30.4
Road (km)	0.2	0.3	0.0	2.5
Land size (m^2)	5,142	17,949	73	293,713
Restricted area				
Land price (won/m^2)	252,703	420,084	1,300	3,850,000
Primary school (km)	1.3	0.8	0.1	3.8
Hospital (km)	1.5	1.2	0.0	4.9
Convenience store (km)	1.4	1.3	0.0	5.4
Seoul (km)	30.8	2.6	26.0	36.5
Road (km)	0.3	0.4	0.0	2.4
Land size (m^2)	10,627	55,242	93	869,225

<Table 3-8> Descriptive statistics of the sample data used sorted by restriction (dummy variables)

Dummy Variables	Number of observations with the value = 1			
	Unrestricted area		Restricted area	
	Number of Observation	%	Number of Observation	%
Total Observations	795	100	286	100
Isolation	123	15.5	63	22.0
Dry field	150	18.9	60	21.0
Factory	25	3.1	14	4.9
Forest	102	12.8	48	16.8
Gas station	1	0.1	0	0.0
Orchard	2	0.3	0	0.0
Paddy field	176	22.1	56	19.6
Pasture	23	2.9	1	0.3
Religion	0	0.0	1	0.3
River	1	0.1	0	0.0
Building site	287	36.1	93	32.5
Sports site	2	0.3	2	0.7
Warehouse	0	0.0	1	0.3
Misc.	26	3.3	10	3.5

The sample data used for this study show that area-weighted average land price of the city of Namyangju is 195,356 won/m^2. The weighted average land price of the unrestricted area and the restricted area are 309,066 won/m^2 and 42,417 won/m^2, respectively, as shown in Table 3-9

<Table 3-9> Area-weighted average land price of the samples used

(Unit: won/m^2)

Total (both unrestricted area restricted area)	Unrestricted area	Restricted area
195,356	309,066	42,417

The above calculations show that there is a significant land price difference between the restricted area and the unrestricted area. The area-weighted average land price of the unrestricted area is more than seven times higher than that of the restricted area. Since the price difference can be a result of various factors, using regression analyses, the following section will examine how much of the land price difference between the unrestricted area and restricted area is caused by the restriction for water quality protection.

3.2.2 Regression Analysis

In order to estimate the land value loss in the city of Namyangju caused by the restriction for water quality protection, the regression analyses were conducted using two hedonic price models, semi-log model and double-log model. The regression technique used in this section is ordinary least square (OLS) regression, and the results are shown in Table 3-10 and Table 3-11.

<Table 3-10> Regression results for Namyangju (semi-log model)

Dependent variable: ln(Land price)		
Independent variables	Parameter estimates	Standard errors
Restriction Variable		
Restriction	**-0.162***	**(0.077)**
Accessibility variables		
Primary School	-0.181***	(0.043)
Hospital	-0.120***	(0.032)
Convenience store	-0.165***	(0.034)
Seoul	-0.038***	(0.007)
Road	-0.652***	(0.072)
Isolation	-0.420***	(0.063)
Land size variable		
Land size	-0.000	(0.000)
Land type variables and constant		
Dry field	-0.988***	(0.058)
Factory	-0.458***	(0.110)
Forest	-3.459***	(0.079)
Gas station	0.877	(0.646)
Orchard	-1.528***	(0.457)
Paddy field	-1.149***	(0.055)
Pasture	-0.777***	(0.137)
Religion	-1.118	(0.646)
River	-1.705**	(0.645)
Sports site	-1.273***	(0.368)
Warehouse	-0.450	(0.645)
Misc.	-0.281*	(0.113)
_cons.	14.827***	(0.140)
N	1081	
R^2	0.852	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

According to the regression results of the semi-log model, the model explains approximately 85.2% of the variation in land prices. In addition, the result shows that there is statistically significant evidence which suggests the land price difference caused by the restriction for water quality protection at the significance level of 0.05. With the conversion, the coefficient of the restriction variable (Restriction) suggests that the land price of the restricted area is approximately 85.0%[1] of that of the unrestricted area with 95% confidence. In other words, the land price of the restricted area is 15.0% lower than that of the unrestricted area.

<Table 3-11> Regression results for Namyangju (double-log model)

Dependent variable: ln(Land price)		
Independent variables	Parameter estimates	Standard errors
Restriction Variable		
Restriction	**-0.220*****	**(0.058)**
Accessibility variables		
ln(Primary school)	-0.138***	(0.031)
ln(Hospital)	-0.148***	(0.017)
ln(Convenience store)	-0.125***	(0.024)
ln(Seoul)	-0.764***	(0.119)
ln(Road)	-0.188***	(0.014)
Isolation	-0.361***	(0.054)
Land size variable		
ln(Land size)	-0.146***	(0.021)
Land type variables		
Dry field	-0.623***	(0.056)
Factory	-0.130	(0.096)
Forest	-2.763***	(0.099)
Gas station	0.875	(0.549)
Orchard	-0.886*	(0.392)
Paddy field	-0.752***	(0.055)
Pasture	-0.396***	(0.120)
Religion	-0.597	(0.551)
River	-1.146*	(0.551)
Sports site	-0.584*	(0.294)
Warehouse	-0.275	(0.549)
Misc.	-0.141	(0.096)
_cons.	15.877***	(0.378)
N	1081	
R^2	0.893	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[1] Change in land price (won/m^2) for being under the restriction = 1
Δln(Land price) = (-0.162)(1) - (-0.162)(0)
Δ(Land price) = exp(-0.162) = 85.0%

The regression results of the double-log model show that it explains approximately 89.3% of the variation in land prices. Like the semi-log model, the result from the double-log model suggests statistically significant evidence that shows the land price difference caused by the restriction for water quality protection at the significance level of 0.001. According to the coefficient of the restriction variable (Restriction), the land price of the restricted area is approximately 80.2%[2] of that of the unrestricted area with 95% confidence; the land price of the restricted area is 19.8% lower than that of the unrestricted area.

Both the semi-log model and double-log model suggest the land price difference between the restricted and the unrestricted area caused by the restriction for water quality protection. The inclusion of variables related with accessibility, land size, and land type in the models implies that the coefficients of the restriction variables in the two models are independent of the impacts from the variables included in the models. From this point of view, the regression results suggest the loss rates for the restricted area of Namyangju, which are not affected by the economic impacts of the variables mentioned, as shown in Table 3-12.

<Table 3-12> Loss rates for the restricted area of Namyangju

Semi-log Model	Double-log Model	Remarks
15.0%	19.8%	The rates are in terms of the land price of the unrestricted area

Using the above rates, the total compensation for water quality protection in Namyangju can be estimated using the following formula:

[2] $\Delta \ln(\text{Land price}) = (-0.220)(1) - (-0.220)(0)$
$\Delta(\text{Land price}) = \exp(-0.220) = 80.2\%$

$TC = LP_U \times R \times A_R$

TC: Total compensation
LP_U: Land price of unrestricted area
R: Loss rate
A_R: Land size of restricted area[3]

The restricted area in Namyangju is approximately 140.4 km^2 after excluding the lands owned by the central government, local government, and military, and the total compensation estimated according to the results of the models used are shown in Table 3-13.

<Table 3-13> Estimated total compensation for water quality protection in Namyangju

(Unit: trillion won)

	Semi-log Model	**Double-log Model**
Total Compensation	6.5	8.6

The total compensation for Namyangju is estimated to be in the range between 6.5 and 8.6 trillion won as shown in Table 3-8. The values in the range is much higher than Water Use Fee collected in the period from 1999 to 2012, which is approximately 4.3 trillion won (Table 2-4). Using a perpetuity compensation model, for the semi-log model, under the discount rates of 3%, 8% and 10%, the annual compensations are estimated to be 0.2, 0.5, and 0.7 trillion won, respectively. Under the double-log model, the annual compensations are 0.3, 0.7, and 0.9 trillion won, respectively, as shown in Table 3-14.

<Table 3-14> Estimated perpetuity compensation for water quality protection in Namyangju[4]

(Unit: trillion won)

Discount rates	**Semi-log Model**	**Double-log Model**
3%	0.2	0.3
8%	0.5	0.7
10%	0.7	0.9

In fact, the annual collection of Water Use Fee in 2012 is approximately 0.5 trillion won (Table 2-4). Considering the fact that Water Use Fee is collected for the entire upstream areas,

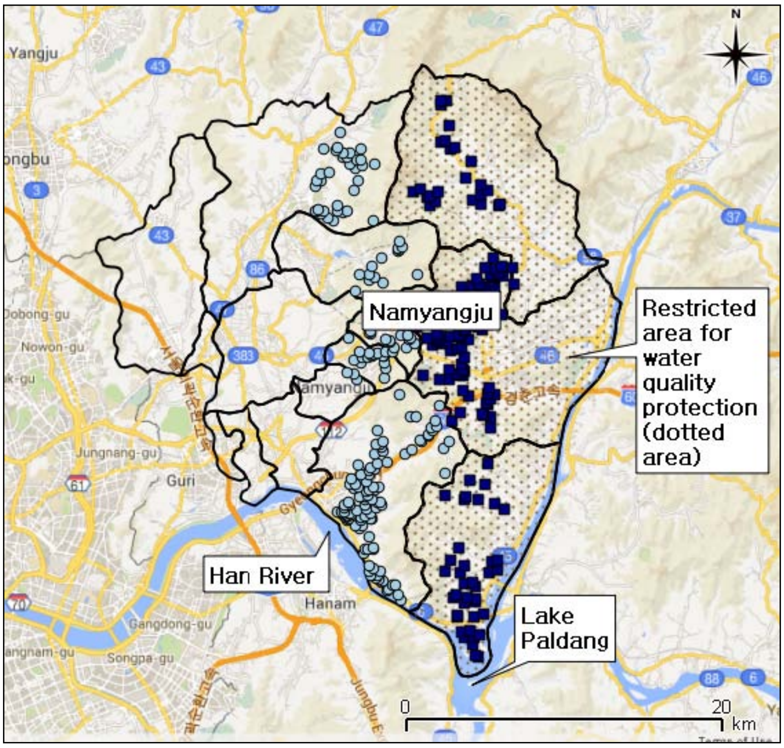
[3] The restricted area excludes the land owned by the central government, local government, and military
[4] Perpetuity compensation = total compensation x discount rate

the current Water Use Fee is not sufficient even under the perpetuity compensation scheme. From this point of view, the estimated compensations suggest that there should be a substantial increase in Water Use Fee in order to adequately compensate for the economics loss caused to the upstream region of the Han River.

3.2.3 Border Analysis

This section presents the analyses on the land prices of the restriction border areas in the city of Namyangju in order to test the land price difference between the restricted and unrestricted area among the samples that are closely located around the restriction border line. The border areas include the restricted areas (Hwado-eup, Sudong-myeon, and Joan-myeon), and the unrestricted areas (Jinjeob-eup, Onam-eup, Hopyeong-dong, Pyeongnae-ding, Wabu-eup), and 322 samples, which are located less than 5 km away from the borderline, are analyzed as shown in Figure 3-2.

<Figure 3-2> Map of the samples used (border analysis)



Source: Google Map generated by QGIS 2.0.1-Dufour

Among 322 samples, the number of the samples from the restricted area is 135 and that of the unrestricted area is 187 as shown in Table 3-15.

<Table 3-15> Number of the sample observations used (border analysis)

Number of observations		
Restricted area	**Unrestricted area**	**Total**
135	187	322

The area-weighted average land prices of the samples used in this section confirm that there is a significant price difference between the restricted area and the unrestricted area. The average value is 190,100 won/m^2 for the unrestricted area and 40,077 won/m^2 for the restricted area as shown in Table 3-16. The average land price of the unrestricted area is more than four times higher than that of the restricted area.

<Table 3-16> Area-weighted average land prices of the samples for Namyangju (border analysis)

(Unit: won/m^2)

Total (both unrestricted area and restricted area)	**Unrestricted area**	**Restricted area**
96,009	190,100	40,077

The descriptive statistics of the sample data show that the land prices are in the range between 1,300 won/m^2 and 3,800,000 won/m^2. For the unrestricted area, the range is between 1,900 won/m^2 and 3,800,000 won/m^2, and the range for the unrestricted area is between 1,300 and 880,000 won/m^2. The values of other continuous variables including distance to primary schools, hospitals, convenience stores, Seoul, and roads are within similar ranges since the samples are chosen around the borderline between the restricted and unrestricted areas as shown in Table 3-17.

<Table 3-17> Descriptive statistics of the sample data used sorted by restriction (excluding dummy variables) (border analysis)

Variable	Mean	SD	Min.	Max.
Total				
Land price (won/m^2)	339,217	527,187	1,300	3,800,000
Primary school (km)	1.3	0.8	0.1	3.8
Hospital (km)	1.4	1.2	0.0	4.9
Convenience store (km)	1.5	1.2	0.0	5.4
Seoul (km)	26.2	3.2	20.6	33.6
Road (km)	0.4	0.5	0.0	2.5
Land size (m^2)	10,888	53,570	95	869,225
Unrestricted area				
Land price (won/m^2)	452,787	653,344	1,900	3,800,000
Primary school (km)	1.2	0.8	0.1	3.6
Hospital (km)	1.3	1.1	0.0	4.2
Convenience store (km)	1.2	0.8	0.0	3.3
Seoul (km)	24.1	2.2	20.6	28.8
Road (km)	0.4	0.5	0.0	2.5
Land size (m^2)	6,990	20,806	95	209,455
Restricted area				
Land price (won/m^2)	181,902	174,187	1,300	880,000
Primary school (km)	1.4	0.9	0.1	3.8
Hospital (km)	1.6	1.2	0.0	4.9
Convenience store (km)	1.9	1.5	0.1	5.4
Seoul (km)	29.0	1.9	26.0	33.6
Road (km)	0.3	0.4	0.0	2.4
Land size (m^2)	16,288	78,886	155	869,225

For the dummy variables, in general, both the restricted and unrestricted areas have similar compositions. There are 80 samples with no direct access to road (Isolation), and this is 24.8% of the total samples of 322. The ratios are similar for the unrestricted area (26.2%)

and the restricted area (23.0%). For the types of land, both the restricted and unrestricted areas show similar compositions with a few differences as shown in Table 3-18.

<Table 3-18> Descriptive statistics of the sample data used sorted by restriction (dummy variables) (border analysis)

Dummy Variables	Number of samples with the value = 1					
	Total		Unrestricted area		Restricted area	
	Number of Samples	%	Number of Samples	%	Number of Samples	%
Total	322	100	187	100	135	100
Isolation	80	24.8	49	26.2	31	23.0
Dry field	74	23.0	43	23.0	31	23.0
Factory	13	4.0	8	4.3	5	3.7
Forest	52	16.1	28	15.0	24	17.8
Gas station	1	0.3	1	0.5	0	0.0
Paddy field	70	21.7	45	24.1	25	18.5
Pasture	4	1.2	4	2.1	0	0.0
Building site	96	29.8	52	27.8	44	32.6
Sports site	2	0.6	0	0.0	2	1.5
Misc.	10	3.1	6	3.2	4	3.0

The results of ordinary least squares (OLS) regression analyses on the samples in the border areas suggest that there is statistically significant evidence for the economic loss caused by the restriction for water quality protection. The regression results of the two models, semi-log and double log model, are shown in Table 3-17 and Table 3-18 as follows:

<Table 3-19> Regression results for Namyangju (semi-log model) (border analysis)

Dependent variable: ln(Land price)		
Independent variables	Parameter estimates	Standard errors
Restriction Variable		
Restriction	**-0.423*****	**(0.124)**
Accessibility variables		
Primary school	-0.065	(0.080)
Hospital	-0.094	(0.049)
Convenience store	-0.145**	(0.053)
Seoul	-0.047*	(0.019)
Road	-0.473***	(0.092)
Isolation	-0.584***	(0.101)
Land size variable		
Land size	0.000	(0.000)
Land type variables and constant		
Dry field	-1.011***	(0.103)
Factory	-0.330	(0.192)
Forest	-3.618***	(0.140)
Gas station	0.637	(0.643)
Paddy field	-1.187***	(0.106)
Pasture	-1.165***	(0.331)
Sports site	-2.027**	(0.624)
Misc.	-0.110	(0.214)
_cons.	14.995***	(0.440)
N	322	
R^2	0.874	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

<Table 3-20> Regression results for Namyangju (double-log model) (border analysis)

Dependent variable: ln(Land price)		
Independent variables	Parameter estimates	Standard errors
Restriction Variable		
Restriction	**-0.374*****	**(0.104)**
Accessibility variables		
ln(Primary school)	-0.079	(0.064)
ln(Hospital)	-0.168***	(0.046)
ln(Convenience store)	-0.173***	(0.047)
ln(Seoul)	-1.305**	(0.437)
ln(Road)	-0.174***	(0.025)
Isolation	-0.539***	(0.089)
Land size variable		
ln(Land size)	-0.076	(0.041)
Land type variables and constant		
Dry field	-0.768***	(0.108)
Factory	-0.231	(0.175)
Forest	-3.201***	(0.196)
Gas station	0.717	(0.568)
Paddy field	-0.897***	(0.112)
Pasture	-0.924**	(0.297)
Sports site	-1.127*	(0.474)
Misc.	0.007	(0.192)
_cons.	17.397***	(1.384)
N	322	
R^2	0.903	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The above results show that the semi-log model explains approximately 87.4% of the land price variation, and the double-log model does approximately 90.3%. In addition, the results suggest the loss rates for the restricted area within the border area of Namyangju. Under the semi-log model, the land price of the restricted area is approximately 65.5%[5] of the unrestricted area with 95% confidence, and the result for the restriction variable (Restriction) is statistically significant at the level of 0.001. The result of the double-log model also

[5] Δln(Land price) = (-0.423)(1) - (-0.423) (0)
Δ(Land price) = exp(-0.423) = 65.5%

suggests statistically significant evidence that supports the land price difference at the significance level of 0.001, and the land price of the restricted area is approximately 68.8%[6] of that of the unrestricted area with 95% confidence. In sum, the loss rates for the restricted area within the border area of Namyangju are 34.5% under semi-log model and 31.2% under double-log model as shown in Table 3-19.

<Table 3-21> Loss rates for the restricted area of Namyangju (border analysis)

Semi-log Model	**Double-log Model**	**Remarks**
34.5%	31.2%	The rates are in terms of the land price of the unrestricted area

The loss rates from the border analysis are higher than those from the previous section of which the analyses were conducted on the samples that represent the entire Namyangju. In the previous section, the results of the analyses suggest that the loss rate is 15.0% under the semi-log model and 19.8% under the double-log model. The higher loss rates from this section cannot be directly utilized to estimate compensation for the entire city of Namyangju due to the fact that the samples in the border analysis do not fully represent Namyangju. However, the results from this section confirm that there is statistically significant evidence that supports the economic loss caused by the restriction for water quality protection, which is in line with the results from the previous section.

[6] $\Delta \ln(\text{Land price}) = (-0.374)(1) - (-0.374)(0)$
$\Delta(\text{Land price}) = \exp(-0.374) = 68.8\%$

3.3 Limitations

Despite the statistically significant evidence that supports the economic loss caused by water quality protection, this study is still exposed to a number of limitations. First of all, the land price data used in this study are officially announced prices of reference lands and thus are not the price data from actual transactions. Due to this reason, there may be difference between the results of this study and those based on the actual willingness-to-pay for the lands in the city of Namyangju. However, the officially announced prices of reference lands serve as official bases for various taxes and surcharges. In addition, there is no reliable public institution in Korea that publicly announce actual transaction land prices on a regular basis. From this point view, based on officially announced prices of reference land, the results from this study can provide a meaningful implication for Water Use Fee, which is a surcharge imposed on the residents of the downstream, who benefit from the clean water from the upstream area.

Secondly, this study is based on cross sectional analyses. This implies that this study assumes that the results of the regression analyses are constant over time. The factors that affect the land price might change over time, and thus the regression results may be affected by the potential changes in the future. From this point of view, the nature of cross sectional analysis should be carefully considered when interpreting the results of this study.

Lastly, the regression analyses of this study do not explain all the variations of the land prices. According the regression results, the semi-log model and the double-log model explain approximately 85.2% and 89.3% of variations in the land prices. This means that the coefficient for the restriction variable may change if the variations of the land prices are fully explained, and thus, the loss rates for the restricted area can be changed. Despite the possibility of having different values, R-squared values of the hedonic price models used are still respectable (the values for semi-log model and double-log model are 85.0% and 89.3%, respectively), and so should be the results of the regression analyses in this study.

4. Conclusion and Policy Implications

Based on the analyses on the samples of officially announced prices of reference lands in Namyangju in the year of 2012, this study demonstrates that there is statistically significant evidence that supports the land price difference between the restricted area and the unrestricted area of Namyangju, which is caused by water quality protection. In specific, under the semi-log model, the loss rate that the restricted area experience is 15.0% of the land price of the unrestricted area. Under the double-log model, the rate is 19.8%.

Using the results from the regression analyses of the semi-log and double-log model, the estimated compensations for the city of Namyangju are in the range between 6.5 and 8.6 trillion won. This is much more than Water Use Fee that collected in the period from 1999, its inception year, to 2012, which is estimated to be approximately 4.3 trillion won. In addition, the previous analysis shows that under the perpetuity compensation scheme at the discount rate of 10%, the estimated annual compensation is in the range between 0.7 and 0.9 trillion won, which is greater than the Water Use Fee collected in 2012, which is approximately 0.5 trillion won. In fact, the restricted area of the Paldang area for water quality protection[7], including Namynagju, is approximately 2,572 km^2; the restricted area in the Paldang area is more than 18 times of that of Namyangju, which is approximately 140 km^2. From this point of view, the results suggest that the rate of Water Use Fee needs to be substantially increased

[7] The area includes the restricted areas in Namyangju, Yangpyeong, Hanam, Yeoju, Icheon, Yongin, Kwangju, and Gapyeong and excludes the land owned by the central government, local government, and military.

to sufficiently compensate the economic loss caused to the upstream areas of the Han River under Korea's current water management system.

The upward adjustment of Water Use Fee following the results of this study would lead to the charge of multi-trillion won on the residents of the downstream areas of the Han River. Considering the social cost associated with the compensation, this implies that in some cases, it would be more economical to adopt alternative policies for Korea's water resource management, which are based on market mechanism and allows to control the water quality at lower costs, rather than to stick with the current system that highly relies on the restriction areas imposed by the law.

The results of this study further imply that the hedonic price method used in this study can provide a meaningful guidance for payment schemes for ecosystem services. Due to the lack of market prices for ecosystem services, in many cases, it is difficult to estimate the ecosystem services including those of freshwater, forest, etc. In fact, through the analyses on the land price of Namyangju, the estimated compensations of this study can be interpreted as the cost associated with the provision of the ecosystem services of freshwater to the downstream area of the Han River, which is levied on Namyangju's restricted areas for water quality protection. Based on the view that ecosystem services can be sustainable with appropriate payment schemes, the analysis method used in this study can be utilized to estimate the cost associated with the ecosystem services and further assist in designing payment schemes and supporting policies for sustainability of various ecosystem services.

Lastly, the results of this study provides implications for developing countries where environmental restrictions are often imposed by the central government without proper compensation schemes. With customization and refinement, the analysis method of this study can be used in estimating the economic loss caused by environmental regulation, and the results could serve as a starting point for policy adjustment, which can contribute in formulating development policies that allow the countries to resolve environmental disputes at the same time to maximize both economic development and environmental conservation.

REFERENCE

REFERENCE

Benson, E. D., Hansen, J. L., Schwartz, A. L. & Smersh, G. T. (1998). *Pricing Residential Amenities: The Value of a View*, Journal of Real Estate Finance and Economics, vol. 16, no. 1, pp. 55-73.

Chattopadhyay, S. (1999). *Estimating the Demand for Air Quality: New Evidence Based on the Chicago Housing Market*, Land Economics, vol. 75, no. 1, pp. 1- 22.

Government of Gyeonggi Province (2013). *2012 Paldang Whitebook* (in Korean).

Han River Watershed Management Committee of Korea. (2013), *Statistics on Han River Watershed Management Fund* (in Korean).

Kendree J M, Rauch D A. (1990). *Toward a Theory on the Effects of View and Size on the Price of Real Estate*, ARES annual meeting Lake Tahoe NV

Kim and Jung. (2012). *An Analysis of the Impact of Locally Unwanted Land Uses on Land Price in Ulsan City,* The Journal of the Korean Urban Administration Association, Vol. 25-3: pp. 161-175

Lake, I. R., Lovett, A. A., Bateman, I. J., Day, B. H. (2000). *Improving Land Compensation Procedures via GIS and Hedonic Pricing*, Environment and Planning C: Government and Policy ,18(6), pp. 681 – 696.

Lancaster, K. J. (1966). *A New Approach to Consumer Theory,* Journal of Political Economy, vol. 74, pp. 132-157.

Ministry of Environment of Korea. (2013). *2013 Environmental Statistics Yearbook* (in Korean).

Ministry of Land, Infrastructure and Transport. (2013). *Official Real Estate Price Guidance* (in Korean), http://www.kreic.org/realtyprice (Accessed on 10 December 2013)

Ministry of Strategy and Finance of Korea. (2013). *Comprehensive Report on Management of Surcharges in 2012* (in Korean).

Murdoch, J. and Thayer, M. (1988). *Hedonic Price Estimation of Variable Urban Air Quality,* Journal of Environmental Economics and Management, 15: 143 – 146.

Rodriguez, M. & Sirmans, C. F. (1994). *Quantifying the Value of a View in Single-family Housing Markets,* Appraisal Journal, vol. 62, pp. 600-603.

Rosen, S. (1974). *Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition*, Journal of Political Economy, vol. 82, no. 1, pp. 35-55.

Sirpal, R. (1994). *Empirical Modeling of the Relative Impacts of Various Sizes of Shopping Centres on the Value of Surrounding Residential Properties*, Journal of Real Estate Research, vol. 9, no. 4, pp. 487-505.

TEEB in Local Policy (2011). *The Economics of Ecosystems and Biodiversity in Local and Regional Policy and Management.* Edited by Heidi Wittmer and Haripriya Gundimeda. Earthscan, London.

Vanderford, S. E. et al (2005). *A Hedonic Price Comparison of Manufactured and Site-Built Homes in the Non-MSA U.S*. Journal of Real Estate Research, vol. 27, no. 1

Wolverton M L. (1997). *Empirical Study of the Relationship between Residential Lot Price, Size and View*, Journal of Property Valuation and Investment, 15(1): 48-57

Zabel, J. and Kiel, K. (2000). *Estimating the Demand for Air Quality in Four Cities in the United States*, Land Economics, 78: 174 – 194.

APPENDICES

Appendix A. Results of Robust Regression

Robust regression is used to conduct a regression analysis when the sample data contain outliers or influential observations. As an appendix to this study, robust regression analyses were conducted using two hedonic models, semi-log and double-log model, to test the regression results in Section 3.2. The analyses of this section confirm the results from the main chapters, which show that there is statistically significant evidence for the economic loss caused by restriction for water quality protection at the significance level of 0.05 under semi-log model and at the significance level of 0.001 under double-log model.

<Table A-1> Robust regression results for Namyangju (semi-log model)

Dependent variable: ln(Land price)		
Independent variables	Parameter estimates	Standard errors
Restriction Variable		
Restriction	**-0.145***	**(0.070)**
Accessibility variables		
Primary School	-0.170***	(0.039)
Hospital	-0.105***	(0.029)
Convenience store	-0.149***	(0.031)
Seoul	-0.039***	(0.006)
Road	-0.746***	(0.066)
Isolation	-0.357***	(0.058)
Land size variable		
Land size	-0.000	(0.000)
Land type variables and constant		
Dry field	-1.050***	(0.053)
Factory	-0.431***	(0.100)
Forest	-3.558***	(0.072)
Gas station	0.878	(0.588)
Orchard	-1.481***	(0.416)
Paddy field	-1.222***	(0.051)
Pasture	-0.686***	(0.125)
Religion	-1.050	(0.589)
River	-1.652**	(0.588)
Sports site	-1.164***	(0.336)
Warehouse	-0.427	(0.588)
Misc.	-0.235*	(0.103)
_cons.	14.793***	(0.127)
N	1081	
R^2	0.876	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

<Table A-2> Robust regression results for Namyangju (double-log model)

Dependent variable: ln(Land price)		
Independent variables	Parameter estimates	Standard errors
Restriction Variable		
Restriction	**-0.233*****	**(0.056)**
Accessibility variables		
ln(Primary school)	-0.132***	(0.029)
ln(Hospital)	-0.142***	(0.016)
ln(Convenience store)	-0.112***	(0.023)
ln(Seoul)	-0.789***	(0.114)
ln(Road)	-0.187***	(0.013)
Isolation	-0.354***	(0.051)
Land size variable		
ln(Land size)	-0.155***	(0.020)
Land type variables		
Dry field	-0.630***	(0.053)
Factory	-0.105	(0.092)
Forest	-2.862***	(0.094)
Gas station	0.844	(0.525)
Orchard	-0.859*	(0.375)
Paddy field	-0.762***	(0.053)
Pasture	-0.346**	(0.115)
Religion	-0.535	(0.527)
Sports site	-0.519	(0.281)
Warehouse	-0.258	(0.525)
Misc.	-0.098	(0.092)
_cons.	16.021***	(0.362)
N	1080	
R^2	0.904	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix B. Results of Quantile Regression

Quantile regression is another regression analysis method that is more robust to outliers than ordinary least squares regressions. It estimates the relationship between the regressors and outcome using the conditional median or other quantiles of the response variables.

In this section, the conditional median (quantile = 0.5) is used, and the results confirm those in Section 3.2 and show that there is statistically significant evidence for the economic loss caused by restriction for water quality protection at the significance level of 0.001 under the double-log model and at the lax significance level of 0.15 under the semi-log model.

<Table B-1> Quantile regression results for Namyangju (semi-log model)

Dependent variable: ln(Land price)		
Independent variables	Parameter estimates	Standard errors
Restriction Variable		
Restriction	**-0.152**	**(0.105)**
Accessibility variables		
Primary School	-0.137^{*}	(0.058)
Hospital	-0.127^{**}	(0.044)
Convenience store	-0.148^{**}	(0.046)
Seoul	-0.037^{***}	(0.009)
Road	-0.697^{***}	(0.098)
Isolation	-0.374^{***}	(0.085)
Land size variable		
Land size	-0.000	(0.000)
Land type variables and constant		
Dry field	-0.995^{***}	(0.079)
Factory	-0.446^{**}	(0.148)
Forest	-3.533^{***}	(0.106)
Gas station	0.931^{***}	(0.069)
Orchard	-2.025^{***}	(0.443)
Paddy field	-1.191^{***}	(0.076)
Pasture	-0.706^{***}	(0.184)
Religion	-1.008^{***}	(0.080)
River	-1.615^{***}	(0.064)
Sports site	-1.068^{*}	(0.419)
Warehouse	-0.377^{***}	(0.067)
Misc.	-0.169	(0.152)
_cons.	14.660^{***}	(0.190)
N	1081	
Pseudo R^2	0.618	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

<Table B-2> Quantile regression results for Namyangju (double-log model)

Dependent variable: ln(Land price)		
Independent variables	Parameter estimates	Standard errors
Restriction Variable		
Restriction	**-0.288*****	**(0.073)**
Accessibility variables		
ln(Primary school)	-0.101**	(0.038)
ln(Hospital)	-0.145***	(0.021)
ln(Convenience store)	-0.101***	(0.030)
ln(Seoul)	-0.770***	(0.148)
ln(Road)	-0.187***	(0.017)
Isolation	-0.371***	(0.067)
Land size variable		
ln(Land size)	-0.159***	(0.026)
Land type variables		
Dry field	-0.650***	(0.070)
Factory	-0.085	(0.118)
Forest	-2.840***	(0.123)
Gas station	0.802***	(0.060)
Orchard	-1.186***	(0.355)
Paddy field	-0.817***	(0.069)
Pasture	-0.358*	(0.148)
Religion	-0.468***	(0.087)
River	-1.129***	(0.083)
Sports site	-0.553	(0.323)
Warehouse	-0.228***	(0.064)
Misc.	-0.090	(0.116)
_cons.	15.997***	(0.471)
N	1081	
Pseudo R^2	0.663	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$